Water Quality Improvement Plan
for

East Fork Des Moines River

Kossuth County, Iowa

Total Maximum Daily Load
for Pathogen Indicators

Iowa Department of Natural Resources
Watershed Improvement Section
2008

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General Report Summary

What is the purpose of this report?

This report serves dual purposes. First, it satisfies the Federal Clean Water Act requirement to develop a Total Maximum Daily Load (TMDL) report for all federally impaired waterbodies. Second, it serves as a resource for guiding locally-driven water quality improvements within the Des Moines River Basin.

What's wrong with the East Fork Des Moines River?

In Iowa, waters designated as Class "A1," "A2," or "A3" in subrule 61.3(5) of the Iowa Code are to be protected for primary contact, secondary contact, and children's recreational uses. A segment in the lower portion of the East Fork of the Des Moines River has been assessed as being impaired for primary contact recreational use (Class "A1) by bacteria, making it unusable for recreational activities.

What is causing the problem?

Pollutants that affect water quality, such as bacteria, may come from point or nonpoint sources, or a combination of both. Point source pollution is the introduction of an impurity into surface water or groundwater from an easily identifiable, distinct location though a direct route, while nonpoint source (NPS) pollution is the introduction of impurities into surface water or groundwater, usually through a non-direct route and from sources that are "diffuse" in nature. Discharges from point sources are regulated, often continuous, and easier to identify and measure, while discharges from nonpoint sources are usually intermittent, associated with rainfall or snowmelt events, and may occur less frequently and for shorter periods. In Iowa, most surface water and groundwater contamination is caused by NPS pollution.

What can be done to improve the East Fork Des Moines River?

The first step to improving water quality within the East Fork Des Moines River watershed, or any watershed, is understanding how the water moves through the watershed over the land and through the soil into the surface water. Land management, both agricultural and urban, can have a large impact on Iowa's water resources. While individuals can make a difference, landowners can have a greater impact as part of an organized watershed project. The IDNR and other organizations have resources to provide assistance in a number of areas, from learning how to control pollution on farms and in homes, to creating a watershed project.

Some general goals for stakeholder involvement and stewardship strategies might be as follows:

- Generate local support for NPS management through public involvement, and through monitoring the results of management actions, and monitoring of streams and possibly tile lines within the watershed.
- Increase individuals' awareness of how they contribute to NPS pollution problems, and implement appropriate strategies to motivate behavioral change and actions to address those problems.

- Provide the educational tools, assistance, and support for addressing NPS problems to target audiences within the watershed.

Information about watershed improvement is available from the IDNR website at http://www.iowadnr.com/water/watershed/wis.html#projects, and the EPA has written a draft handbook to help communities, watershed organizations, and state, local, tribal and federal environmental agencies develop and implement watershed plans to meet water quality standards and protect water resources. The EPA handbook is available at http://www.epa.gov/owow/nps/watershed_handbook/.

Required Elements of the TMDL

Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:	The East Fork Des Moines River, sub-segment IA 04-EDM-0010_1, located between the mouth in Humboldt County and Highway 169 at Devine Access in Section 26, T94N, R29W, Kossuth County.
Impaired waterbody segment identification number:	IA 04-EDM-0010_1
Current surface water classification and use designation (dependent upon final use attainability analysis):	A1 (Primary contact recreation) B(WW1) (Aquatic life), HQR
Impaired use:	A1 (Primary contact recreation)
TMDL priority level:	Consent Decree waterbody
Identification of the pollutants and applicable water quality standards:	High levels of indicator bacteria, the stream segment did meet requirements for addition to Iowa's Section 303(d) list. The applicable water quality standards for bacteria (E. coli) are a seasonal geometric mean of 126 CFU/100 ml of water, and a single maximum value of 235 CFU/100 ml. .

Quantification of the pollutant loads that may be present in the waterbody and still allow attainment and maintenance of water quality standards:	Because bacteria are expressed as a density of bacterial colonies, mass load is not relevant for assessing the level of contamination. The targets are therefore expressed as a concentration, with the units being number of organisms, or CFU per 100 ml of water, as is the standard. The target of this TMDL is an E. coli level, which does not exceed a geometric mean of 126 CFU/100 ml of water or a sample maximum of 235 CFU/100 ml of water. This criterion applies during the recreational season from March 15 to November 15 of each year.
Quantification of the amount or degree by which the current pollutant loads in the waterbody, including the pollutants from upstream sources that are being accounted for as background loading, deviate from the pollutant loads needed to attain and maintain water quality standards:	Existing pathogen load is 3.39E+13 CFU/day, the estimated pathogen loading capacity is 4.63E+12 CFU/day, and the targeted reduction is 86 percent.
Identification of pollution source categories:	Nonpoint sources of pathogen indicators have been identified as the main cause of the primary contact recreation use impairment for this segment of the East Fork Des Moines River. Point sources include four permitted facilities and Animal Feeding operations are likely contributors to the total pathogen load.
Wasteload allocations for pollutants from point sources:	The wasteload allocations (WLA) for point source dischargers to the East Fork Des Moines River will be equivalent to the water quality criteria associated with the primary contact recreation beneficial use. Therefore, the WLA is a monthly geometric mean of 126 CFU/100 ml and a maximum daily value of 235 CFU/100 ml for facilities discharging directly to the impaired reach or a higher value for those contributing to tributaries of the impaired reach.
Load allocations for pollutants from nonpoint sources:	The load allocations (LA) for this TMDL will be based upon the applicable water quality standards for the stream's

	designated use. Therefore, the LA is a monthly geometric mean of 126 CFU/100 ml and a maximum daily value of 235 CFU/100 ml
A margin of safety:	A margin of safety is implicit by employing a phased/adaptive TMDL strategy and by conservative assumptions made in load estimates. An explicit MOS is set by multiplying the flow rate from the USGS gaging station at Dakota City by 211.5 CFU/100 ml
Consideration of seasonal variation:	This TMDL was developed based on the Iowa water quality standards primary contact recreation season that runs from March 15 to November 15. For the technical modeling, a load duration analysis was used to assign bacterial concentrations to variable streamflow conditions so that seasonal variations could be accounted for.
Reasonable assurance that load allocations and wasteload allocations will be met:	Wasteload allocations will be implemented under the NPDES permitting program for point source dischargers. Load allocations can be achieved voluntarily via watershed/water quality assistance grants provided by state government agencies and technical support from local Soil and Water Conservation Districts.
Allowance for reasonably foreseeable increases in pollutant loads:	There was no allowance for future growth included in this TMDL because current watershed land uses are predominantly agricultural and the addition/deletion of animal feeding operations (which could increase or decrease pathogen indicator loading) cannot be predicted or quantified at this time.
Implementation plan:	An implementation plan is outlined in section 4 of this TMDL. The reduction of bacterial pathogen concentrations will be carried out through a combination of non-regulatory activities and monitoring for results. Nonpoint source pollution will be addressed using available programs, technical advice, information and education, and financial incentives.

1. Introduction

The Federal Clean Water Act requires the IDNR to develop a TMDL for waters that have been identified on the State's 303(d) list as impaired by a pollutant. One segment of the East Fork Des Moines River (segment IA 04-EDM-0010_1) was included in the 1998 Iowa 303(d) List as impaired by excessive indicator bacteria. A TMDL is a calculation of the maximum allowable pathogen load for the impaired segment of the East Fork Des Moines River while still meeting water quality standards. Phasing TMDLs is an iterative approach to managing water quality that becomes necessary when the origin, nature and sources of water quality impairments are not well understood. Section 4 of this TMDL includes a description of planned monitoring. The TMDL will have two phases. Phase 1 will consist of setting specific and quantifiable targets for fecal coliform. Phase 2 will consist of implementing the monitoring plan, evaluating collected data, and readjusting target values if needed. Monitoring is essential to all TMDLs in order to:
assess the future beneficial use status, determine if the water quality is improving, degrading or remaining status quo, and evaluate the effectiveness of implemented best management practices.

Additional data will be used to determine if the implemented TMDL and watershed management plan have been, or are, effective in addressing the identified water quality impairment. The data and information can also be used to determine if the TMDL has accurately identified the required components (i.e. loading/assimilative capacity, load allocations, in-stream response to pollutant loads, etc.) and if revisions are appropriate.

2. Description and History of the East Fork Des Moines River

The East Fork Des Moines River originates in Tuttle Lake within Emmet County, Iowa, on the Iowa-Minnesota boarder (Figure 1). The east fork flows south-southeast about 120 miles through the cities of Armstrong, Algona, St. Joseph, Livermore, and Dakota City to its confluence with the West Fork Des Moines River, about 5 miles south of the USGS gaging station at Dakota City, within Humboldt County. The two forks join at Frank Gotch State Park to become the Des Moines River, which then flows roughly southward through Fort Dodge.

2.1 East Fork Des Moines River

Hydrology. The total drainage area of the East Fork Des Moines River is 1,308 square miles (837,120) acres. Major tributaries that flow directly into the impaired segment include Lotts Creek HUC 10 (draining 164 square miles) and Bloody Run Creek HUC 10 (draining 122 square miles). The remaining 1,023 square miles of watershed above the impaired segment are drained by seven other HUC 10 sub-basins. Table 1 summarizes pertinent information for the East Fork Des Moines River USGS gage.

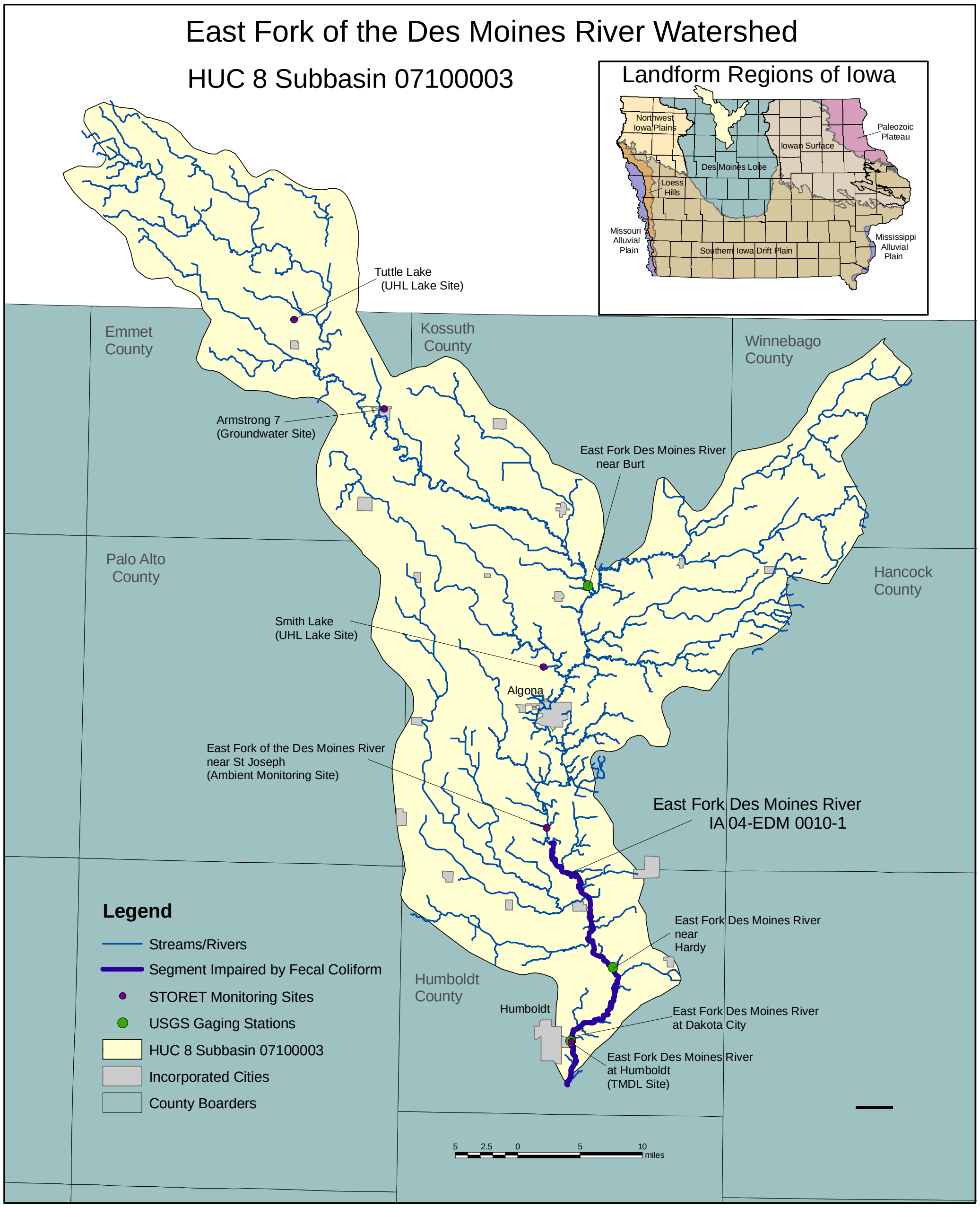


Figure 1. Map of the East Fork Des Moines River watershed above the impaired stream segment. Also shown is the location of the watershed within the landform regions of Iowa.

Table 1. USGS gaging station on the East Fork Des Moines River.

Site number	05479000
Station Name	East Fork Des Moines River at Dakota City, IA
Latitude	42°43’26’’
Longitude	94°11’30’’
Altitude (NGVD29)	1,038.71
HUC	07100003
Drainage area (mi.^{2})	1308
Discharge begin date	03/01/1940
Discharge end date	9/30/2007

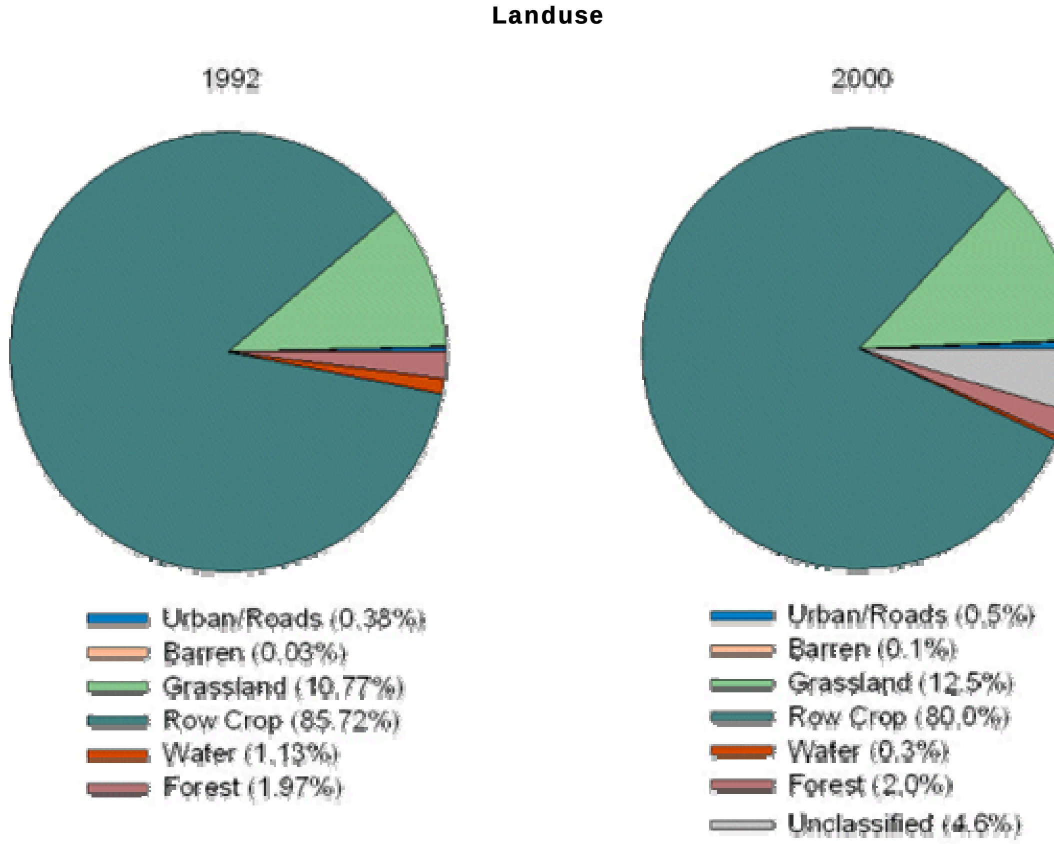
Morphometry & Substrate. The East Fork Des Moines River flows through a light to moderately timbered floodplain with numerous heavily-grazed pastures extending to the river edge, resulting in some bank erosion. Beginning near Bancroft in Kossuth County, the river contains numerous logjams, timbered canopies and occasional fences. Within this reach, snags and deep pools occur on outside bends. A constructed fishing riffle occurs about five miles upstream of Algona, at the Plum Creek Dam access, and another constructed riffle occurs on the north edge of Algona near Veterans Park. As the East Fork leaves Kossuth and enters Humboldt County, the logjams and fences decrease, while the timbered canopy remains, and riffle areas and rocky substrate increase. There is an area containing rubble from an old dam at Dakota City Park.

2.2 The East Fork Des Moines River Watershed

The East Fork Des Moines River watershed is a Y-shaped HUC 8 sub-basin, located in north central Iowa, with a portion of the northwest branch of the watershed extending into southern Minnesota. The northeast branch of the watershed consists of the East Fork Des Moines River-Soldier Creek, Mud Creek-East Fork Des Moines River, East Fork Des Moines River-Prairie Creek, and Black Cat Creek HUC 10 sub-basins. The northwest branch contains the Buffalo Creek-East Fork Des Moines River and East Fork Des Moines River-Plum Creek HUC 10 sub-basins. The lower portion of the watershed consists of the Lotts Creek, East Fork Des Moines River-Purcell Creek, and East Fork Des Moines River-Bloody Run HUC 10 sub-basins. The watershed includes parts of six counties in Iowa and two counties in Minnesota, and was formed within the Des Moines Lobe landform region, described in the following section.

Land Use. Land-use has remained relatively stable within the watershed above the ambient monitoring site from 1992 through 2000. Agriculture is the primary land use within the watershed and includes row crop farming, small grains, hay production, and pastureland (Figure 2 and Table 2). Livestock feeding operations occur throughout the watershed, with hog and beef operations being the most common. Row crop farming is relatively uniform across the entire watershed, with corn and soybeans accounting for over 84 percent of the land use during the 2002 crop season.

Table 2. Land use within the East Fork Des Moines River watershed in 1992 and 2002.



Watershed Characteristics		Landuse Percentages (Iowa portion of the watershed only)	(%)
Drainage Area (mi^2)	1186.8	Artificial	0.4
Drainage Area (Acres)	759,542	Barren	0.0
Basin Length (mi)	75.5	Grass	10.5
Average Basin Slope (%)	1.5	Row Crop	86.8
Main Channel Length (mi) (Iowa portion of the watershed only)	100.9	Water	0.6
		Forest	1.8

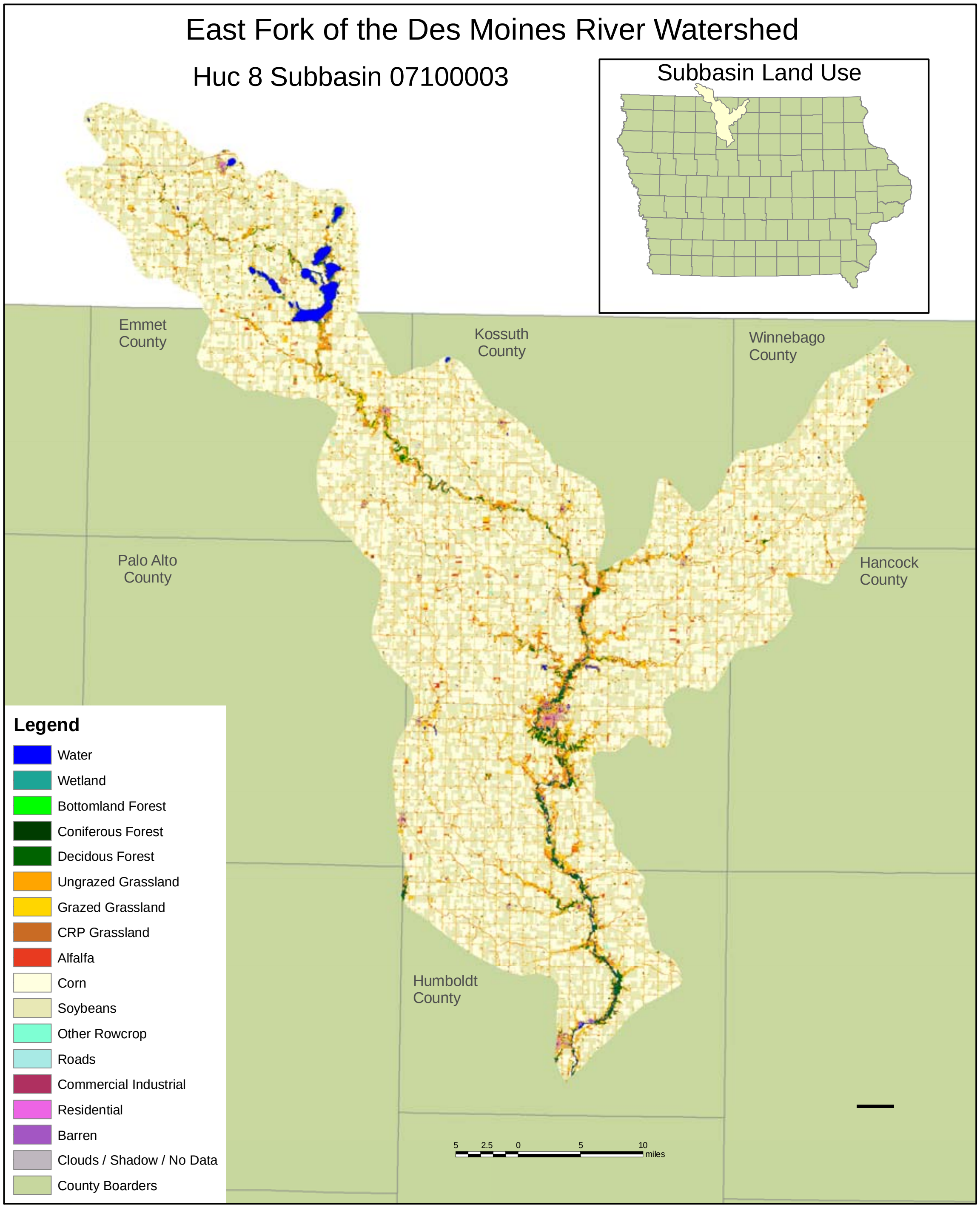


Figure 2. Land use within the East Fork Des Moines River watershed in 2002.

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Climate. The annual rainfall is normally adequate for growing corn, soybeans and small grains. The climatic results discussed in the following paragraphs are based on data collected in Algona from 1951 to 1973 (Jones, 1982). In winter the average temperature for Kossuth County is 19 degrees Fahrenheit (°F), and the daily minimum temperature is 9 °F. In summer, the average temperature is 71 °F, and the average daily maximum temperature is 83 °F. The total annual precipitation for Kossuth County is 29.22 inches on average, with 21 inches, or 75 percent, falling during the April through September growing season. The average annual snowfall is approximately 38 inches but this varies widely from year to year. During the period from January 1, 1975 through June 30, 2006, the average annual precipitation for Algona was 30.08 inches, and the average annual snowfall was 25.19 inches. This data suggests that in recent years, more precipitation is occurring as rainfall, rather than snowfall.

Groundwater Vulnerability. The East Fork Des Moines River watershed overlies alluvial and drift aquifers, as well as good and viable bedrock aquifers (Figure 3). Alluvial aquifers consist of the unconsolidated sand and gravel deposits located beneath floodplains. These aquifers have generally excellent natural water quality and are capable of high yields in larger valleys, but have a high potential for both aquifer and well contamination.

Within, and down gradient of, the East Fork Des Moines River watershed, are a number of agricultural drainage wells (ADWs) that drain surface runoff and tile effluent into Mississippian carbonate aquifers. The drainage water delivered to groundwater by ADWs often contains relatively high concentrations of agricultural contaminants such as nitrate-nitrogen and herbicides. In addition, concerns exist about the transport of pathogen and viral constituents from land applied manure and animal feedlots into deeper groundwater, particularly in areas with large numbers of livestock.

Soils. The major soil associations found within the East Fork Des Moines River watershed include Canisteo, Nicollet, Clarion, Webster, Harps, Okoboji, and Kossuth. Canisteo soils are poorly drained, moderately permeable soils that occur on upland swales (Jones, 1982). Nicollet soils are somewhat poorly drained, moderately permeable soils that are formed on uplands. Clarion soils are well drained, moderately permeable soils formed on convex upland knolls, ridges, and side slopes. Webster soils are poorly drained, moderately permeable soils formed on upland swales, slightly higher on the landscape than calcareous Canisteo soils. Harps soils are poorly drained moderately permeable soils formed on rims of depressions on broad upland flats. Okoboji soils are very poorly drained, moderately slowly permeable soils formed in upland depressions, and Kossuth soils are poorly drained, moderately slowly permeable soils, formed on level to slightly concave slopes on uplands.

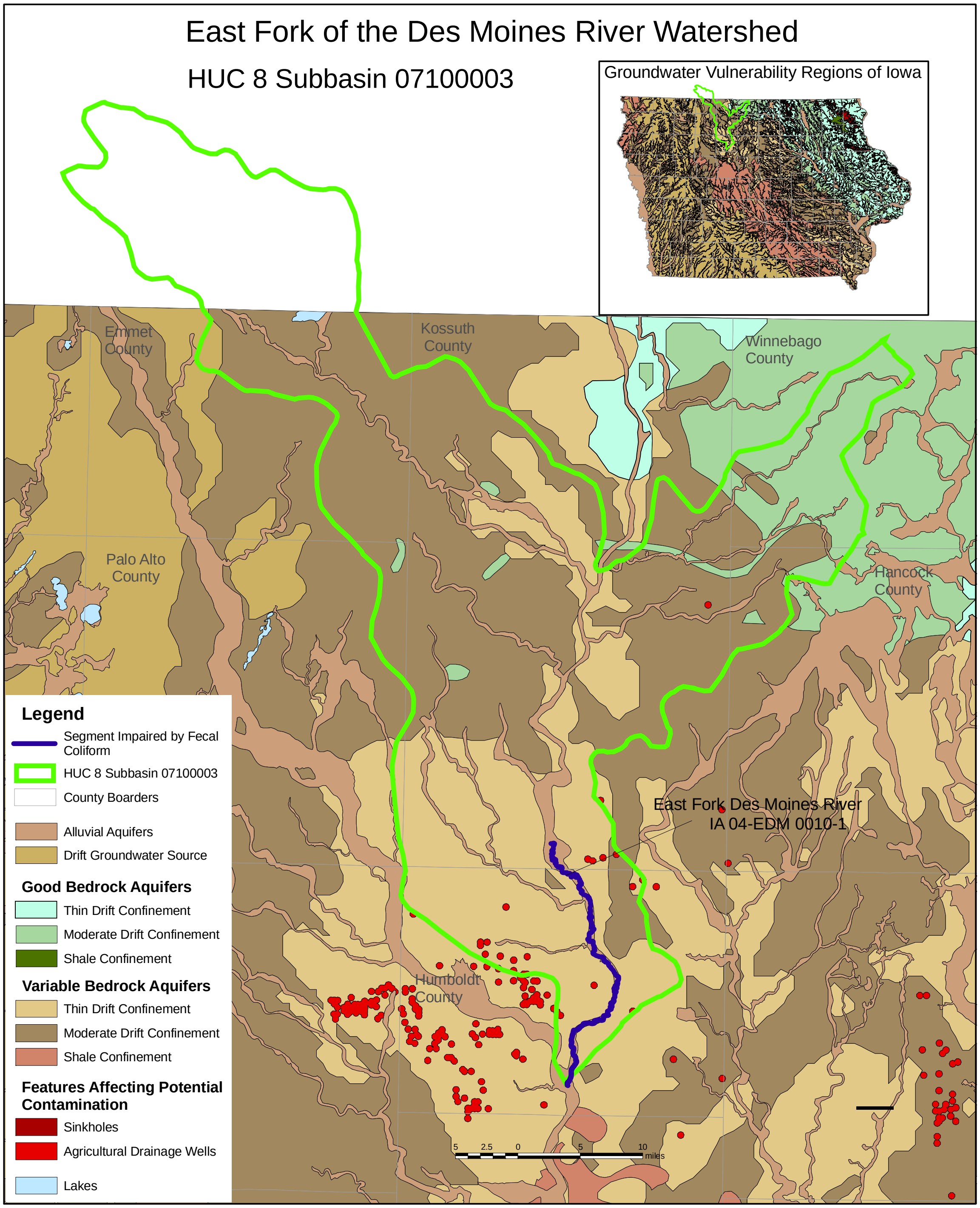

Figure 3. Groundwater Vulnerability Regions near the East Fork Des Moines River watershed.

3. Total Maximum Daily Load (TMDL) for Pathogen Indicators

A Total Maximum Daily Load (TMDL) is required for the impaired segment of the East Fork Des Moines River by the Federal Clean Water Act. This chapter will quantify the maximum amount of pathogen indicators that the East Fork Des Moines River can tolerate without violating the State's water quality standards.

3.1 Problem Identification

The methodology for impaired waters listings is explained in *The methodology for Iowa's 2004 water quality assessment, listing, and reporting pursuant to sections 305(b) and 303(d) of the federal Clean Water Act*, on the IDNR Watershed Monitoring and Assessment page at http://wqm.igsb.uiowa.edu/WQA/303d.html#2004 in *.pdf format. The waterbody classifications and water quality standards are specified on the IDNR Water Quality Standards page at http://www.iowadnr.com/water/standards/criteria.html. This information is a summary of specific chemical water quality criteria published in the Iowa Administrative Code, Environmental Protection Rule 567, Chapter 61, "Water Quality Standards."

The 2002 Section 305(b) Assessment Report for Iowa lists the East Fork Des Moines River as divided into eight stream reaches consisting of thirteen segments for water-quality assessment purposes. One of the segments, East Fork Des Moines River mouth (Humboldt Co.) to Hwy 169 at Devine Access in S26, T94N, R29W, Kossuth Co., Waterbody ID No.: IA 01-EDM-0010-1, is impaired for pathogen indicators and is addressed by this TMDL.

Problem Statement

The following two paragraphs, which are the basis for the assessment, are from the IDNR 2004 305(b) Water Quality Report for the Des Moines River Basin, East Fork Des Moines River Subbasin. This report is available in *.pdf format from the IDNR website at http://wqm.igsb.uiowa.edu/wqa/305b/2004/2004_305b.html.

> *The Class A (primary contact recreation) uses of the stream segment were assessed (monitored) as "partially supported" due to high levels of indicator bacteria. The Class B (WW) aquatic life uses were assessed (monitored) as "partially supported" due to a fish kill in December 2001. Support of fish consumption uses was "not assessed" due to the lack of fish contaminant monitoring in the river reach. The sources of data for the assessment include results from the IDNR ambient monthly monitoring station near St. Joseph in Kossuth County (STORET station 10550001) from January 2000 through December 2002 and the occurrence of a fish kill in the river segment in December of 2001. Because the party responsible for the fish kill was identified, and restitution for the kill was sought, the impairment was not considered appropriate for Section 303(d) listing. However, due to high levels of indicator bacteria, the stream segment did meet requirements for addition to Iowa's Section 303(d) list.*
>
> *The Class A uses were assessed (monitored) as "partially supported" based on results of monitoring for indicator bacteria (fecal coliforms). For purposes of Section 305(b) assessments, IDNR uses the long-term average monthly flow plus one standard deviation of*

this average to identify river flows that are materially affected by surface runoff. According to the Iowa Water Quality Standards (IAC 1990:8), the water quality criterion for fecal coliform bacteria (200 CFU/100 ml) does not apply "when the waters are materially affected by surface runoff." Eighteen of the 21 samples collected from the St. Joseph station during the 2000, 2001, and 2002 recreational seasons (4/1-10/31) were collected at flows not materially affected by surface runoff. The geometric mean level of indicator bacteria (fecal coliforms) in these 18 non-runoff-affected samples (142 CFU/100 ml) was below the Iowa Class A water quality criterion of 200 CFU/100 ml. However, five of the 18 samples (28 percent) exceeded the U.S. EPA-recommended single-sample maximum value of 400 CFU/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting, if more than 10 percent of the samples exceed the single-sample maximum value of 400 CFU/100 ml, the primary contact recreation uses are "partially supported" (see pgs 3-33 to 3-35 of U.S. EPA 1997b).

This segment of the East Fork Des Moines River is on the State of Iowa 303(d) list of impaired waters for indicator bacteria. Bacteria sources may include runoff from land applied manure and feedlots, wastewater treatment plant discharges, urban storm sewers, septic tanks, and wildlife. Bacteria problems often occur following heavy rainfall events.

Impaired Beneficial Uses and Applicable Water Quality Standards

The Surface Water Classification document (IDNR, 2004b) lists the designated uses for the impaired segment as Class A1, Class B (WW1) and HQR. Results of monitoring at the St. Joseph ambient monitoring station during the 2000-2002 assessment period show no violations of Class B (WW) (aquatic life) water quality criteria in the 36 samples analyzed for dissolved oxygen, pH, and ammonia or in the nine samples analyzed for pesticides. These results suggest that the aquatic life uses of this river segment are "fully supported." The occurrence of a fish kill during the most recent three years, however, suggests that the Class B(WW) are only "partially supported." This kill occurred in mid-December 2001. The kill, which began in Lotts Creek northeast of Whittemore in southwestern Kossuth County, resulted from nitrogen fertilizer discharged from a damaged pipeline. The kill included a 31-mile reach of Lotts Creek and an 18.5-mile reach of the East Fork Des Moines River from its confluence with Lotts Creek downstream to Dakota City in Humboldt County. According to IDNR's assessment methodology for Section 305(b) reporting, the occurrence of a single pollution-caused fish kill within the most recent three-year period indicates that the aquatic life uses of a waterbody are only "partially supported." Thus, the Class B (WW) aquatic life uses of this river reach were assessed as "partially supported." Since the party responsible for the fish kill was identified, and restitution for the kill was sought, the impairment was not considered appropriate for Section 303(d) listing. However, the primary contact recreation (Class A1) beneficial use remains impaired. The Iowa Water Quality Standards (IAC, 2004) describes this use classification as follows:

- Primary contact recreational use (Class “A1”). Waters in which recreational or other uses may result in prolonged and direct contact with the water, involving considerable risk of ingesting water in quantities sufficient to pose a health hazard. Such activities would include, but not be limited to, swimming, diving, waterskiing, and water contact recreational canoeing.

In 2003, Iowa changed its bacteria standards to use *E. coli*, rather than total fecal coliform, as its indicator bacteria. At this time, Iowa also extended the time period when the standards are in force, from April 1 though October 31, to March 15 through November 15. The state also changed the Class A use designation into three separate use designations (A1-primary contact recreational use; A2-secondary contact recreational use; and A3-children's recreational use) with variable allowable *E. coli* bacteria limits. In addition, although the previous fecal coliform standards allowed exceptions to the standards when river flows were materially affected by surface runoff, the current *E. coli* standards do not allow exceptions based on flow.

Since Iowa is now using *E. coli* rather than fecal coliform as its indicator bacteria, the TMDL target, assessment and allocation for the East Fork Des Moines River watershed will be based on *E. coli*, even though the impairment was based on fecal coliform. Currently the Iowa standards for Class A1 waters are that the geometric mean should not exceed 126 organisms/100 ml or a single sample concentration of 235 organisms/100 ml for *E. coli* bacteria during the recreation season.

The current Iowa water quality standards for the primary contact recreation use are based on *E. coli*, rather than fecal coliform bacteria (Table 3).

Table 3. *E. coli* Bacteria Criteria (CFU/100 ml of water) for Class A waters (IAC, 2004).

Use	Geometric Mean	Sample Maximum
Class A1		
3/15 – 11/15	126	235
11/16 – 3/14	Does not apply	Does not apply
Class A2 (Only)		
3/15 – 11/15	630	2880
11/16 – 3/14	Does not apply	Does not apply
Class A2 and B(CW) or HQ		
Year-Round	630	2880
Class A3		
3/15 - 11/15	126	235
11/16 - 3/14	Does not apply	Does not apply

Relationship of E. coli to Fecal Coliform. To investigate the relationship between *E. coli* and fecal bacteria in Iowa, the Watershed Monitoring and Assessment Section of the Iowa Geological Survey reviewed data from 6,310 water samples with analyses for both *E. coli* and fecal bacteria from the same collection event, collected from the IDNR ambient monitoring network during 1998 through 2004. According to the review, *E. coli* accounted for 91.67 percent of the fecal coliform bacteria (O'Brien, personal communication).

To determine the relationship between *E. coli* and fecal coliform within the East Fork Des Moines River watershed, data from 147 water samples with analyses for both *E. coli* and fecal bacteria, collected at the St. Joseph ambient monitoring site from 10/08/86 through 07/13/04 were reviewed. For this sample set, *E. coli* accounted for 96 percent of the fecal coliform bacteria. Ratios of *E. coli* to fecal coliform were computed for 135 sample sets that had at least one detectable bacteria constituent, then a mean, median, and standard deviation were computed for the ratios (Figure 4). The relationship suggests that *E. coli* data may be an appropriate substitute for fecal coliform data to assess current conditions and develop percentage reduction targets. Water samples from the St. Joseph site were analyzed for *E. coli*, *Enterococci*, and fecal bacteria from 10/08/86 through 07/13/04, while samples collected after 07/13/04 were analyzed for only *E. coli* bacteria. Although the pathogen impairment was based on the previously used fecal coliform standards, the TMDL targets for the East Fork Des Moines River will be based on the current *E. coli* standards. Since *E. coli* bacteria are considered a subset of fecal coliform bacteria, the ratio should not exceed 1.

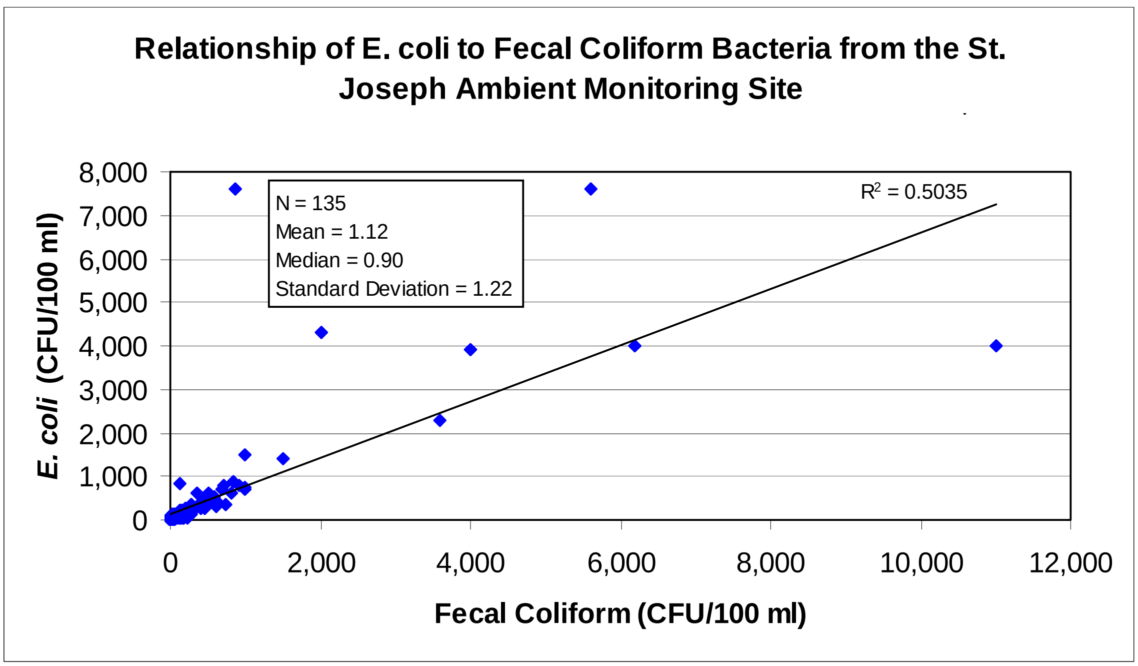

Figure 4: Relationship of *E. coli* to fecal coliform bacteria samples collected from the St. Joseph monthly monitoring site from 10/08/86 through 07/13/04.

Data Sources. Water quality data for this TMDL assessment were obtained from the following sources:

- Results from the IDNR ambient monthly monitoring station near St. Joseph in Kossuth County (STORET station 10550001; Figure 5).
- Information from the Minnesota Pollution Control Agency (MPCA).

- *E. coli* analyses from the Raccoon River near the City of Des Moines Water Works for calibration of the Soil and Water Assessment Tool (SWAT) model. (See Appendix D for a detailed discussion of SWAT modeling methodology.)

Interpreting East Fork Des Moines River Data. As discussed, eighteen of 21 monthly samples collected from the St. Joseph station during the 2000 - 2002 recreational seasons (4/1-10/31) were collected at flows not materially affected by surface runoff, as defined by exceeding the long-term average monthly flow plus one standard deviation of this average. The geometric mean of the indicator bacteria (fecal coliforms) in these 18 non-runoff-affected samples (142 CFU/100 ml) was below the Iowa Class A water quality criterion of 200 CFU/100 ml for fecal coliform. However, five of the 18 samples (28 percent) exceeded the U.S. EPA-recommended single-sample maximum value of 400 CFU/100 ml for fecal coliform. According to U.S. EPA guidelines for Section 305(b) reporting, if more than 10 percent of the samples exceed the single-sample maximum value of 400 CFU/100 ml, the primary contact recreation uses are "partially supported".

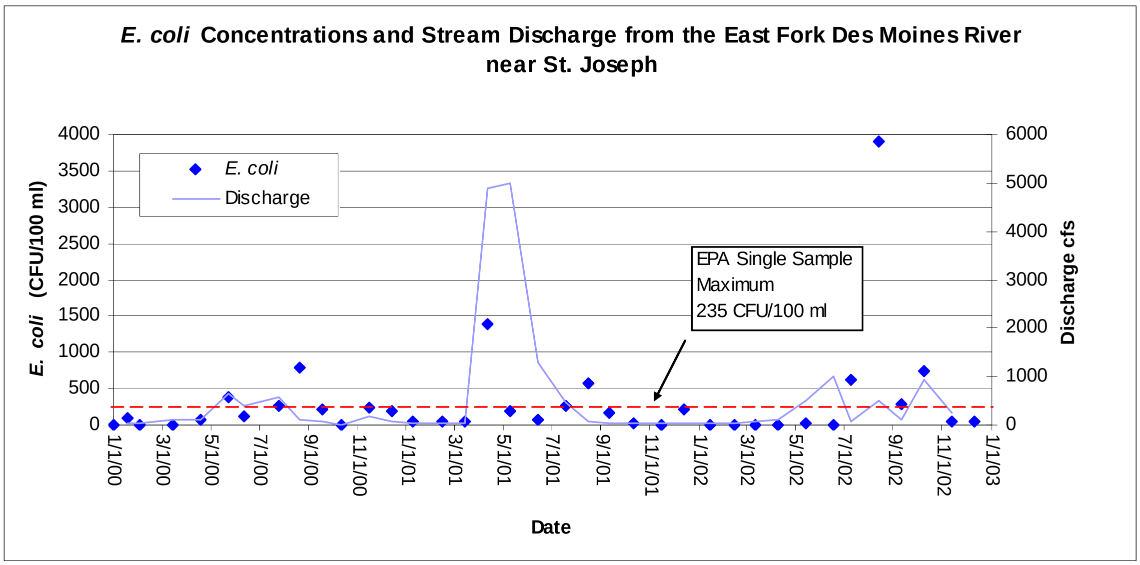

Figure 5. E. coli concentrations and stream discharge from the IDNR ambient monthly monitoring station on the East Fork Des Moines River near St. Joseph.

3.2 TMDL Target

General Description of Pollutant. Bacteria are carried into the water with fecal material. Fecal contamination of surface water occurs due to surface runoff from improperly constructed or maintained animal feeding operations and lands containing applied manure or wildlife and pet droppings, improperly constructed and operated septic systems and sewage treatment plants, manure spills, or direct contamination from waterfowl, or livestock in the water Overland runoff and infiltration after heavy rainfall or snowmelt may transport high levels of bacteria from the land surface and drainage tiles into surface water. Additionally, the increased runoff also increases the amount of sediment in the water decreasing light penetration which aids bacteria since they are destroyed by sunlight.

Selection of environmental conditions. This TMDL was developed based on the Iowa water quality standards primary contact recreation season that runs from March 15 to November 15. For the technical modeling, a load duration analysis was used to assign bacterial concentrations to variable streamflow conditions so that seasonal variations could be accounted for.

Water Pollutant Loading Capacity (TMDL). The TMDL was based on a load duration curve. SWAT modeling was also used to look at the distribution of loading within subbasins. Using the duration curve method to calculate the existing loading under moist conditions (flow exceedance percentile = 10-40 percent), the 25th percentile exceedance flow was multiplied by the 90th percentile of *E. coli* concentrations measured within the 10-40th percentile flows. Based on this method, the existing pathogen load is 3.39E+13 CFU/day, the estimated pathogen loading capacity is 4.63E+12 CFU/day, and the targeted reduction is 86 percent (for a review of reading scientific notation see Appendix A). Using this same moist hydrologic condition from the duration curve, the load allocation, comprised of nonpoint sources, accounts for 99.8 percent of *E. coli* loading within the watershed, while the wasteload allocation, comprised of permitted point source discharge from wastewater treatment facilities (WWTP), accounts for 0.2 percent of the *E. coli* loading. According to the Soil and Water Assessment Tool (SWAT) model, from 1985 through 2004, the average annual *E. coli* load from the watershed was 4.26E + 15 CFU, with a range of 1.70E + 15 CFU to 1.38E + 16 CFU, while the modeled monthly average load was 3.55E + 14 CFU, with a range of 3.19E + 12 CFU to 1.06E + 16 CFU. Modeling suggests that nonpoint sources account for 99.5 percent, and point sources for 0.5 percent of E. coli loading within the East Fork Des Moines River watershed. The different proportions of nonpoint and point source allocations produced by the duration curve and SWAT model, result because the duration curve uses only WWTP discharge as a point source input, while the model considers contributions of pathogens from cattle in streams, septic system discharge, and WWTP discharge as point source inputs.

Once defined, the load capacity (LC) or TMDL for a watershed can then be divided among the point sources (wasteload allocation or WLA), wasteload allocation reserve (WLA-R) and nonpoint sources (load allocation or LA) with an allowance for an implicit or explicit MOS. The MOS ensures a conservative estimate of the pollutant load, and is often calculated to account for the inherent error that exists due to the high number of variables that exist in a dynamic stream system. The resulting equation is:

$$TMDL = LC = WLA + WLA\text{-}R + LA + MOS$$

Figure 6 shows the load duration curve and flow intervals obtained from simulated and measured values from the St. Joseph monitoring site on the East Fork Des Moines River from 10/01/1986 through 12/31/2005. For the simulated values, which are the LC, an explicit MOS is set by multiplying the flow rate from the USGS gaging station at Dakota City by 211.5 CFU/100 ml, or 90 percent of the *E. coli* single sample water quality standard. By using 211.5 CFU/100 ml, rather than the 235 CFU/100 ml water quality standard, the LC curve is lowered by 10 percent. The measured values were calculated by multiplying *E. coli* sample concentrations by the corresponding flow rate from the gaging station. Also shown is the WLA for the watershed, which is expressed as a constant value or horizontal line across the entire duration curve, since it is not expected to change significantly with streamflow during most flow conditions.

To convert pathogen values from the St. Joseph monitoring site and the continuous point source discharges into the desired units of CFU/day, the following equation was used:

Daily load = flow [m^3/s] · pathogen concentration [CFU/100 ml] · 86,400[s/day] · 10,000[100ml/m^3]

Decision criteria for water quality standards attainment. The decision criteria for water quality standards attainment in the East Fork Des Moines River are based on meeting Iowa standards for Class A1 waters for pathogens. This requires achieving and maintaining the Iowa standards for Class A1 waters and that the geometric mean should not exceed 126 organisms/100 ml or a single sample concentration of 235 organisms/100 ml for *E. coli* bacteria during the recreation season.

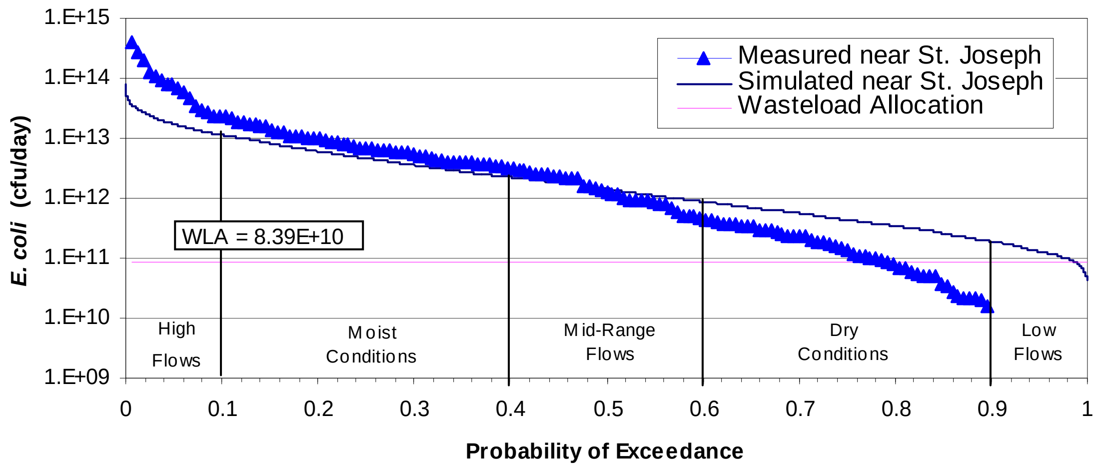

Figure 6. Load duration curve of *E. coli* concentrations collected from the IDNR ambient monthly monitoring station on the East Fork Des Moines River near St. Joseph.

3.3 Pollution Source Assessment

Identification of Pollutant Sources. The sources of bacterial pollutants within the East Fork Des Moines River watershed can be divided into two major categories: point source, including wastewater treatment plants and animal feeding operations, and nonpoint source contributors that do not have localized points of release into streams. These two categories are sub-divided and explained in detail in the following paragraphs.

Point Sources. Municipal wastewater treatment and industrial and commercial facilities act as point source contributors within watersheds. In Iowa, National Pollutant Discharge Elimination System (NPDES) permittees that discharge treated sanitary wastewater must meet state water quality standards for fecal coliform bacteria at the point of discharge There are four permitted facilities located in the watershed that have a fecal coliform discharge limit. Table 4a lists the permitted flow and fecal coliform concentration as compiled from the Permit Compliance System (PCS) database and the Wastewater Treatment Plant state-wide, environmental regulation coverage in the NRGIS library. Table 4b lists permitted facilities in the watershed that have no specified limitation on effluent fecal coliform, but may be potential sources. Ten facilities are controlled discharge lagoons, which are supposed to discharge only when receiving streamflows are high. These lagoons are denoted with an asterisk.

Table 4a. Permitted wastewater treatment facilities with fecal coliform limits in the East Fork Des Moines River watershed.

Facility Name	EPA NPDES ID	Receiving Stream	Facility	Population Equivalent	Design AWW Flow (MGD)	Maximum Design Flow (MGD)	Fecal Coliform Limits (CFU/100ml)
City of Ceylon, Minnesota	MNG 580006-SD-1	Okamanpeedan Lake, Unnamed Stream, Unnamed Wetland	Waste Stabilization Lagoon*	439	0.061	n/a	Avg. N/A Max. N/A
City of Dunnell, Minnesota	MN 0056103-SD-1	County Ditch #53 to Soldier Creek	Activated Sludge	198	0.050	n/a	Avg. 21 Max. 210
City of Sherburn, Minnesota	MN 0024872-SD-2	County Ditch #11	Activated Sludge	1,082	0.332	n/a	Avg. 20 Max. 148
City of Dakota City, Iowa	IA 0048003	East Fork Des Moines River	Activated Sludge	1,329	0.30	0.50	Avg. 200 Max. 370

* Denotes controlled discharge

The feedlot listed at the bottom of Table 4b should not discharge to any receiving stream, but is included because it is a permitted facility in the watershed.

Animal feeding operations (AFOs) within the East Fork Des Moines River watershed range in size from small farms with a few animals to large feeding operations. Unlike livestock on pasture, animals in AFOs are kept in small areas where feed and manure become more concentrated.

Iowa has two types of AFOs that are regulated by the IDNR:

- confinement animal feeding operations (CAFOs) and
- open feedlots.

Both regulated AFO types have animals confined (kept and fed for 45 days or more per year) within a lot, yard, corral, building or other area, and both types include manure storage structures, but do not include livestock markets.

Table 4b. Permitted facilities without limits in the East Fork Des Moines River watershed.

Facility Name	EPA NPDES ID	Receiving Stream	Facility	Population Equivalent	Design AWW Flow (MGD)	Maximum Design Flow (MGD)
City of Whittemore, Iowa	IA0033430	Lotts Creek	Waste Stabilization Lagoon*	1,102	0.1600	0.3060
City of Swea City, Iowa	IA0047813	Mud Creek	Waste Stabilization Lagoon*	970	0.0630	0.0945
City of Algona, Iowa	IA0022055	East Fork Des Moines River	Trickling Filter	23,952	1.9760	2.7600
City of Burt, Iowa	IA0027405	Drainage Ditch to East Fork Des Moines River	Waste Stabilization Lagoon*	587	0.1150	0.2400
City of City of Livermore, Iowa	IA0023566	East Fork Des Moines River	Waste Stabilization Lagoon*	719	0.1100	0.1650
City of Bancroft, Iowa	IA0057762	Mud Creek	Waste Stabilization Lagoon*	1,760	0.1690	0.2535
City of Bode, Iowa	IA0047805	Lotts Creek	Waste Stabilization Lagoon*	489	0.0380	0.0570
Oak Lake Maintenance Inc.	IA0065242	East Fork Des Moines River	Waste Stabilization Lagoon*	144	0.0150	0.0230
City of Titonka, Iowa	IA0033375	Buffalo Creek	Waste Stabilization Lagoon*	763	0.1150	0.1725
Southdale Addition	IA0068284	East Fork Des Moines River	Activated Sludge	215	0.0210	0.0315
City of Ringstead, Iowa	IA0057436	Black Cat Creek	Waste Stabilization Lagoon*	647	0.0770	0.1155
South Oak Estates MHP	IA0065269	East Fork Des Moines River	Activated Sludge	175	0.0150	0.0225
City of Armstrong, Iowa	IA0028517	East Fork Des Moines River	Aerated Lagoon	1,269	0.3250	0.6250
Sentral Community School District	IA0078115	Unnamed Tributary to Black Cat Creek	Trickling Filter	n/a	0.0060	0.0060
Ulrich Feedlot (Jerry Ulrich)	IA0078573	n/a	n/a	n/a	n/a	n/a

* Denotes controlled discharge

A CAFO confines animals to areas that are totally roofed. In Iowa, these facilities are not allowed to discharge manure to surface waters. CAFOs typically utilize earthen or concrete structures to contain and store manure prior to land application. Pathogens, nutrients and other oxygen demanding materials from these facilities can be delivered to surface water via runoff from land-applied manure and from leaking or failing storage structures. Currently, CAFOs with more than 500 animal units must have an approved manure management plan. Regardless of size, all CAFOs must report manure releases.

An open feedlot is unroofed or partially roofed with no vegetation or residue ground cover while the animals are confined. Large open feedlots in Iowa are allowed to discharge to surface waters under certain conditions, such as during a storm event larger than the 25-year, 24-hour storm. The runoff from open feedlots can deliver substantial quantities of pathogen indicators, nutrients, sediment, and oxygen demanding materials to surface waters, depending upon factors such as proximity to the waterbody, number and type of livestock, and configuration of manure control structure(s). Open feedlots with more than 1,000 animal units are required to have an operating permit or NPDES permit. In addition, Iowa has a voluntary registration program for open feedlots.

Nonpoint Sources. Nonpoint sources within the East Fork Des Moines River watershed include:

- Land application of hog, cattle, and poultry manure
- Grazing animals
- Cattle contributions directly deposited in the stream
- Failing septic systems and unsewered communities
- Urban areas
- Wildlife

The contributions from each of these sources were estimated using information currently available. The IDNR contacted several agencies to refine the data assumptions made in determining pathogen loading. IDNR wildlife biologists provided information regarding deer, geese and raccoon populations in the watershed. Some county sanitarians estimated the failure of septic tank systems in their area. NRCS and ISU researchers provided information on manure application practices and loading rates for hog and cattle operations. The location and magnitude of these loads will be dependant on the different land uses in the East Fork Des Moines River watershed.

Livestock Estimates for the Watershed are provided in tables 5 and 6. Table 5 provides the estimated number of farm animals in the watershed, and Table 6, the expected fecal coliform and *E. coli* loading in CFU/animal/day, for animals in the East Fork Des Moines River watershed, including hogs, sows, pigs, beef cattle, dairy cows, chickens, and turkeys. There may also be a very small number of horses and sheep in the watershed from time to time, but the pathogen contribution from these animals is thought to be very small and inconsistent. The animal inventory estimates were based on IDNR agricultural GIS coverages, examination of AFOs using infrared aerial photography, and also information provided by the Minnesota PCA. Although livestock inventories can vary throughout the year depending on sale and slaughter rates, it was assumed that the animal numbers were representative of the average population throughout the year.

Table 5. Estimated number of farm animals in the East Fork Des Moines River watershed.

Hogs (55-300 lbs)	Sows (>300 lbs)	Pigs (<55 lbs)	Beef Cattle	Dairy Cows	Chickens	Turkeys
533,514	9,899	49,805	26,280	1,314	220,800	400

Figure 7 shows the distribution and annual output of facilities that apply manure within the watershed. Manure and litter are potential contributors of bacteria, as they can be transported by runoff into surface waters. Application rates vary monthly according to management practices currently used in the watershed. In general, the majority of manure is applied during the months of October, November, and December in this area of Iowa. Cattle manure is assumed to be applied to cropland and pastureland, whereas hog and poultry litter is applied only to cropland. .

Table 6. Fecal coliform and *E. coli* loading expected for livestock within the East Fork Des Moines River watershed.

Type of Animal	Fecal Coliform (CFU/animal/day)	*E. coli* (CFU/animal/day)	Number of Animals	*E. coli* load (CFU/day)
Hogs	1.08E+10	6.75E+09	533,514	3.60E+15
Sows	1.08E+10	6.75E+09	9,899	6.68E+13
Pigs	1.08E+10	6.75E+09	49,805	3.36E+14
Beef Cattle	1.04E+11	6.50E+10	1,314	8.54E+13
Dairy Cows	1.04E+11	6.50E+10	26,280	1.71E+15
Chickens	1.36E+8	8.50E+07	220,800	1.88E+13
Turkeys	9.30E+7	5.81E+07	400	2.33E+10

E. coli is calculated as fecal coliform * 0.625.

Beef cattle and dairy cows may spend some time grazing on pastureland and deposit manure directly onto the land surface. During precipitation, or snowmelt, a portion of this fecal matter may be delivered to surface waters by runoff.

Access to pastureland by grazing cattle varies throughout the year. According to researchers at ISU, cattle are 80 percent confined from January to March. During the spring and summer months (April through October) they spend 100 percent of their time grazing. In November and December, they have slightly reduced access, and spend approximately 80 percent of their time grazing (Russell, personal communication). It is assumed that dairy cattle are confined in feedlots, and thus their waste is applied as manure.

Cattle often have direct access to streams that run through pastureland. In Iowa, about 90 percent of grazing cattle have direct access to a stream. The *E. coli* bacteria deposited in these streams by grazing cattle are modeled as a direct input of bacteria to the stream. Preliminary research in Iowa suggests that cattle spend 1 - 6 percent of their time in streams from April through December. The contribution of indicator bacteria from all grazing animals is probably relatively small in the East Fork Des Moines River watershed, since as of 2002, less than two percent of the watershed was grazed grassland.

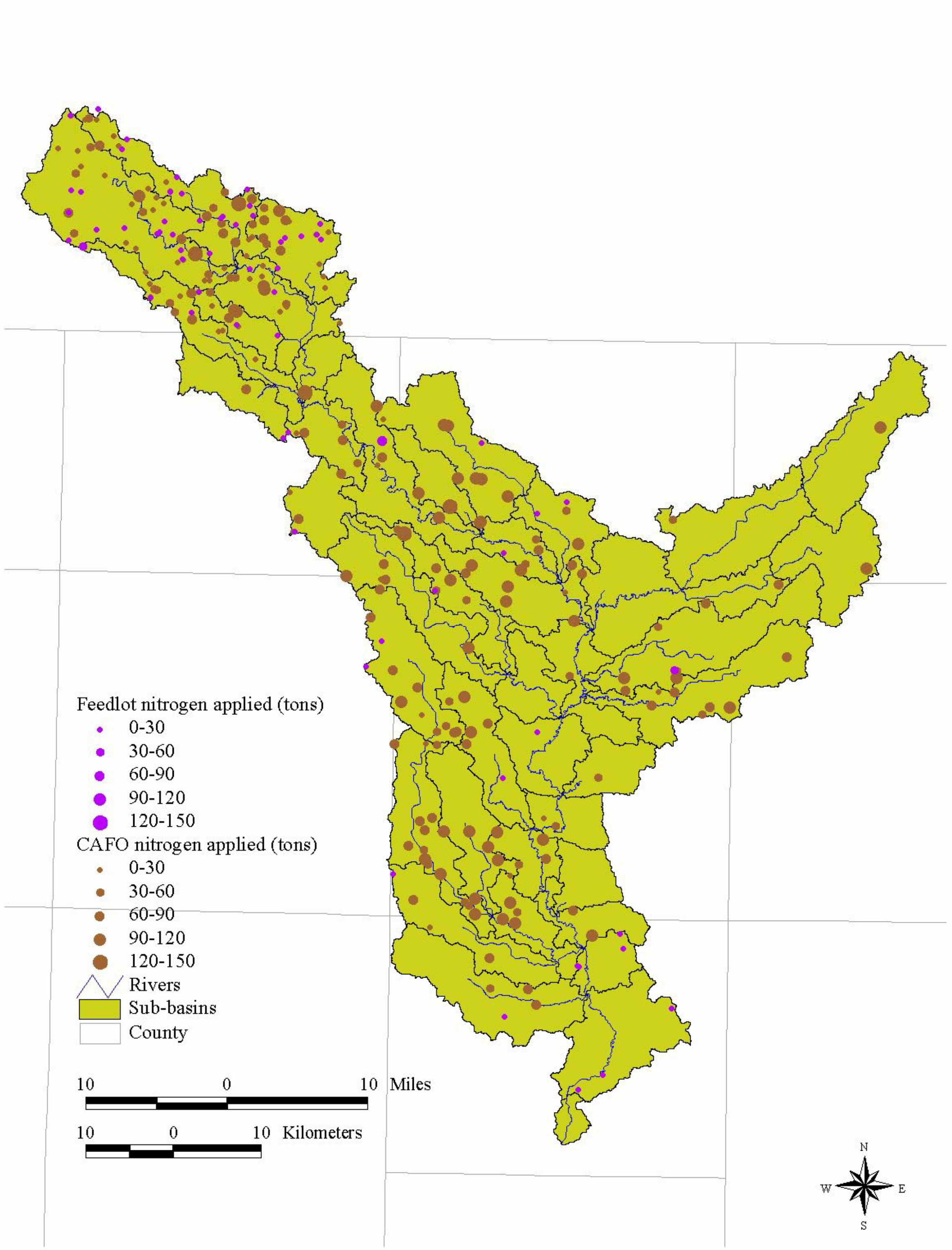

Figure 7. Distribution of feedlot and CAFO manure applied annually within the East Fork Des Moines River watershed, as tons of Nitrogen/facility.

Septic systems may deliver pathogen loads to surface waters due to malfunctions, failures, or direct pipe discharges. Septic systems can fail when the lateral pipes become broken or plugged, or when the underground substrate becomes clogged or flooded. . Direct bypasses from septic tanks to streams also cause bacteria contamination. In order to keep wastewater from percolating up to the land surface in failed lateral fields, pipes are sometimes extended from septic tanks or lateral lines to the nearest stream. This practice provides a direct path for contaminants to enter surface waters, and is illegal in Iowa.

For counties within, or partially within the East Fork Des Moines River watershed, county sanitarians were contacted and asked to provide estimated rates of septic system failure. Unfortunately, most county sanitarians could not provide estimates. The most concise estimate received was that 1,800 septic systems are currently failing in Hancock, Kossuth and Winnebago counties (Bradley, personal communication). Because accurate rates of septic system failure could not be attained, a 100 percent failure rate for septic systems within the watershed was assumed. In addition, since it was not possible to accurately estimate a failure rate for septic systems within the watershed, the contribution of human pathogen loading from septic systems within the watershed was modeled and distributed within sub-watersheds based on the rural population within the watershed, rather than an estimated number of failing septic systems within the watershed. Even at 100 percent failure, the contribution of pathogens from septic tanks is negligible.

Using population and housing data from the 2000 U. S. Census, the rural population within the East Fork Des Moines River watershed was estimated to be 10,185. The SWAT model used a factor of 2.0E + 9 CFU/person/day, multiplied by the rural population to calculate a rate of human pathogen loading of 2.04E + 13 CFU/day within the watershed. The model assumed that pathogen concentrations are reduced by 99.5 percent before being discharged directly into the streams.

Pathogen contributions from urban areas may result from runoff through stormwater sewers (e.g. residential, commercial, industrial, and road transportation), illicit discharges of sanitary wastes, and runoff contribution from improper disposal of waste materials. The failure of sewer and septic systems and subsequent migration with stormwater runoff is also a potential source of pathogens. Twenty incorporated communities in Iowa, and two in Minnesota are located entirely or partially in the watershed. Since roads, commercial industrial and residential land use accounts for approximately 1 percent of the watershed area, the nonpoint source contribution of pathogens from these areas is considered relatively small.

Wildlife within the watershed also contribute *E. coli* bacteria to the land surface where it may be transported with runoff into surface waters. The SWAT model, accounted for pathogen contributions from deer within forested areas within the watershed, but did not account for contributions from deer outside of forested areas or contributions from other wildlife. The reasoning for this was because estimates of deer numbers for land-use types other than forested areas are not available, and since wetland accounts for about 0.3

percent of the watershed, and forest accounts for less than 1.3 percent of the watershed, it was thought that the contribution from other wildlife such as geese and raccoons would be relatively insignificant.

For SWAT modeling, an average value of 100 deer per square mile was used for forest cover, with a value of 5.0E + 8 CFU/animal/day to estimate pathogen loading from deer within the forested areas of the watershed. The SWAT model used to estimate the bacteria contribution from various sources is limited in its ability to represent seasonal variation. In addition, the estimates are limited by the assumption that the wildlife population remains constant throughout the year, and that wildlife is present on all land classified as forestland. It was also assumed that the wildlife were evenly distributed throughout the aforementioned land-use type.

Existing Load. Using the duration curve method to calculate the existing loading under moist conditions (flow exceedance percentile = 10-40 percent), the 25th percentile exceedance flow was multiplied by the 90th percentile of *E. coli* concentrations measured within the 10-40th percentile flows. Based on this method, the existing pathogen load is 3.39E+13 CFU/day. The development of the WLA for the continuous point source discharges is relatively straightforward. As mentioned, it plots as a horizontal line, since it is relatively constant during most flow conditions. The WLA was calculated using very conservative assumptions within the duration curve framework. Best management practices (BMPs) for point source pollution control measures are typically based on requirements of the appropriate NPDES permits. For wastewater treatment plants within the watershed with fecal coliform limits, the WLA was calculated by multiplying the design flow, or maximum design flow (when provided) by the maximum fecal coliform limit (when provided). For the city of Ceylon Minnesota, which did not provide a maximum fecal coliform limit or a maximum design flow, the design flow was multiplied by the 400 CFU/100 ml fecal coliform single sample water quality standard. For wastewater treatment plants and other permitted facilities within the watershed that did not have maximum fecal coliform limits, the maximum design flow for each facility was multiplied by the 400 CFU/100 ml fecal coliform single sample water quality standard. In addition to the above conservative assumptions, no in-stream bacterial die-off was assumed using the duration curve method. The only permitted facility within the watershed that was not included in the wasteload allocation was a feedlot that is not allowed to discharge.

For computation of the WLA, the protocol for estimating point source fecal coliform as described in Herring 2006b was used. Following computation, the daily loads from all permitted facilities within the watershed totaled 4.78E + 10 CFU/day. Using the maximum design flows and maximum fecal coliform limits, and assuming no bacterial die-off from the time the indicator bacteria leave the permitted facilities to reaching the impaired river segment, assures that the WLA is probably overestimated, and results in a implicit MOS.

The development of the LA for nonpoint sources of pollutants is more complicated than that of the WLA because pollutants are transported to surface waters by a variety of mechanisms such as, runoff from precipitation and snowmelt, groundwater infiltration, resuspension of pollutants, etc. In addition, the loads from nonpoint sources often change with streamflow conditions. Most BMPs for the nonpoint source allocation generally focus on source control and/or contaminant delivery reduction. The load duration curve can be used to develop load allocations, and characterize various flow conditions under which exceedances of pathogen standards are occurring.

A common way to look at duration curves is by dividing them into flow intervals, with one interval representing high flows (0-10 percent), another for moist conditions (10-40 percent), one covering mid-range flows (40-60 percent), another for dry conditions (60-90 percent), and one representing low flows (90-100 percent). The midpoints of the moist, mid-range, and dry flow intervals on the duration curve are at the 25th, 50th, and 75th percentiles respectively (i.e., the quartiles), while the high flow interval is centered at the 5th percentile, and the low flow interval is centered at the 95th percentile. In general, exceedances that occur in the 0 to 10 percent area of the curve (0 to 0.1 on Figure 7) represent unique high flow problems that may exceed feasible BMP remedies, while exceedances in the 99 to 100 percent area (0.99 to 1.0 on Figure 7) reflect extreme drought conditions.

Since different loading mechanisms can dominate at different flow regimes, the load duration curve can also be used to differentiate between nonpoint and point source problems. In general, exceedances of the curve during higher flows are indicative of nonpoint source problems, while exceedances during lower flows are indicative of point source problems. Duration curves can also be used to express seasonal variation. Since spring months tend to be wetter, spring flows and loads generally plot in the high and moist flow intervals, while late summer and fall tend to be drier, and these flows and loads often plot in the mid to low flow intervals.

It is often difficult to estimate current nonpoint loading due to limited specific water quality and flow information that would assist in estimating the relative proportion of non-specific sources within a watershed. Since the ambient monitoring data for the East Fork Des Moines River watershed are limited to monthly samples, existing instream loads were used as a conservative surrogate for nonpoint loading. As mentioned, the loads were calculated by multiplying *E. coli* concentrations by the flows matched to the specific sampling dates. Then using the hydrologic flow intervals shown in Table 7, the existing loading was calculated as the 90^{th} percentile of measured *E. coli* concentrations under each flow interval multiplied by the flow at the middle of the flow interval. For example, in calculating the existing loading under moist conditions (flow exceedance percentile = 10-40 percent), the 25^{th} percentile exceedance flow was multiplied by the 90^{th} percentile of *E. coli* concentrations measured within the $10\text{-}40^{th}$ percentile flows. The “high flow” and “low flow” hydrologic conditions are usually not selected as critical conditions because they are not representative of typical conditions, and often few observations are available to estimate loads under these conditions.

Departure from load capacity. Since the duration curve method results in multiple estimates of existing loading, and TMDLs are typically expressed as a load or concentration under a single scenario, it is often assumed that if the highest percent reduction (excluding the high flow interval) associated with the difference between the existing loading and the TMDL is achieved, the water quality standard will be attained under all other flow conditions. Using this assumption for the East Fork Des Moines River watershed, an 86 percent reduction is needed, based on the moist hydrologic condition. Using this same condition, the load allocation, comprised of nonpoint sources, accounts for 99.8 percent of *E. coli* loading within the watershed, while the wasteload allocation, comprised of point source discharge from wastewater treatment facilities, accounts for 0.2 percent of the *E. coli* loading.

Since EPA recommends that states apply the entire duration curve in the context of a TMDL, the entire duration curve is to be considered the TMDL for the East Fork Des Moines River watershed.

Table 7. Load capacity, load and wasteload allocations for the East Fork Des Moines River near St. Joseph divided into flow regimes.

Loads from East Fork Des Moines River within duration curve intervals in CFU/day					
Flow Interval Percentile	**High 5th**	**Moist 25th**	**Mid-Range 50th**	**Dry 75th**	**Low 95th**
TMDL*	1.72E+13	4.63E+12	1.45E+12	4.34E+11	1.29E+11
LA	5.67E+14	3.39E+13	6.63E+12	5.93E+11	n/a
WLA+WLA-R	4.93E+10	4.93E+10	4.93E+10	4.93E+10	4.93E+10
% Reduction Needed	97	86	78	37	n/a

* Computed using 211.5 CFU/100 ml, or 90 % of the *E. coli* single sample water quality standard.

As discussed, an explicit MOS is applied to the load duration curve for the East Fork Des Moines River watershed by multiplying the flow rate from the USGS gaging station at Dakota City by 211.5 CFU/100 ml, or 90 percent of the *E. coli* single sample water quality standard. In addition, an implicit MOS is set by using very conservative assumptions in the derivation of numeric targets for the WLA and LA. Furthermore, since the wastewater treatment plants in the watershed are required to meet the water quality standards at their discharge and to demonstrate this by monitoring, the uncertainty of compliance is very low.

Allowance for Reasonably Foreseeable Increases in Pollutant Loads. There was no allowance for future growth included in this TMDL because current watershed land uses are predominantly agricultural and the addition or deletion of animal feeding operations (which could significantly increase or decrease pathogen indicator loading) cannot be predicted or quantified at this time. The WLA-R is not set aside for future growth but for already existing communities that have not developed a sewer system but will be in the future.

3.4 Pollutant Allocation

Wasteload Allocation. Since point sources do not appear to be contributing significantly to the impaired segment of the East Fork Des Moines River, the total wasteload allocation for this TMDL is set to the existing target levels for *E. coli* water quality standards of the 126 CFU/100 ml geometric mean or 235 CFU/100 ml single sample maximum (Table 8).

For *E.coli* bacteria, very few wastewater treatment facilities monitor for bacteria in their effluent. Therefore, estimates of the quantities of bacteria are derived from generic conservative assumptions based on type of treatment, quantity and quality of influent wastewater, and per capita pollutant generation. For *E.coli*, virtually all NPDES associated documentation and records use fecal coliforms as the standard for measuring pathogen indicators and not *E.coli*. Thus, all assessment and calculations of bacteria loadings from point sources apply to fecal coliform only. However, the use of fecal coliform as surrogates for *E.coli* is treated as a conservative estimate in this TMDL. Because *E.coli* is a subset of fecal coliform (FC * 0.92 = EC in surface water), use of fecal coliform in estimating point source discharges will overestimate *E.coli* losses to streams. Thus estimates of *E.coli* point source loads from WWTPs provide a worst-case estimate of their inputs to East Fork Des Moines River receiving waters. The methods used to estimate point source fecal coliform loads in the East Fork Des Moines River are provided in Herring, 2006.

Estimating daily loads from WWTPs with controlled discharge presents challenges in TMDL development. For the East Fork Des Moines River TMDL, monthly discharge records from WWTPs were examined to see if monthly patterns of discharges emerged. In the majority of cases, there was a typical spring and late fall discharge period, but the actual months of discharge varied year-by-year. While many previous TMDLs could evaluate discharge loads from facilities with controlled discharge on an annual basis and thus avoid problems related to the timing of releases, current EPA guidance indicates loads are to be calculated on a daily basis only.

The approach used tends to overestimate the influence of the controlled discharge WWTP's at low flows since these facilities would not typically discharge during these periods and underestimate their effect at high flows when they would typically discharge.

The amount of bacteria discharged into a stream was estimated using a three-tiered approach. If a facility had bacteria monitoring data, then the monitoring data were used (Estimate Type 1). If the facility had no monitoring data available, an estimated discharge amount was assumed based on the population estimate (Estimate Type 2). The total bacteria amount produced by the population was then reduced by 99.99 percent from the wastewater treatment process. For controlled discharge facilities, the same rate of bacteria generation by population was used but the reduction rate varied depending on the length of time the wastewater was in storage and were multiplied by estimated remaining fraction per site (Estimate Type 3). Again these numbers are for Fecal Coliform and since FC * 0.92 = EC in surface water, a margin of safety is implicitly built into the calculations. Point sources will have to meet new standards at the end of the pipe if discharging into a permanently flowing stream. Waste load allocations will be set at water quality standards for each permit.

Table 8. Summary of daily loads and WLA for permitted wastewater treatment facilities with fecal coliform limits and facilities without limits in the East Fork Des Moines River watershed

EPA NPDES ID	Facility Name	Facility	Population Equivalent	Design AWW Flow (MGD)	Maximum Design Flow (MGD)	FC estimate type	Fecal Coliform Limits (CFU/100ml)	Daily EC Load (CFU)	WLA for EC Load (CFU)
MNG580006-SD	City of Ceylon, Mn	Waste Stabilization Lagoon*	439	0.061	n/a	2	n/a	na	na
MN0056103-SD-1	City of Dunnell, Mn	Activated Sludge	198	0.05	n/a	1	210	na	na
MN0024872-SD-2	City of Sherburn, Mn	Activated Sludge	1,082	0.332	n/a	1	148	na	na
IA48003	City of Dakota City, Ia	Activated Sludge	1,329	0.3	0.5	1	370	2.66E+08	4.45E+09
IA0033430	Ciry of Whittemore, Ia	Waste Stabilization Lagoon*	1,102	0.16	0.306	3	n/a	1.06E+08	2.72E+09
IA0047813	City of Swea City, Ia	Waste Stabilization Lagoon*	970	0.063	0.0945	3	n/a	1.28E+08	8.41E+08
IA0022055	City of Algona, Iowa	Trickling Filter	23,952	1.976	2.76	2	n/a	4.79E+09	2.45E+10
IA0027405	City of Burt, Iowa	Waste Stabilization Lagoon*	587	0.115	0.24	3	n/a	1.17E+08	2.13E+09
IA0023566	City of City of Livermore, Iowa	Waste Stabilization Lagoon*	719	0.11	0.165	3	n/a	1.44E+08	1.47E+09
IA0057762	City of Bancroft, Iowa	Waste Stabilization Lagoon*	1,760	0.169	0.2535	3	n/a	3.52E+08	2.25E+09
IA0047805	City of Bode, Iowa	Waste Stabilization Lagoon*	489	0.038	0.057	3	n/a	9.78E+07	5.07E+08
IA0065242	Oak Lake Maintenance Inc.	Waste Stabilization Lagoon*	144	0.015	0.023	3	n/a	2.88E+07	2.05E+08
IA0033375	City of Titonka, Iowa	Waste Stabilization Lagoon*	763	0.115	0.1725	3	n/a	1.06E+08	1.53E+09
IA0068284	Southdale Addition	Activated Sludge	215	0.021	0.0315	2	n/a	4.30E+07	2.80E+08
IA0057436	City of Ringstead, Iowa	Waste Stabilization Lagoon*	647	0.077	0.1155	3	n/a	4.26E+06	1.03E+09
IA0065269	South Oak Estates MHP	Activated Sludge	175	0.015	0.0225	2	n/a	1.29E+08	2.00E+08
IA0028517	City of Armstrong, Iowa	Areated Lagoon	1,269	0.325	0.625	2	n/a	3.50E+07	5.56E+09
IA00078115	Sentral Community School Dist.	Trickling Filter	60	0.006	0.006	2	n/a	1.20E+07	5.34E+07
							**Total	5.15E+10	4.78E+10

**Total includes both facilities with limits and facilities without limits*

Acccording to Iowa water quality standards, in addition to a daily maximum daily load, all facilities operating under an NPDES permit must meet a 30 day geometric mean *E. coli* concentration of 126 CFU/100ml (Table 9). This is calculated based on the following permitting protocols for bacteria monitoring:

1. All facilities must collect and analyze a minimum of five *E. coli* samples in one calendar month during each three-month period during the appropriate recreation season associated with the receiving stream designation,
2. Samples must be spaced over one calendar month,
3. No more that one sample can be collected on any one day,
4. There must be a minimum of two days between each sample, and
5. No more than two samples may be collected in a period of seven consecutive days.

The geometric mean must be calculated using all valid sample results collected during a month. The geometric mean formula is as follows:

Geometric Mean = (Sample 1*Sample 2*Sample3*…SampleN) $^{(1/N)}$

Where N is the number of samples collected over given sampling period.

The geometric mean is used as opposed to an arithmetic mean because it handles highly skewed data or data with large variation/outliers better.

Table 9. Summary of 30 day geometric mean loads based on a 126/100ml geometic mean for permitted wastewater treatment facilities with fecal coliform limits and facilities without limits in the East Fork Des Moines River watershed

EPA NPDES ID	Facility Name	Facility	Population Equivalent	Design AWW Flow (MGD)	FC estimate type	WLA for EC Load (CFU) 126 CFU/100ml Geometric Mean
MNG580006-SD	City of Ceylon, Mn	Waste Stabilization Lagoon*	439	0.061	2	na
MN0056103-SD-1	City of Dunnell, Mn	Activated Sludge	198	0.05	1	na
MN0024872-SD-2	City of Sherburn, Mn	Activated Sludge	1,082	0.332	1	na
IA48003	City of Dakota City, Ia	Activated Sludge	1,329	0.3	1	1.43E+09
IA0033430	Ciry of Whittemore, Ia	Waste Stabilization Lagoon*	1,102	0.16	3	7.63E+08
IA0047813	City of Swea City, Ia	Waste Stabilization Lagoon*	970	0.063	3	3.00E+08
IA0022055	City of Algona, Iowa	Trickling Filter	23,952	1.976	2	9.42E+09
IA0027405	City of Burt, Iowa	Waste Stabilization Lagoon*	587	0.115	3	5.48E+08
IA0023566	City of City of Livermore, Iowa	Waste Stabilization Lagoon*	719	0.11	3	5.25E+08
IA0057762	City of Bancroft, Iowa	Waste Stabilization Lagoon*	1,760	0.169	3	8.06E+08
IA0047805	City of Bode, Iowa	Waste Stabilization Lagoon*	489	0.038	3	1.81E+08
IA0065242	Oak Lake Maintenance Inc.	Waste Stabilization Lagoon*	144	0.015	3	7.15E+07
IA0033375	City of Titonka, Iowa	Waste Stabilization Lagoon*	763	0.115	3	5.48E+08
IA0068284	Southdale Addition	Activated Sludge	215	0.021	2	1.00E+08
IA0057436	City of Ringstead, Iowa	Waste Stabilization Lagoon*	647	0.077	3	3.67E+08
IA0065269	South Oak Estates MHP	Activated Sludge	175	0.015	2	7.15E+07
IA0028517	City of Armstrong, Iowa	Areated Lagoon	1,269	0.325	2	1.55E+09
IA00078115	Sentral Community School Dist.	Trickling Filter	60	0.006	2	2.86E+07
						1.67E+10

Waste Load Allocation Reserve. There are several unsewered communities within the East Fork Des Moines watershed (figure 8). A community is required to obtain a NPDES permit to develop a sewer system. To ensure these communities are not denied permitting due to a TMDL being in place, a Waste Load Allocation Reserve (WLA-R) was created. This reserve may only be used for developing sewer systems for these specified communities and not for the development of commercial or private dischargers.

To ensure communities will be able to obtain the necessary permits, a WLA-R was calculated by estimating the maximum design flows for facilities that may be built. The total population of unsewered communities is 814, with no one community over 250 (table 10). The estimate was determined by using systems typical for similar communities within the watershed. The maximum design flows for these communities ranged from .006 MGD to .061MGD with an average of .028 MGD. This average was rounded up to .030MGD and used to derive the WLA-R using the type 2 calculation used in the WLA calculations. The type 2 calculation was used instead of the type 3 because there is no way to estimate storage times for facilities that do not yet exist. However, both type 2 and 3 use the same reduction parameter. The type 1 calculation was not used because this method is associated with facilities designed for areas of higher population.

Table 10. The unsewered communities and their population within the East Fork Des Moines Watershed.

Facility Name	County	Population Equivalent
Hardy	Humboldt	60
Irvington	Kossuth	38
Lone Rock	Kossuth	166
Ottosen	Humboldt	54
River Road Area	Kossuth	24
Robinson Area	Kossuth	42
Sexton	Kossuth	28
St.Benedict	Kossuth	54
St.Joseph	Kossuth	50
Western/Royale	Kossuth	20
Woden	Hancock	140
WoodAcres	Kossuth	42
Woodlyn Hills	Kossuth	96
Total Population		**814**

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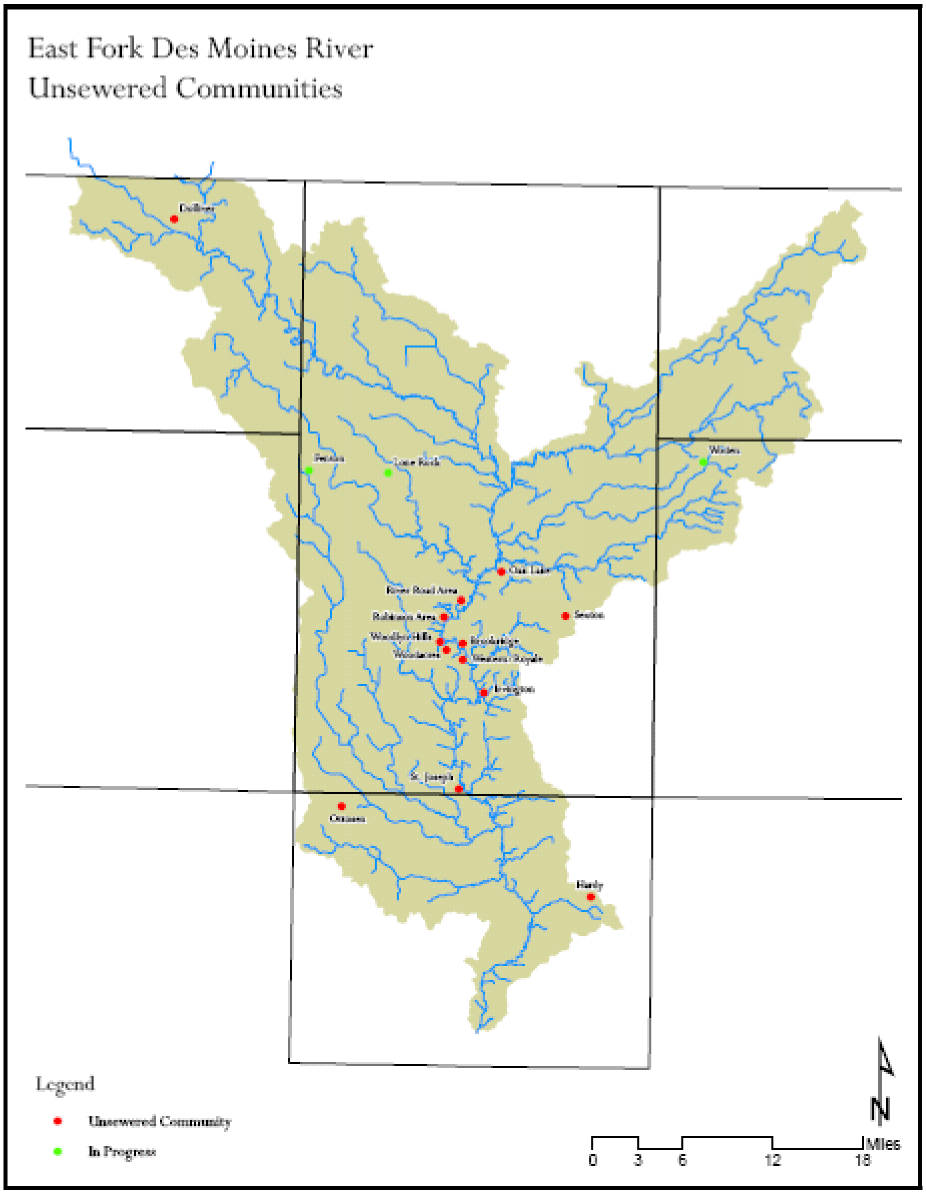

Figure 8. Unsewered communities within the East Fork Des Moines Watershed.

The calculation results in a WLA-R of 1.50E+9 CFU/day reserve for a total population of 814 unsewered residents throughout the watershed. This allows for different treatment facility designs to be used in each community, thereby easing possible cost restraints placed on smaller communities developing sewer systems.

The total point source contribution is determined by adding the WLA and the WLA-R. This results in a total point source contribution of 4.93E+10.

Load Allocation. To achieve targeted indicator pathogen loading, large reductions in nonpoint sources will be necessary. Using the WLA and WLA-R conservatively set at 4.93E + 10 CFU/day, the duration curve results indicate that nonpoint sources account for 99.8 percent of *E. coli* loading within the watershed, and that an 86 percent reduction is needed to meet water quality standards, based on the moist hydrologic condition (Table 7).

As discussed, SWAT modeling suggests that the nonpoint source LA accounts for 99.5 percent of *E. coli* loading within the watershed, and that the point source loading from livestock is much greater than that from human inputs. The model indicates a large percentage of pathogen loading results from nonpoint sources within the watershed. Therefore, future remediation efforts should concentrate on reducing nonpoint source inputs.

Margin of Safety. This TMDL was computed using 211.5 CFU/100 ml, or 90 percent of the *E. coli* single sample water quality standard. This part of the margin of safety is thereby explicit. In addition, very conservative assumptions were used in the derivation of numeric targets for the WLA and LA, constituting an implicit margin of safety. Since there is no EPA-approved method for measuring *E. coli* concentrations from wastewater effluent, fecal coliform concentrations should be measured to meet the 126 CFU/100 ml geometric mean, or 235 CFU/100 ml single sample maximum water quality standards for *E. coli*. Because *E. coli* is a subset of fecal coliform, within a given sample, the *E. coli* level should always be lower than the corresponding fecal coliform level. An additional margin of safety is set implicitly by targeting fecal coliform reductions for the specific WLAs by using *E. coli* standards.

Using the maximum design flows and maximum fecal coliform limits to compute the WLA, and assuming no bacterial die-off from the time the indicator bacteria leave the permitted facilities to reaching the impaired river segment, assures that the WLA is probably overestimated, and results in an implicit MOS. The monitoring requirements make the uncertainty of compliance much lower for WWTP point sources than for nonpoint sources.

3.5 Reasonable Assurance

The EPA defines reasonable assurance as demonstrating that each wasteload and load allocation in a TMDL will be implemented, usually through regulatory or voluntary actions. When establishing a TMDL, states allocate load reductions of a particular pollutant among the pollutant sources within the waterbody. These sources usually include both point sources and nonpoint sources. For point sources regulated under section 402 of the Clean Water Act, reasonable assurance is demonstrated by procedures that ensure that enforceable NPDES permits will be issued expeditiously to implement applicable wasteload allocations for point sources. For nonpoint sources, states must provide reasonable assurance that those nonpoint sources will meet their allocated reductions by using specific procedures and mechanisms such as, the implementation of pollution control measures, developing and implementing nonpoint source control plans, and if available, using other state regulations and policies governing such facilities. If a state cannot provide reasonable assurance that certain nonpoint sources will meet their allocated reductions, states authorized to administer the NPDES program may designate these sources as point sources and require that they obtain an NPDES permit. By designating these sources as point sources and issuing them an NPDES permit, reasonable assurance is attained.

Reasonable assurance for the reduction of pathogen loading from nonpoint sources will be accomplished through the implementation of best management practices that reduce the impacts from runoff and leachate from agricultural fields, animal feeding operations, construction sites, lawns, gardens and failing septic systems, and runoff from streets and parking lots, as described in the sections 4.0 and 4.2.

4. Implementation Plan

This implementation plan is not a requirement of the Federal Clean Water Act. However, the IDNR recognizes that technical guidance and support are critical to achieving the goals outlined in this TMDL. Therefore, this plan is included for use by local professionals, watershed managers, and citizens for decision-making support and planning purposes. The BMPs listed below and in section 4.2 represent a comprehensive list of tools that may help to achieve water quality goals if applied in an appropriate and timely manner. It is, however, up to land owners, citizens, and local conservation technicians to determine how best to implement them. This plan will follow a phased approach, in which during phase 1, specific reductions will be suggested and practices will be implemented, and during phase 2, water quality will be monitored over time to determine if improvements can be documented and to see if further work is needed.

As discussed previously, modeling and analysis suggest the following:

- An 86 percent reduction in pathogen loading is needed within the watershed, based on the moist hydrologic condition of the duration curve.
- Nonpoint sources (from croplands, pastures, and other areas) account for 99.5 to 99.8 percent of *E. coli* loading within the watershed.
- The greatest nonpoint source loading occurs in subbasins containing greater concentrations of CAFOs and cattle feedlots, and areas where manure is applied.
- The greatest point source loading occurs in subbasins containing areas where cattle have access to streams, and areas with higher numbers of septic systems and WWTPs.
- Pathogen loading from cattle delivering manure directly into streams is much more significant than loading from septic systems and WWTPs.
- Fixed reductions in fecal coliform limits from wastewater effluent as dictated by this TMDL.

Since it is difficult to measure reductions in source loading, efforts should be focused on implementing practices that address known problems to achieve overall reductions.

An implementation plan is used to select management measures, set schedules and milestones, identify financial and technical resources, and develop information and education programs. The implementation of a watershed management plan involves a variety of expertise and skills, including project management, technical expertise, group facilitation, data analysis, communication, and public relations. A local watershed advisory group with members that have these skills should be formed to implement the plan. Once a plan is developed, it should be followed, using any partnerships formed during plan development to work toward efficient implementation of the plan. The implementation of a watershed management plan involves the identification of priority areas and implementing BMPs and when addressing nonpoint source pollution, requires strong local support to garner voluntary cooperation to achieve water quality improvements.

Pathogen loading to the East Fork Des Moines River watershed originates primarily from nonpoint sources within the watershed. The primary sources include livestock and application of manure. Reductions in pathogen loads will require incremental changes in waste and land management that will take time to implement. Documenting any related incremental changes in stream water quality within the watershed will also take time, and any water quality changes that may occur can be obfuscated by climatic and seasonal effects.

BMPs that will reduce bacteria delivery, particularly *E. coli*, should be emphasized in the watershed. The large watershed area would benefit from involving as many individuals and groups within the watershed as possible in using good watershed management to protect water quality. Sediment sources from the watershed (such as eroding banks and agricultural runoff) should be controlled to reduce sediment delivery to the streams within the watershed. These practices should include the following:

- Using appropriate manure application rates.
- Manure application should utilize incorporation or subsurface application of manure while controlling soil erosion. Incorporation will physically separate the fecal material from surface runoff.
- Feedlot runoff control.
- Open pasture runoff control.
- Protection/rotation of areas where livestock congregate (loafing areas).
- Buffer strips along stream corridors for runoff interception.
- Conservation tillage and rotations, which improve infiltration and, reduce surface runoff from fields.
- Cattle access to streams in pastures should be limited and alternative watering sources should be explored.
- Failing and improperly constructed or connected septic systems should be found, and replaced with systems that meet current standards.

As discussed, bacterial numbers are reduced in surface waters by increasing light penetration. Decreasing sediment inputs to streams within the watershed would help to reduce non-algal turbidity while the associated decrease in phosphorus inputs would reduce algal turbidity. Therefore, the implementation of additional BMPs to address sediment delivery to the streams is encouraged.

In addition to the implementation of best management practices for nonpoint sources, point source dischargers will need to ensure that effluent is properly treated before it is discharged. Point Source permits (NPDES) will be modified to include WLA from the TMDL. Point source discharges will be expected to meet the WQS for the receiving stream. Changes to permits will be made at time of permit renewal.

Land management changes will take time to implement, as will any resulting measurable changes in stream water quality. Since it will be difficult to document reductions in source loading as specified above, efforts should focus on implementing practices that address known problem areas to achieve overall reductions during Phase 1. During Phase II the success of these measures will be evaluated.

As discussed, the contribution from tile drainage within the East Fork Des Moines River watershed was not evaluated for this TMDL, but SWAT modeling for the Raccoon River watershed estimated that tile flow accounted for 25.6 percent of total flow and 44.1 percent of base flow during the concurrent 20-year modeling period (Wolter, personal communication). Since manure is stored in basins and land applied throughout the watershed, and drainage tiles, with and without surface inlets, are widely used in the watershed and north-central Iowa, it is highly probable that drainage tiles are contributing significant *E. coli* loading within the watershed, especially during and following precipitation and snowmelt events. To better manage watersheds for pathogen loading, TMDLs should begin to consider bacterial inputs from groundwater sources as well as surface-water sources.

4.1 General Approach & Reasonable Timeline

To achieve sustainable and permanent improvements in pathogen loading within the East Fork Des Moines River watershed, consideration must be given to the critical conditions, temporal variations, source behavior and day to day activities that facilitate the movement of pathogens from the landscape into the surface water. The impairments occur in the upper half of the flow regime, indicating a predominately nonpoint source of pathogens. In addition, the wasteload allocation for the watershed is a very small portion of the TMDL. Since nonpoint surface runoff tends to exert a greater effect on water quality during higher flow conditions, and point sources tend to have the most dominant effect on water quality during low flow conditions, the allocations and reduction targets for the watershed should primarily focus on source control, contaminant delivery reduction mechanisms, and best management practices that address nonpoint sources of indicator pathogens. While practices to reduce pathogen loading from point sources and direct deposition of waste from livestock into streams may be implemented relatively quickly, and generate almost immediate decreases in loading, the greater overall reductions from incremental changes in waste and land management will take much longer to document. The implementation plan is intended to reduce indicator pathogen loading from all sources within the watershed.

Table 11 provides a general timeline for actions or activities that local stakeholders might use to improve water quality in the East Fork Des Moines River watershed. The rate at which these activities are completed will be dependent on the level of initiative that local stakeholders and citizens are willing to commit to making the appropriate changes within the watershed. The IDNR and local, state and federal agencies will be available to provide technical assistance in these efforts, but the ultimate success of the TMDL will depend on the involvement of those living within the watershed.

Table 11. General timeline for actions or activities used to improve water quality in the East Fork Des Moines River watershed.

Year	Action or Activity
2008-2009	Identify, assess, and rank potential nonpoint sources within the watershed, and select BMPs for various source types. Develop and implement monitoring plan and information and education programs, identify and recruit stakeholders.
2008-2015	Begin implementation of BMPs for nonpoint sources by priority ranking. Continue assessment of monitoring results to determine if further actions are needed, and if monitoring plan is adequate.
2009-2015	Continue information and education program to involve additional local businesses, and citizens to work together to implement and maintain appropriate BMPs. Continue diagnostic monitoring and targeted BMP performance monitoring.
2015-2020	Continue assessing and ranking nonpoint sources and selecting and implementing BMPs until the entire watershed has been enrolled. Continue monitoring and evaluation of BMP performance. Continue information and education programs and continue evaluation and refinement of monitoring program, based on assessment of water quality changes.

4.2 Best Management Practices

Best Management Practices for this watershed should focus on controlling nonpoint source pollution with primary focus on controlling nutrients from manure application. Applying the correct amount and form of plant nutrients can optimize yields and minimum impacts on water quality. After taking soil tests, setting realistic yield goals, and taking credit for contributions from previous year's crops and manure applications, crop nutrient needs are determined. Nutrients are then applied at the proper time using the proper application method. Nutrient sources include animal manure, biosolids and commercial fertilizers. Proper nutrient management will help reduce the potential for nutrients to go unused and for organic material and pathogens to wash or infiltrate into water supplies. Sound nutrient management reduces input costs and protects water quality by preventing over-application of commercial fertilizers and animal manure.

Manure storage structures protect water bodies from manure runoff by storing the manure until conditions are appropriate for field applications. The best type of manure storage to use depends upon the type of livestock operation, animal waste management system and nutrient management plan that are utilized. Several options include earthen storage ponds, concrete in-ground structures or aboveground structures. Manure can be pumped, scraped and hauled, pushed or flushed into your storage structure. The structure's main purpose is to safely contain the manure and keep nutrient loss and pollution of downstream water bodies to a minimum by preventing runoff.

Nose pumps are a trough or tank that can be installed to provide livestock water from a spring, pond, well, or other source. Selectively placed watering troughs can make pasture management easier. By having water available in several locations, farmers can control grazing more efficiently, prevent erosion, and keep livestock from polluting streams.

Managing roof runoff allows clean water to be directed away from animal feed lots and erosive areas by using gutters on roofs of buildings. An important system associated with a waste storage facility that prevents clean water from reaching the waste system and in turn helps farmers manage their farms.

Fences can provide a controlling barrier to exclude livestock. They can help keep livestock from streams, ponds, and reservoirs and be used to limit livestock grazing time in a particular pasture. They also provide streambank protection, reduce erosion, and increases water quality.

Water quality in streams and rivers can be protected by managing nutrients more efficiently, scouting fields for pests, establishing buffer zones of vegetation along streams and creeks and storing animal manure until conditions are right for field application. In addition, soil erosion can be reduced by leaving more residue on crop fields, building terraces, and farming the contours of the land surface.

The implementation of best management practices can help landowners reduce soil losses and related pathogen loading, and improve the surface and groundwater quality within their watershed.

In addition to the preceding information, the IDNR provides two erosion control manuals to serve as a guide for reducing erosion from construction sites and streams:

- Iowa Construction Site Control Manual
- How to control Streambank Erosion

These publications were written in the 1980s and 1990s and have recently been updated. They are available in pdf format from the IDNR at http://www.ctre.iastate.edu/erosion/.

5. Future Monitoring

Water quality monitoring is a critical element in assessing the current status of water resources and the historical trends. Furthermore, monitoring is necessary to track the effectiveness of water quality improvements made in the watershed and document the status of the waterbody in terms of achieving total maximum daily loads. Developing an effective monitoring program requires including the following elements: 1) monitoring objectives; 2) monitoring design; 3) sampling locations; 4) sampling parameters; and 5) sampling frequency. The following briefly discusses each of these requirements in how they pertain to the East Fork Des Moines River.

5.1 Monitoring Plan to Track TMDL Effectiveness

Monthly water quality monitoring is ongoing at the IDNR ambient monitoring site on the East Fork Des Moines River near St. Joseph, Iowa. Currently, no additional monitoring is scheduled, although the IDNR Ambient Monitoring Program is annually reviewed and updated, so locations for additional data collection could be added in the future.

As discussed previously, ribotyping or microbial source tracking (MST) is a technology used to determine more specifically, the animal sources of *E. coli* bacteria. Several MST methods are currently available, and are being evaluated by IDNR staff to determine which method(s) are most feasible for Iowa surface waters. As a part of Phase 2, the IDNR hopes to add MST to the monitoring plan as the technology becomes more accurate and affordable.

5.2 Monitoring Objectives.

A monitoring program for pathogen indicators within the East Fork Des Moines River watershed should be designed to with the objective of meeting pathogen load reduction goals and attaining state water quality standards. It is important to realize that meeting load reduction goals and attaining state water quality standards within the East Fork Des Moines River will take time. There are many steps, such as identifying crucial areas, gaining landowner and public participation, and developing management measures, which will all require time and effort on the part of all parties involved before a change will be seen within the watershed. A water body becomes impaired over time and therefore, clean-up will also require time.

5.3 Monitoring Design.

Monitoring design is how a monitoring program is set up to meet the monitoring objective. For the East Fork Des Moines River a monitoring design to reduce pathogen loads within the watershed should be used.

An idealized monitoring design, might be modeled after the design and implementation used in the Big Spring Basin Water-Quality Monitoring Program (Littke and Hallberg, 1991). The design used a nested approach to monitor the effects of changes in land use and best management practices on hydrology and water quality within a graduated series of watersheds. Key sites were instrumented for continuous and/or event-related measurement of water discharge and chemistry, and for automated sample collection. These sites complemented routine and event related sampling collected by project personnel. The smallest areas monitored with instrumentation were individual fields or land-use tracks (5 to 40 acres) with known management. From these field sites, the nested monitoring scheme followed the natural drainage system hierarchy, and watersheds of increasing size were instrumented and monitored, up to the main basin surface water and groundwater outlets (70.7 mi^2 and 103 mi^2).

A nested monitoring design would allow tracking of water and chemical responses to recharge events through the hydrologic system, from individual fields to the main watershed outlet. Within the East Fork Des Moines River watershed, the design could be used to monitor water quality changes just downstream of a field plot with known management practices. The smaller scale would allow a more rapid response in water quality changes to changes in land use and best management practices. The nested approach could then be continued at the outlets of the HUC 12, HUC 10, and HUC 8 watersheds that contain the field plot. Instrumentation could collect continuous and/or event related samples to complement ambient and event related samples collected by project personnel or volunteers. The changes in pathogen concentrations will not be as great or as immediate at increasingly larger scales, but the linkage from small to larger scale watersheds should become apparent over time.

5.4 Sampling Locations.

Sampling locations in a watershed are often related to the type of sampling design developed for that watershed. Most often the primary sampling location is the mouth of the watershed. By sampling this location regularly and tracking changes in water quality, it is possible to measure how well the BMPs are working within the watershed. Sampling should also be done at or near locations where the BMPs are implemented to track how well individual changes in land use are affecting water quality. This also allows for constant evaluation of the effectiveness of each BMP. If a single BMP appears to be less effective it can then be re-designed.

In the case of the East Fork Des Moines River watershed, sampling sites should include areas of high livestock concentration and where livestock have direct access to streams. These are also sites where BMPs would be most effective at reducing the pathogen load.

5.5 Sampling Parameters.

Sampling parameters include discharge monitoring, chemical concentrations, pathogen concentrations and other related parameters. It is recommended discharge monitoring be included as a sampling parameter to accurately measure the streamflow portion of a total load. In the East Fork Des Moines River measuring discharge along with pathogen concentration will allow for determination of how total loads respond to storm events, low flow events and where highest amounts of water and pathogens enter the watershed.

Because elevated pathogen concentrations are associated primarily with high surface runoff periods following rainfall, an event based sampling protocol coupled with a fixed sampling schedule would be recommended to track changes over time. To clearly document incremental water quality improvements, and relate them to changes in land use and best management practices within a large watershed like that of the East Fork Des Moines River, would require collecting a large number of ambient and event samples, from a number of sites, for a relatively long period of time. It is also important to collect as much baseline data as possible, for as long as possible, prior to the implementation of any new management practices intended to improve water quality.

5.6 Sampling Frequency and Duration.

After deciding sampling parameters, deciding how long to sample becomes the next step. How long should a monitoring program be implemented is a function of the design of the sampling program. It is possible for water quality improvements to occur without anybody noticing unless the response is measurable and a suitable program is in place. The design of the program determines the ability to detect a water quality change against the background of natural variability. Sampling frequency is a key determinant of how long it will take to document change. Simply stated, fewer samples collected will result in a longer period of monitoring needed to detect water quality improvements. At a minimum the sampling duration should be on the order of three to five years, not including a recommended pre-BMP monitoring program. For example, in the Walnut Creek watershed where large tracts of row crop lands are being replaced with native prairie at the Neal Smith National Wildlife Refuge, a minimum of three years of water quality monitoring was needed before the first statistically significant change was detected in stream nitrate concentrations (Schilling et al., 2006).

5.7 Data Assessment and Reevaluation.

Once the BMPs and monitoring program have been designed and implemented, data should be analyzed yearly to evaluate changes to water quality. After an appropriate period of time the monitoring program should be evaluated to assess whether or not the program is meeting the objectives. At this time changes within the program should be made to maximize effectiveness.

6. Public Participation

Public involvement is important in the TMDL process since it is the land owners, tenants, and citizens who directly manage land and live in the watershed that determine the water quality in the East Fork Des Moines River watershed.

In addition to monitoring by watershed professionals, the importance of monitoring by volunteers should also be emphasized. Those living within a watershed are more familiar with potential problem areas, and day to day activities in the watershed, and have a vested interest in seeing water quality improvements. Individuals can make a difference, and they can make an even greater difference as part of an organized watershed project. Some agencies that might be helpful in organizing and funding a watershed project include the Iowa Association of County Conservation Boards, IDALS, NRCS, and IDNR.

IOWATER is a volunteer water-quality monitoring program that empowers citizens to take a proactive approach to water quality. By monitoring the water resources in their backyards, volunteers can ensure the protection, longevity and productivity of high quality water resources, as well as evaluate, assess, and improve those of lower quality. The program provides training and monitoring equipment, and allows volunteers the freedom to monitor wherever and whenever they choose. This brings people closer to the landscape around them and encourages them to develop a sense of place within the watersheds in which they live.

In the past, water-quality programs focused on targeted sources of pollution, such as sewage discharges, or individual water resources, like a river segment or wetland. While this approach may be successful in monitoring specific problems, it often fails to document more subtle and chronic problems, such as nonpoint source pollution, that contribute to a watershed's decline. The structure of IOWATER allows volunteers to monitor not only for specific problems but also to track many inputs within a larger water network.

In 2001, IOWATER began tracking the organization of watershed groups within its ranks, and began development of a watershed directory as groups submitted their data, methods, and monitoring plans. By using a watershed approach, more complete data is collected, and the integrated data can be used to determine what actions are needed to protect or restore the resource. The approach also saves time and money by eliminating duplicate trips, reducing travel and equipment costs, and enhancing the quality of data collected through the use of standardized procedures. As individuals become interested in their local watershed, they often become more involved in decision making, protection and restoration efforts. Watershed monitoring builds a sense of community, increases commitment to meeting environmental goals, and ultimately, improves the likelihood of success for environmental programs. A well informed and educated public will feel a stronger connection with their water resources, and that will lead to better understanding, respect, and protection of Iowa's waters long into the future.

Additional information about organizing and funding a watershed project is available from the IDNR at http://www.iowadnr.com/water/watershed/wis.html#projects, and more information about IOWATER is available at http://www.iowater.net/default.htm.

6.1 Public Meetings

Public Meeting East Fork Des Moines River 12/05/06

Algona Public Library
210 N. Phillips, Algona, IA
06:00 p.m.

Public Meeting Des Moines and Raccoon Rivers 12/13/06

Des Moines Botanical Center
909 Robert D. Ray Drive, Des Moines, IA
06:00 p.m.

A statewide press release from the DNR announcing the availability of the draft East Fork Des Moines River TMDL was issued on February 7, 2007. Public notices announcing the availability of the draft East Fork Des Moines River TMDL were published on February 14, 2008 in the Humboldt Independent and the Algona Upper Des Moines newspapers.

6.2 Written Comments

The closing date for receipt of public comments for the draft TMDL was March 17, 2008. One public comment was received in response to the draft TMDL. See appendix E for a copy of the comment letter and DNR's response letter.

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Appendix A --- Glossary of Terms, Acronyms, and Notation

Table A-1. Terms and acronyms commonly used in TMDL reports.

303(d) list:	Refers to section 303(d) of the Federal Clean Water Act, which requires a listing of all public surface water bodies (creeks, rivers, wetlands, and lakes) that do not meet their general and/or designated uses. Also called the State's "Impaired Waters List."
305(b) assessment:	Refers to section 305(b) of the Federal Clean Water Act, it is a comprehensive assessment of the State's public water bodies ability to support their general and designated uses. Those bodies of water which are found to be not supporting or just partially supporting their uses are placed on the 303(d) list.
AFO:	Animal Feeding Operation. A livestock operation, either open or confined, where animals are kept in small areas (unlike pastures) allowing manure and feed become concentrated.
Base flow:	The fraction of discharge (flow) in a river which comes from groundwater.
BMIBI:	Benthic Macroinvertebrate Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of bottom-dwelling invertebrates.
BMP:	Best Management Practice. A general term for any structural or upland soil or water conservation practice. For example terraces, grass waterways, sediment retention ponds, reduced tillage systems, etc.
CAFO:	Confinement Animal Feeding Operation. An animal feeding operation in which livestock are confined and totally covered by a roof, and not allowed to discharge manure to a water of the state.
Credible data law:	Refers to 455B.193 of the Iowa Administrative Code, which ensures that water quality data used for all purposes of the Federal Clean Water Act are sufficiently up-to-date and accurate.
Cyanobacteria (blue-green algae):	Members of the phytoplankton community that are not true algae but can photosynthesize. Some species can be toxic to humans and pets.
Designated use(s):	Refer to the type of economic, social, or ecologic activities that a specific waterbody is intended to support. See Appendix B for a

description of all general and designated uses.

DNR (or IDNR): Iowa Department of Natural Resources. State government agency responsible for compliance with the Federal Clean Water Act.

Ecoregion: A system used to classify geographic areas based on similar physical characteristics such as soils and geologic material, terrain, and drainage features.

EPA (or USEPA): United States Environmental Protection Agency. The federal management agency which governs compliance with the Clean Water Act among states.

FIBI: Fish Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of fish species.

FSA: Farm Service Agency (United States Department of Agriculture). Federal agency responsible for implementing farm policy, commodity, and conservation programs.

General use(s): Refer to narrative water quality criteria that all public water bodies must meet to satisfy public needs and expectations. See Appendix B for a description of all general and designated uses.

GIS: Geographic Information System(s). A collection of map-based data and tools for creating, managing, and analyzing spatial information.

Gully erosion: Soil movement (loss) that occurs in defined upland channels and ravines that are typically too wide and deep to fill in with traditional tillage methods.

HEL: Highly Erodible Land. Defined by the USDA Natural Resources Conservation Service (NRCS), it is land which has the potential for long term annual soil losses to exceed the tolerable amount by eight times for a given agricultural field.

Integrated report: Refers to a comprehensive document which combines the 305(b) assessment with the 303(d) list, as well as narratives and discussion of overall water quality trends in the State's public water bodies. The Iowa Department of Natural Resources submits an integrated report to the EPA biennially in even numbered years.

LA: Load Allocation. The fraction of the total pollutant load of a waterbody which is assigned to all combined *nonpoint sources* in a watershed. (The total pollutant load is the sum of the waste load and load allocations.)

Load: The total amount (mass) of a particular pollutant in a waterbody.

MOS: Margin of safety. In a total maximum daily load (TMDL) report, it is a set-aside amount of a pollutant load to allow for any uncertainties in the data or modeling.

MS4 Permit: Municipal Separate Storm Sewer System Permit. A license required for some cities and universities which obligates them to ensure adequate water quality and monitoring of runoff from urban stormwater and construction sites, as well as public participation and outreach.

Nonpoint source pollution: A collective term for contaminants which originate from a diffuse source.

NPDES: National Pollution Discharge Elimination System, which allows a facility (e.g. an industry, or a wastewater treatment plant) to discharge to a water of the United States under regulated conditions.

NRCS: Natural Resources Conservation Service (United States Department of Agriculture). Federal agency which provides technical assistance for the conservation and enhancement of natural resources.

Periphyton: Algae that are attached to substrates (rocks, sediment, wood, and other living organisms).

Phytoplankton: Collective term for all self-feeding (photosynthetic) organisms which provide the basis for the aquatic food chain. Includes many types of algae and cyanobacteria.

Point source pollution: A collective term for contaminants which originate from a specific point, such as an outfall pipe. Point sources are generally regulated by an NPDES permit.

PPB: Parts per Billion. A measure of concentration which is the same as micrograms per liter (µg/l).

PPM: Parts per Million. A measure of concentration which is the same as milligrams per liter (mg/l).

Riparian:	Refers to site conditions that occur near water, including specific physical, chemical, and biological characteristics that differ from upland (dry) sites.
RUSLE:	Revised Universal Soil Loss Equation. An empirical method of estimating long term, average annual soil losses due to sheet and rill erosion.
Secchi disk:	A device used to measure transparency in water bodies. The greater the secchi depth (measured in meters), the more transparent the water.
Sediment delivery ratio:	A value, expressed as a percent, which is used to describe the fraction of gross soil erosion which actually reaches a waterbody of concern.
Seston:	All particulate matter (organic and inorganic) in the water column.
Sheet & rill erosion	Soil loss which occurs diffusely over large, generally flat areas of land.
SI:	Stressor Identification. A process by which the specific cause(s) of a biological impairment to a waterbody can be determined from cause-and-effect relationships.
Storm flow (or stormwater):	The fraction of discharge (flow) in a river which arrived as surface runoff directly caused by a precipitation event. *Stormwater* generally refers to runoff which is routed through some artificial channel or structure, often in urban areas.
STP:	Sewage Treatment Plant. General term for a facility which processes municipal sanitary sewage into effluent suitable for release to public waters.
SWCD:	Soil and Water Conservation District. Agency which provides local assistance for soil conservation and water quality project implementation, with support from the Iowa Department of Agriculture and Land Stewardship.
TMDL:	Total Maximum Daily Load. As required by the Federal Clean Water Act, a comprehensive analysis and quantification of the maximum amount of a particular pollutant that a waterbody can tolerate while still meeting its general and designated uses.
TSI:	Trophic State Index. A standardized scoring system (scale of 0-

100) used to characterize the amount of biomass in a lake or wetland.

TSS: Total Suspended Solids. The quantitative measure of seston, all materials, organic and inorganic, which are held in the water column.

Turbidity: The degree of cloudiness or murkiness of water caused by suspended particles.

UAA: Use Attainability Analysis. A protocol used to determine which (if any) designated uses apply to a particular waterbody. (See Appendix B for a description of all general and designated uses.)

UHL: University Hygienic Laboratory (University of Iowa). Provides physical, biological, and chemical sampling for water quality purposes in support of beach monitoring and impaired water assessments.

USGS: United States Geologic Survey (United States Department of the Interior). Federal agency responsible for implementation and maintenance of discharge (flow) gauging stations on the nation's water bodies.

Watershed: The land (measured in units of surface area) which drains water to a particular body of water or outlet.

WLA: Wasteload Allocation. The fraction of the total pollutant load of a waterbody which is assigned to all combined *point sources* in a watershed. (The total pollutant load is the sum of the wasteload and load allocations.)

WQS: Water Quality Standards. Defined in Chapter 61 of Environmental Protection Commission [567] of the Iowa Administrative Code, they are the specific criteria by which water quality is gauged in Iowa.

WWTP: Wastewater Treatment Plant. General term for a facility which processes municipal sanitary sewage into effluent suitable for release to public waters.

Zooplankton: Collective term for all animal plankton which serve as secondary producers in the aquatic food chain and the primary food source for larger aquatic organisms.

Scientific Notation

Scientific notation is the way that scientists easily handle very large numbers or very small numbers. For example, instead of writing 45,000,000,000 we write 4.5E+10. So, how does this work?

We can think of 4.5E+10 as the product of two numbers: 4.5 (the digit term) and E+10 (the exponential term).

Here are some examples of scientific notation.

10,000 = 1E+4	24,327 = 2.4327E+4
1,000 = 1E+3	7,354 = 7.354E+3
100 = 1E+2	482 = 4.82E+2
1/100 = 0.01 = 1E-2	0.053 = 5.3E-2
1/1,000 = 0.001 = 1E-3	0.0078 = 7.8E-3
1/10,000 = 0.0001 = 1E-4	0.00044 = 4.4E-4

As you can see, the exponent is the number of places the decimal point must be shifted to give the number in long form. A **positive** exponent shows that the decimal point is shifted that number of places to the right. A **negative** exponent shows that the decimal point is shifted that number of places to the left.

Appendix B --- General and Designated Uses of Iowa's Waters

Introduction

Iowa's water quality standards (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code) provide the narrative and numerical criteria by which water bodies are judged when determining the health and quality of our aquatic ecosystems. These standards vary depending on the type of waterbody (lakes vs. rivers) and the assigned uses (general use vs. designated uses) of the waterbody that is being dealt with. This appendix is intended to provide information about how Iowa's water bodies are classified and what the use designations mean, hopefully providing a better general understanding for the reader.

All public surface waters in the state are protected for certain beneficial uses, such as livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and other incidental uses (e.g. withdrawal for industry and agriculture). However, certain rivers and lakes warrant a greater degree of protection because they provide enhanced recreational, economical, or ecological opportunities. Thus, all public bodies of surface water in Iowa are divided into two main categories: *general* use segments and *designated* use segments. This is an important classification because it means that not all of the criteria in the State's water quality standards apply to all water ways; rather, the criteria which apply depend on the use designation & classification of the waterbody.

General Use Segments

A general use segment waterbody is one which does not maintain perennial (year-round) flow of water or pools of water in most years (i.e. ephemeral or intermittent waterways). In other words, stream channels or basins which consistently dry up year after year would be classified as general use segments. Exceptions are made for years of extreme drought or floods. For the full definition of a general use waterbody, consult section 61.3(1) in the State's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

General use waters are protected for the beneficial uses listed above, which are: livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses. The criteria used to ensure protection of these uses are described in section 61.3(2) in the State's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Designated Use Segments

Designated use segments are water bodies which maintain flow throughout the year, or at least hold pools of water which are sufficient to support a viable aquatic community (i.e. perennial waterways). In addition to being protected for the same beneficial uses as the general use segments, these perennial waters are protected for more specific activities such as primary contact recreation, drinking water sources, or cold-water fisheries. There are a total of thirteen different designated use classes (Table B-1) which may apply, and a waterbody may have more than one designated use. For definitions of the use classes and more detailed descriptions, consult section 61.3(1) in the State's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Table B-1. Designated use classes for Iowa water bodies.

Class prefix	Class	Designated use	Brief comments
A	A1	Primary contact recreation	Supports swimming, water skiing, etc.
	A2	Secondary contact recreation	Limited/incidental contact occurs, such as boating
	A3	Children's contact recreation	Urban/residential waters that are attractive to children
B	B(CW1)	Cold water aquatic life – Type 2	Able to support coldwater fish (e.g. trout) populations
	B(CW2)	Cold water aquatic life – Type 2	Typically unable to support consistent trout populations
	B(WW-1)	Warm water aquatic life – Type 1	Suitable for game and nongame fish populations
	B(WW-2)	Warm water aquatic life – Type 2	Smaller streams where game fish populations are limited by physical conditions & flow
	B(WW-3)	Warm water aquatic life – Type 3	Streams that only hold small perennial pools which extremely limit aquatic life
	B(LW)	Warm water aquatic life – Lakes and Wetlands	Artificial and natural impoundments with "lake-like" conditions
C	C	Drinking water supply	Used for raw potable water
Other	HQ	High quality water	Waters with exceptional water quality
	HQR	High quality resource	Waters with unique or outstanding features
	HH	Human health	Fish are routinely harvested for human consumption

Designated use classes are determined based on a Use Attainability Analysis, or UAA. This is a procedure in which the waterbody is thoroughly scrutinized, using existing knowledge, historical documents, and visual evidence of existing uses, in order to determine what its designated use(s) should be. This can be a challenging endeavor, and as such conservative judgment is applied to ensure that any potential uses of a waterbody are allowed for. Changes to a waterbody's designated uses may only occur based on a new UAA, which depending on resources and personnel, can be quite time consuming.

It is relevant to note that on March 22, 2006, a revised edition of Iowa's water quality standards became effective which significantly changed the use designations of the State's surface waters. Essentially, the changes that were made consisted of implementing a "top down" approach to use designations, meaning that all water bodies should receive the highest degree of protection applicable until a UAA could be performed to ensure that a particular waterbody did not warrant elevated protection. For more information about Iowa's water quality standards and UAAs, contact the Iowa DNR's Water Quality Bureau.

Appendix C --- Spreadsheets Related to Figures 4, 5, 7 and 9

The following is a list of figures from this report followed by the name of the electronic spreadsheet containing the supporting data. These spreadsheets include much of the key data and analysis used in the development of this TMDL. The procedures and assumptions in them are described in detail in this report. The spreadsheets are accessible upon request using the Iowa Geological Survey FTP site at ftp://ftp.igsb.uiowa.edu/pub/Download/ or can be accessed by email, depending on file size.

Figure 4: Relationship of *E. coli* to fecal coliform bacteria samples collected from the St. Joseph monthly monitoring site from 10/08/86 through 07/13/04.
EFDMecolivsfecal19862004.xls

Figure 5: *E. coli* concentrations and stream discharge from the IDNR ambient monthly monitoring station on the East Fork Des Moines River near St. Joseph.
EFDMecolivsdischarge20022003plot.xls

Figure 6: Load duration curve of *E. coli* concentrations collected from the IDNR ambient monthly monitoring station on the East Fork Des Moines River near St. Joseph.
Loadcurve19862005pointsourceconvertint3.xls

Figure D2: Base flow separation of uniformly distributed monthly runoff for the East Fork Des Moines River at Dakota City from January 2000 through January 2004.
EFDMdischargebaseflow.xls

Appendix D --- Swat Modeling Methodology

D.1 SWAT Model Set-up and Description

The SWAT hydrology model (http://www.brc.tamus.edu/swat/) was developed by the U.S. Department of Agriculture, Agricultural Research Service (USDA ARS) to assess the impact of changes in various land use and land management practices on water, nutrient, and bacteria yields. The model can be used for long-term, continuous, watershed-scale simulation of daily contaminant loading. It operates on a daily time step and is based on a water balance equation. A distributed SCS curve number is generated for the computation of overland flow runoff volume, given by the standard SCS runoff equation (USDA, 1986). A soil database is used to obtain information on soil type, texture, depth, and hydrologic classification. Infiltration is defined as precipitation minus runoff, and moves into the soil profile where it is routed through soil layers. A storage routing flow coefficient is used to predict flow through each soil layer, with flow occurring when a layer exceeds field capacity. When water percolates past the bottom layer, it enters the shallow aquifer zone (Arnold and others, 1993). Channel transmission loss and pond/reservoir seepage replenishes the shallow aquifer while the shallow aquifer interacts directly with the stream. Flow to the deep aquifer system is effectively lost and cannot return to the stream (Arnold and others, 1993). Based on surface runoff calculated using the SCS runoff equation, excess surface runoff not lost to other functions makes its way to stream channels where it is routed downstream. Sediment yield used for instream transport can be determined from the Modified Universal Soil Loss Equation (MUSLE; Arnold, 1992). For sediment routing in SWAT, deposition calculation is based on fall velocities of various sediment sizes. Rates of channel degradation are determined from Bagnold's (1977) stream power equation. Sediment size can be estimated from the primary particle size distribution (Foster and others, 1985) for soils the SWAT model obtains from the STATSGO (USDA 1992) database. Stream power also is accounted for in the sediment routing routine, and is used for calculation of re-entrainment of loose and deposited material in the system until all of the material has been removed.

The SWAT model can be used to simulate *E. coli* loading year-round (Arnold et al., 1998). The methodology relies on a mathematical computer simulation that calculates *E. coli* loads and concentrations. The model takes into account climate, hydrology, soil temperature, crop growth, physical landscape features, and land management factors. One of the reasons for using the model for this TMDL was to integrate daily flow data from the USGS gaging station on the East Fork of the Des Moines River at Dakota City with monthly *E. coli* data from the St. Joseph ambient monitoring site, in order to establish water-quality baseline characteristics. All modeling for the East Fork Des Moines River TMDL was done by Cal Wolter of the Geographic Information Section of the Iowa Geological Survey.

For model set-up, it was necessary to use daily pathogen data from the Raccoon River near the Des Moines Water Works facility, because the monthly *E. coli* data from the St. Joseph monitoring site were not adequate for model calibration. The Des Moines Water Works collected and analyzed water samples for *E. coli* concentrations on weekdays, and estimated *E. coli* concentrations during weekends, from 1997-2004. As discussed, instream pathogen concentrations exhibit great variability, due to changes in source behavior, changes from climatic and seasonal effects, and great temporal and spatial variability within the water column at monitoring sites due to natural and/or methodological causes. Because of this variability, precise calibration of the SWAT model for *E. coli* loading was not possible without daily *E. coli* concentrations and daily stream discharge data.

The SWAT model can divide pathogen output into loads from nonpoint sources and waste loads from point sources, and be adjusted to simulate various load and wasteload allocation scenarios based on different climatic and land-use input variables. The model was calibrated and ran over a multi-year period (1984-1994 for calibration of stream discharge, 1997-2004 for calibration of pathogen loading, and 1995-2004 for validation of pathogen modeling) to insure that it accounted for a wide range of climatic, discharge, land use, and loading conditions. The model was calibrated for stream discharge using data from the Dakota City gaging station, and calibrated for pathogen loading using data from the Des Moines Water Works.

For modeling purposes, the watershed was divided into 42 HUC 12 subbasins (Figure D1). Then, each subbasin was further subdivided into approximately 10 to 12 nearly homogeneous units that have distinct land use, soil type, and management practices. These units are called hydrologic response units (HRUs). For the East Fork Des Moines River watershed, the sub-basins were selected on the basis of the natural tributaries to the East Fork Des Moines River and on the existing water quality monitoring point and USGS gaging station location. The Arciew® SWAT (AVSWAT) interface was used to delineate subbasin and HRU boundaries within the watershed, using a 30-meter Digital Elevation Model (DEM) loaded into the model, and a 1:100,000 scale National Hydrography Dataset (NHD) to place the stream network into the DEM.

The HRUs were delineated in AVSWAT by loading the Soil Survey Geographic (SSURGO) data and 2002 land-cover grid as polygon coverages, and using thresholds of 1 percent for land cover and 5 percent for soils. For grass land cover in SWAT, Indian grass was used for CPR, tall fescue was used for pasture and smooth brome was used for ungrazed grassland. These assumptions maximized the amount of pasture used by the model, so cattle on pasture could be distributed as accurately as possible. The model computes flow and water quality concentrations at the HRU level, then sums loads at the subbasin level, and routes them downstream through tributaries and the main channel.

Figure D1. Map of the East Fork Des Moines River watershed showing HUC 12 subbasins. Also shown is the location of the watershed within the landform regions of Iowa.

SWAT simulates many of the physical processes that impact water quality. The model requires inputs, some readily available with the use of GIS technology (elevations, soils, slopes, and land use), some specific to the area, and some not readily known (manure and crop management, pasture and litter management, grazing practices, etc.). A technical advisory group (TAG) was asked to help provide area specific inputs for the model. Additional watershed inputs came from other agencies, including the Natural Resources Conservation Service (NRCS), Iowa State University (ISU), Iowa Department of Agriculture and Land Stewardship (IDALS), IDNR, and various other federal, state, county, and city agencies.

The model uses daily precipitation and temperature as the driving force and calculates flow values, sediment, pollutant loads and concentrations, as well as crop yields. The program includes equations that represent the physical processes that control water movement, sediment erosion and transport, crop growth, nutrient cycling and transport, chemical transport, and other processes on a daily time step. It simulates nonpoint source runoff and associated pollutant loads, and routes them through the secondary and primary channel network. Direct inflows and their associated loads can be added anywhere in the watershed with the flow and pollutant loads being added to what is already in the stream. Comparison of measured and calculated values for surface runoff, crop yields, and agricultural chemical movement validate the input given to the model. The model output allows the analysis of water quality at the outlet of each subbasin in the watershed.

This TMDL is intended to estimate when and how much pathogen pollution occurs and the source of the pathogens. Once a baseline is established, the model evaluates the projected impacts of alternative management practices implemented at the watershed level on the *E. coli* concentrations in the East Fork Des Moines River watershed. The TMDL relies on the analysis of monitoring data and the results of a hydrologic model to determine the current (baseline) water quality characteristics and the impacts of the proposed management changes. The model setup required monitoring data collected during this project, as well as data from other sources, including:

- *E. coli* analyses from the IDNR ambient monthly monitoring station near St. Joseph in Kossuth County (STORET station 10550001),
- the occurrence of a fish kill in the river segment in December of 2001,
- information from the Minnesota Pollution Control Agency (MPCA) for the portion of the watershed extending into Minnesota,
- USGS flow data,
- *E. coli* analyses from the Raccoon River near the City of Des Moines Water Works for calibration of the model,
- 30-meter DEM from the USGS (http://seamless.usgs.gov),
- 1:100,000 scale NHD from the USGS,
- 2002 land-cover grid from the Iowa Geological Survey,
- 12-didit HUC boundaries from the NRCS,
- Climate data from the National Oceanic and Atmospheric Administration (NOAA),
- Soil Survey Geographic (SSURGO) soil data from the NRCS,

- Iowa Soil Properties and Interpretations Database (ISPAID) from the Iowa Cooperative Soil Survey,
- Animal Feeding Operations database from the IDNR,
- 2002 Iowa agricultural statistics from the USDA-NASS, and
- Wastewater Treatment Plant (WWTP) data from the IDNR.

D.2 Data Inputs and Model Assumptions

In order to facilitate the watershed modeling process, several assumptions were made concerning the watershed. These assumptions, which have an impact on the outcome of the model and are listed below.

1. Measured daily rainfall and temperature data from several official weather stations surrounding the watershed are assumed to be representative of daily weather within the watershed. However, the localized nature of convective summer precipitation events can introduce errors into the model's results compared with measured variables.

2. In each subbasin, each land use representing 1 percent or more of the subbasin area is represented in the model and each soil that represents 5 percent or more of that land use area is represented.

3. Management operations (tillage, crop rotations, grazing, nutrient application, seed harvest, and hay cuts) are defined by fixed dates. The model does not modify these dates based on precipitation events or on annual weather. Livestock numbers and manure loading rates for the 1985 through 2004 modeling period are based on 2002 Iowa agricultural statistics from the USDA-NASS and do not change through time.

Input Data Requirements: The SWAT model requires input data to describe the climate, hydrology, soils, and land-use characteristics of the watershed. When possible, input and parameterization were completed using a SWAT model input program called iSWAT developed by the Iowa State University Center for Agricultural and Rural Development. The different types and sources of input data used to develop the TMDL for the East Fork Des Moines River watershed are discussed below.

Flow Data: Flow data is used during the model calibration to adjust the model parameters to within reasonable ranges, in order to:

- calculate simulated flow values that match measured ones, and
- produce a simulated ratio of groundwater flow and surface runoff that matches the ratio estimated from the measured data.

Daily flow data are available from the USGS gaging station on the East Fork Des Moines River at Dakota City, Iowa (http://waterdata.usgs.gov/ia/nwis/uv/?site_no=05479000). The period of record for the station is from March 1940 to the present, with data collected prior to October 1, 1954 published as "near Hardy". The average daily discharge from March 1940 to September 2005 was 30.2 cubic meters per second (cms) (1,068 cubic feet per second [cfs]). The greatest daily mean discharge during the period was 504 cms (17,800 cfs), recorded on June 21, 1954, while the smallest daily discharge, 0.136 cms (4.8 cfs), was recorded on January 11, 1977. The greatest peak discharge during the period, 532 cms (18, 800 cfs), was recorded on June 21, 1954, while the smallest instantaneous discharge, 0.136 cms (4.8 cfs), was recorded on January 11, 1977.

The USGS HYSEP program (Sloto and Crouse, 1996) was applied to daily discharge values to separate hydrographs into surface runoff, and base flow, which is the part of stream discharge that is contributed by shallow groundwater flow from alluvial aquifers and springs. The base flow contribution varies with the depth of water in shallow aquifers. When the water level in the aquifer is higher than the water level in a stream, groundwater flows through the banks into the stream. When groundwater levels are lower than the surface water level, the stream looses water through the streambanks. Changes in base flow caused by rainfall and snowmelt events are typically more muted, with a longer time delay, than changes in surface runoff, depending on factors like existing soil moisture, type and maturity of vegetation, temperature, etc. The East Fork Des Moines River is a stream that is largely dependent on groundwater discharge. From January 1941 through December 2006, base flow accounted for 75 percent of the total flow, while from January 2000 through January 2004, base flow accounted for 74 percent of the total discharge (Figure D2).

Climatological Data: Data required by the model included measured daily precipitation and maximum and minimum temperatures from the National Oceanic and Atmospheric Administration (NOAA) National Weather Service Stations in Algona, Britt, Estherville, Forest City, and Humboldt, in Iowa, and Jackson, Pipestone, Windom, and Worthington, in Minnesota (http://mesonet.agron.iastate.edu). For each subbasin within the watershed, the model uses data from the weather stations nearest to the centroid of the subbasin.

Hydrologic Data: The hydraulic, and hydrology parameters required by the model were defined using soil, land-use, and topographic characteristics. The secondary channels' hydraulic characteristics for each subbasin were defined by the AVSWAT interface. Soil slopes and slope lengths were assigned, by soil and topographic characteristics. Overland Manning coefficients were assigned by land use. The soil evaporation compensation factor (ESCO) was 0.95. All other parameters were set at their default values.

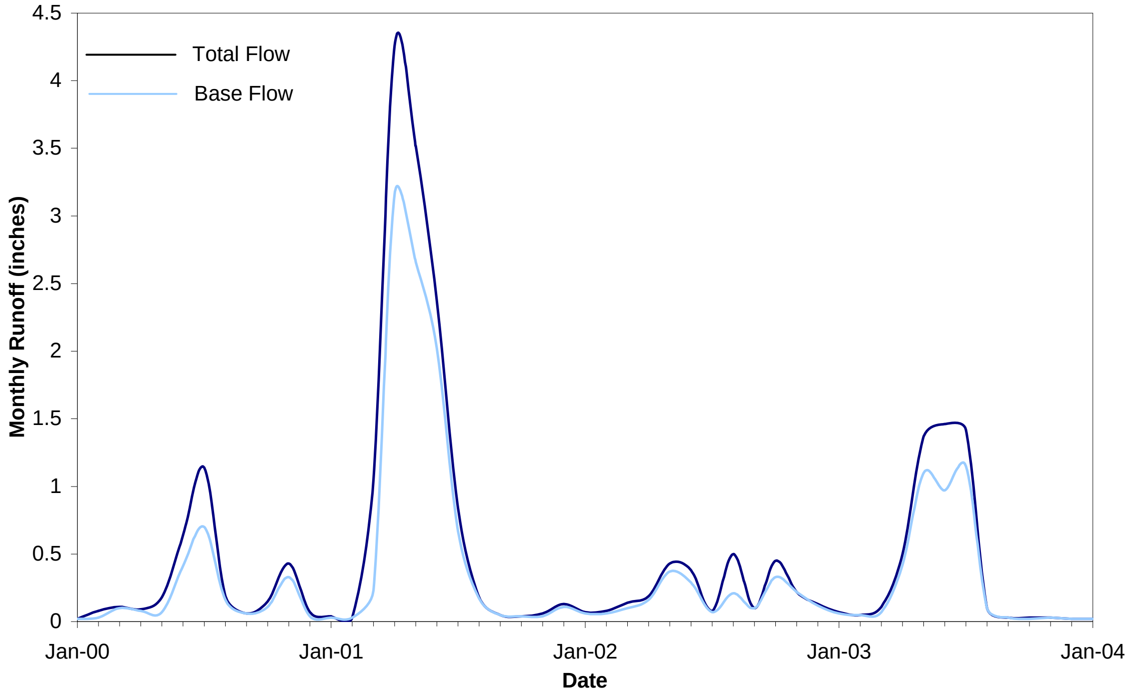

Figure D2. Base-flow separation of uniformly distributed monthly runoff for the East Fork Des Moines River at Dakota City from January 2000 through January 2004.

Most of the main channel characteristics were defined by the AVSWAT interface. Slope values were recalculated using elevation data for the stream extremities. When discrepancies occurred, the elevation-based value was used. Manning coefficients can also be estimated by visual comparison of the streams with descriptions and photos found in Chow (1988). Hydraulic conductivities were estimated, based on the soil characteristics in the channel. For erodibility and cover factor, the default values provided by SWAT were used.

Soils Data: As mentioned, soil maps and soil characteristics from the SSURGO database were used for the analysis. The soils coverages and associated metadata for Iowa soils are available from the NRGIS Library at http://www.igsb.uiowa.edu/nrgislibx/ as both county-wide and state-wide datasets. The major soil associations within the East Fork Des Moines River watershed include Canisteo, Nicollet, Clarion, Webster, Harps, Okoboji, and Kossuth. A total of 1,159 HRUs were defined by the model.

Land Use Data: The East Fork Des Moines River basin includes about 338,782 hectares (ha) in north-central Iowa, in an area dominated by recent glacial deposits of the Des Moines Lobe. The streams have not fully dissected the post glacial terrain, and internally drained 'potholes' and linked depressions are common. Hydric soils occupy over 50 percent of the watershed. Over the past 150 years, most native wetlands were drained, and the resulting channelized streams and tile lines provide a relatively direct conduit between the agricultural landscape and the surface water and groundwater. Agriculture is the primary land use within the watershed with about 80-85 percent of the area in corn and soybean rotations. About 221 CAFOs occur throughout the watershed, with hog operations being the most common. In general, the majority of manure is applied during the months of October, November, and December, with cattle manure being applied to cropland and pastureland, while hog and poultry litter is applied only to cropland. While there are some alternative uses of poultry litter, such as utilization as cattle feed, almost all of it is used as fertilizer. It is assumed that any horse and sheep manure would be applied only to pastureland.

Some of the variables needed for modeling of rural management practices used for the analysis include the following:

- manure application rates for N and P for each animal type, timing of applications, and which crops manure is applied to,
- number and type of animals,
- start and length of grazing period,
- dry weight of biomass consumed daily (kg/ha/day),
- dry weight of manure deposited daily (kg/ha/day),
- percent of animals with access to streams, and
- percent of time animals spend in streams (monthly or seasonally).

Manure Application: Pathogen losses from manure applications within the East Fork Des Moines River watershed are derived from hog, chicken, and turkey manure from CAFOs, and cattle manure from feedlots and grazing operations.

The manure from CAFOs and feedlots was distributed within the watershed based on existing GIS coverages of CAFOs and feedlots. The locations of cattle feedlots were used to estimate the amount of manure that was applied near the feedlots. A manure distribution program from the USDA National Soil Tilth Lab was used to determine how many hectares of row crop would be needed to distribute manure within each subbasin at a rate of 200 kg N/ha for two-year crop rotations. The number of hectares needed in each subbasin was then matched up with hectares of row crop in HURs in that subbasin. A similar method was used to distribute manure from CAFOs within the watershed. Manure was distributed on land to be planted to corn, with half applied in the spring and half applied in the fall.

The number of cattle on pasture in each subbasin was calculated using pasture polygons greater than two acres that were not within urban areas. The number of pastured cattle within each county, based on the 2002 Ag Census data, was divided by the area of land in pasture from the 2002 land-cover coverage for that county to obtain cattle loading rates per hectare of pasture. This loading rate was then multiplied by the number of hectares for each pasture polygon in that county to obtain the number of cattle in each polygon of pasture. This procedure was completed for each county in, or partially in the watershed, then the number of cattle on pasture in each subbasin were compiled using the subbasin boundaries and pasture polygon shapefile.

To determine the amount of forage consumed and manure loading rate for cattle per hectare needed to enter into the pasture management file for each subbasin, the number of cattle on pasture in each subbasin was divided by the number of acres of pasture in each subbasin. The cattle were assumed to graze on pasture from May through October.

As mentioned earlier, the manure contribution from grazing deer was calculated based on a population of 100 deer per square mile of forest.

Urban Sources of E. coli: In addition to agricultural and wildlife sources of *E. coli*, potential urban sources of pathogens include municipal wastewater treatment facilities, improperly maintained septic or sanitary systems, and pet waste. The contribution of *E. coli* from these sources is probably limited, since urban areas comprise less than 1 percent of the watershed.

Point Source Inputs: The SWAT model considers contributions of pathogens from cattle in streams, septic system discharge, and wastewater treatment plant (WWTP) discharge as point source inputs. This approach differs from the duration curve method, which uses only WWTP discharge as a point source input to compute the wasteload allocation. Combining these three potential point sources together as a single point source input is primarily a function of how the model distinguishes between point and nonpoint sources. In the SWAT model, point sources are those that discharge directly into a stream. Since the point source inputs from these three sources are individually assessed, and then summed for each subbasin for input into the model as a single point source file, the contributions from each source can be evaluated individually, using various modeling scenarios. These three pathogen input sources are discussed in the following paragraphs.

The number of cattle with access to streams was estimated by intersecting the pasture polygon coverage with the NHD stream network coverage and summing the number of cattle in the selected polygons in each subbasin. It was then assumed that cattle with access spend 6 percent of their time in streams from May through October. This value is within the range used for the Maquoketa River pathogen TMDL, but is lower than that used for the Big Sioux River pathogen TMDL. After determining the number of cattle with access, and their bacteria output, the amount of bacteria input directly into streams from the cattle was calculated by multiplying the daily bacteria output of the cattle by 6 percent during the May through October grazing period.

The pathogen contribution from septic systems was estimated for each subbasin by summing the rural population within the subbasin from the 2000 census block coverage and multiplying the population by the average daily bacteria output per person. It was assumed that 2E + 09 CFU/person/day of fecal bacteria were generated (USEPA, 2000). An implicit margin of safety occurs from using fecal coliform for the computation, since *E. coli* is a subset of fecal coliform, within a given sample, the *E. coli* level should always be lower than the corresponding fecal coliform level. An additional margin of safety is implied by assuming that all septic systems within the watershed are contributing pathogens. To match measured values, the model assumed that pathogen concentrations were reduced by 99.5 percent before being discharged directly into the streams

For constant discharge WWTPs, the estimated discharge was based on a population estimate. Then the total bacteria discharge was then reduced by 99.9 percent following treatment to compute a daily discharge rate. For controlled discharge WWTPs, the same assumptions were used, except for the reduction rates, which varied depending on the length of time that the wastewater was in storage.

For SWAT modeling, loads from WWTPs were input in monthly time steps. Because the model was set up to run and initiate calibration in 1983, average monthly WWTP loads were needed to extend back to this point in time. To do this, monthly discharge rates for pathogens were estimated by averaging the months of data that were available, and applying these averages back in time. For the WWTPs with controlled discharge, the months with discharge were examined to see which months had discharge most often. Average WWTP loads for those months were then estimated from available data and the same patterns of monthly and annual loads were applied back to 1983.

D.3 Model Calibration

As mentioned earlier, the model was calibrated from 1985-1994 for stream discharge, and from 1997-2004 for pathogen loading. The model was then run from 1995-2004 for validation of pathogen modeling. The multiple year periods were used to insure that the model accounted for a wide range of climatic, discharge, land use, and loading conditions. The model was calibrated for stream discharge using data from the Dakota City gaging station, and calibrated for pathogen loading using data from the Raccoon River near the Des Moines Water Works, for reasons described earlier.

The model was run over a twenty year period, including the 1985-1994 calibration and the 1995-2004 validation periods. Parameter adjustment occurred only during the calibration period. For validation, the model was run using the previously calibrated input parameters. The calibration was performed manually by adjusting hydrologic and bacteria transport parameters, as described below, then comparing the model output with measured data. The model was first calibrated for stream hydrology and then calibrated for *E. coli*, since there was much more hydrologic data available for calibration. It is also reasonable to calibrate stream hydrology first, since the water transports the pathogens.

The calibration and validation periods were evaluated using graphic comparisons and two statistical measures, including the coefficient of determination (R^2) and the Nash Sutliffe simulation efficiency (E) developed by Nash and Sutliffe (1970). The R^2 value indicates the strength of the relationship between measured and simulated values, while the E value measures how well the simulated values agree with the measured values. Both measures typically range from zero to one, with a value of one considered a perfect match.

Streamflow Calibration: Streamflow for the East Fork Des Moines River watershed was calibrated by varying several hydrologic SWAT calibration parameters within acceptable ranges to adjust the predicted annual and monthly streamflow time series values to match measured values. The calibration parameters that were varied include curve number, soil available water capacity, evaporation compensation coefficient, and groundwater delay.

The SWAT model was used to compare simulated streamflow with that measured at the Dakota City gaging station at annual and monthly time steps (figures D3 and D4). The hydrographs show that the SWAT model accurately simulated annual and monthly streamflow from 1985 through 2004. During the simulation period, the modeled average annual streamflow at Dakota City was 8.15 inches, and the measured annual average value was 7.89 inches. The modeled average monthly streamflow was 15.6 inches, while the measured monthly average was 16.7 inches during the period. The statistical measures of R^2 and E also confirmed a good match of simulated and measured streamflow, being 0.96 and 0.94 for the annual averages and 0.83 and 0.83 for the monthly averages.

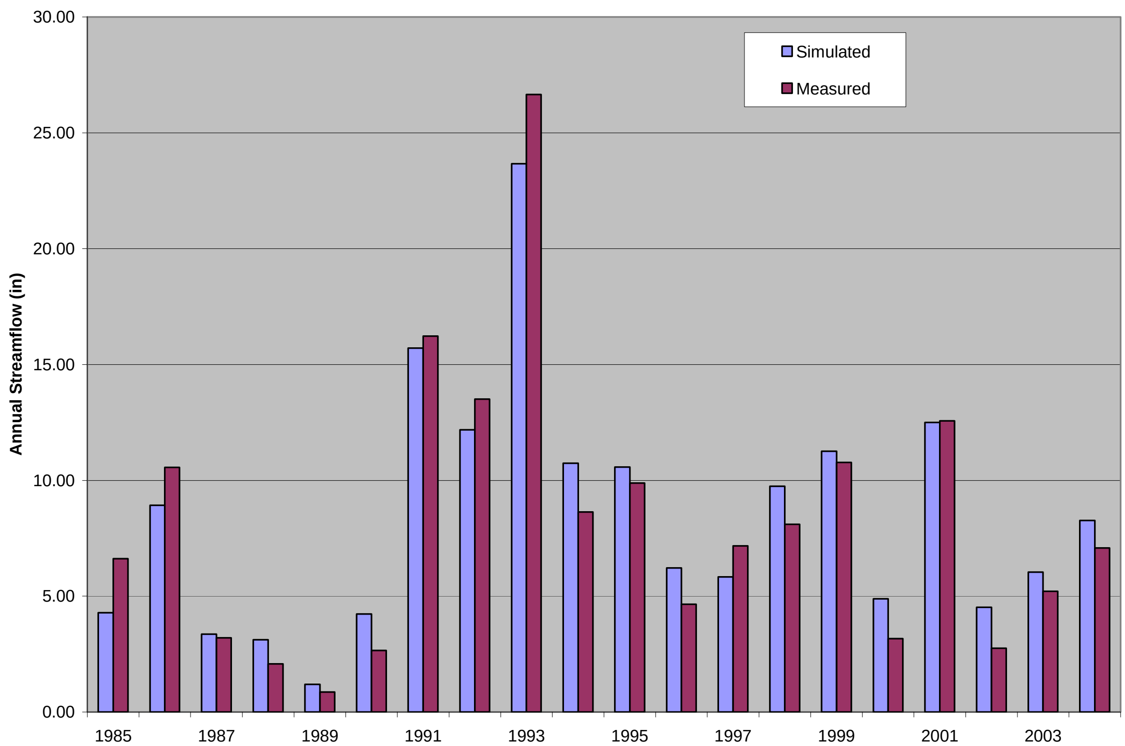

Figure D3. Comparison of simulated and measured annual streamflow from the East Fork Des Moines River at Dakota City from 1985 through 2004.

Following calibration for streamflow, the average annual balance between base flow and total flow components of the East Fork Des Moines River watershed was determined. As discussed, base flow is the portion of streamflow derived from groundwater entering the stream through the streambank, streambed and tile lines. Total flow includes both groundwater and surface runoff into the stream. During the twenty year modeling period, base flow accounted for 62 percent of the total flow, as compared with 75 percent of the total flow from January 1941 through December 2006, and 74 percent of the total flow from January 2000 through January 2004, based on hydrograph separations.

The contribution from tile drainage within the East Fork Des Moines River watershed was not evaluated for this TMDL, but SWAT modeling for the Raccoon River watershed estimated that tile flow accounted for 25.6 percent of total flow and 44.1 percent of base flow during the concurrent 20-year modeling period (Wolter, personal communication).

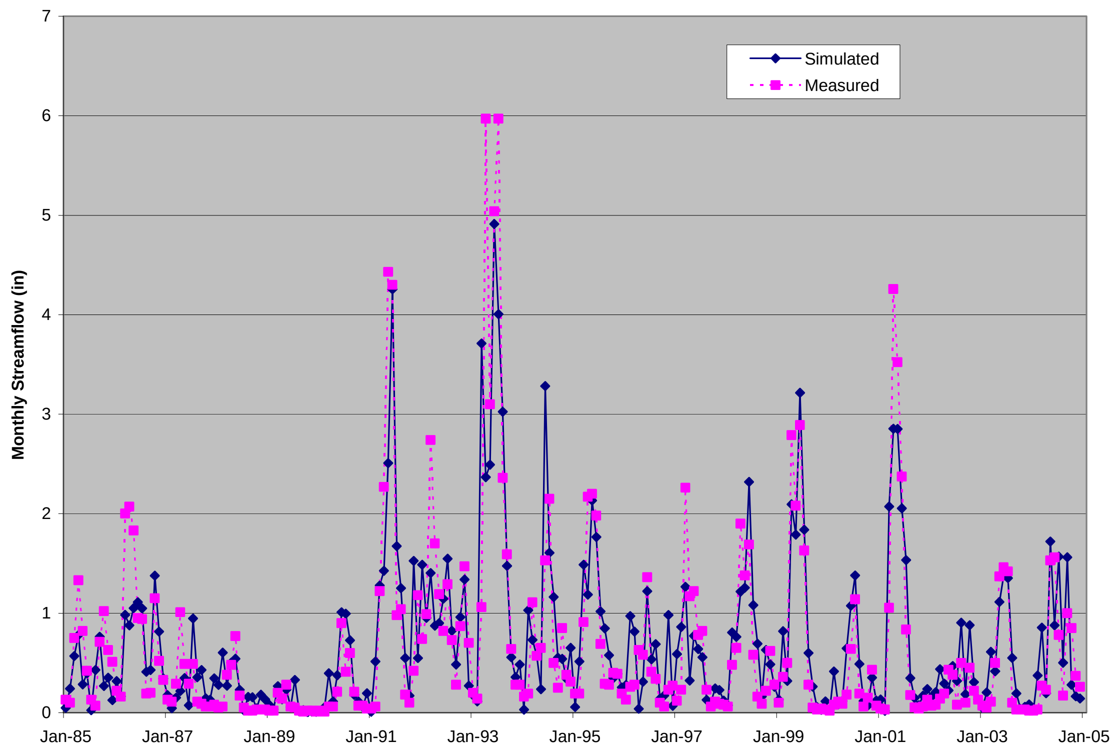

Figure D4. Comparison of simulated and measured monthly streamflow from the East Fork Des Moines River at Dakota City from January 1985 through December 2004.

Streamflow Distribution: The SWAT model was used to assess the distribution of average annual water yields within the East Fork Des Moines River watershed (Figure D5). The results show that most portions of the watershed yield between 5.5 to 9.75 inches of water per year, with the greatest yields in the northeastern portion of the watershed, and the smallest yields in the northwestern part of the watershed. The differences in water yields between the headwaters in northeastern and northwestern portions of the watershed may be related to differences in land use and precipitation. The northwestern portion of the watershed contains wetlands and lakes that may capture and store some of the surface runoff. In addition, this part of the watershed has had less precipitation than the northeastern portion during the modeling period. There may also have been a higher percentage of grassland, and lower percentage of row crop in the northwestern part of the watershed.

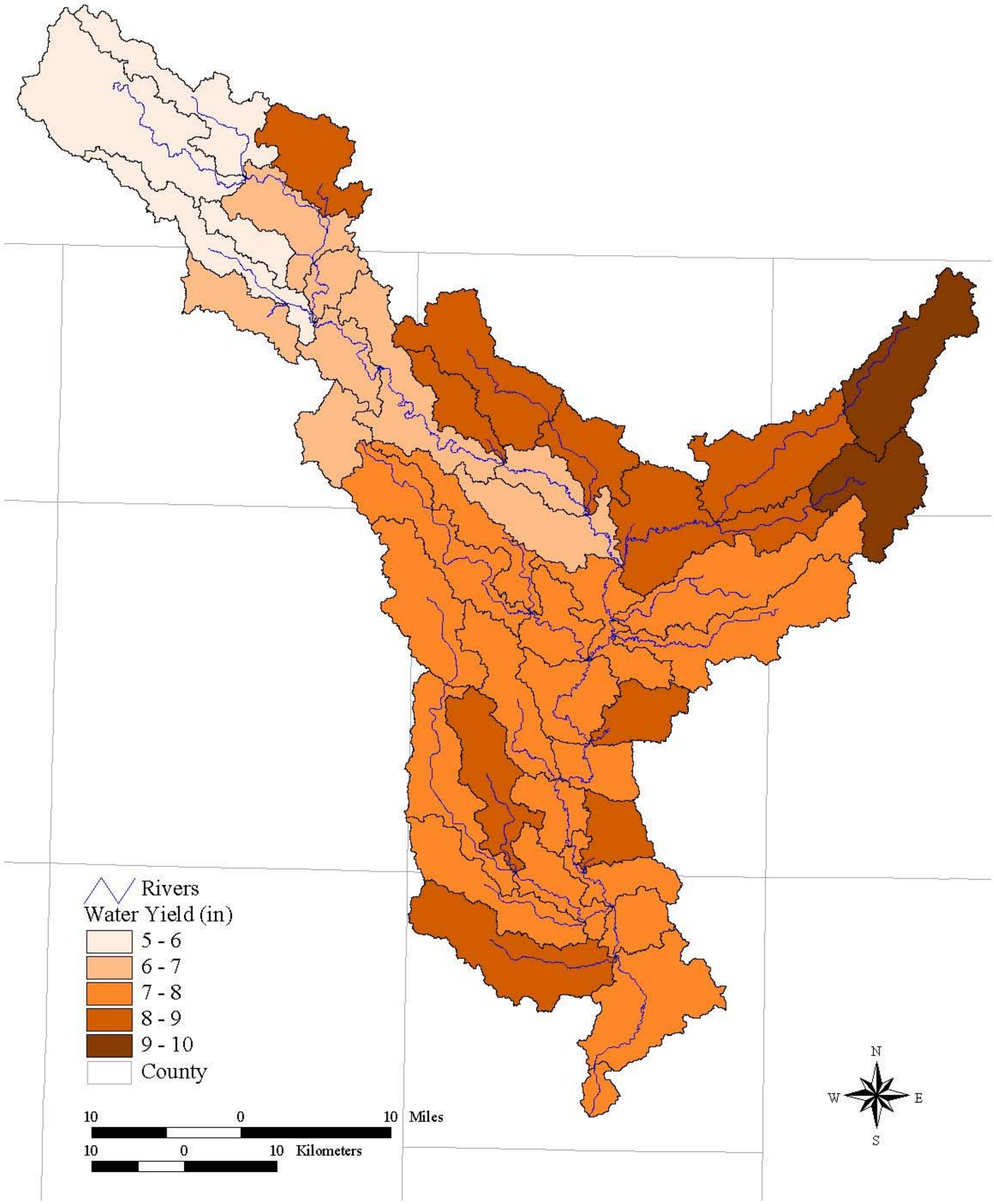

Figure D5. Distribution of average annual water yields within the East Fork Des Moines River watershed from 1985 through 2004.

E. coli Calibration: The SWAT model was calibrated for *E. coli* using daily analyses from the Raccoon River near the Des Moines Municipal Water Works from 1997-2004, rather than using monthly analyses from the monitoring site on the East Fork Des Moines River near St. Joseph. While this is not ideal, it would not have been possible to calibrate the model using only monthly data, due to the great temporal and spatial variability of pathogen concentrations within streams. Calibration would have benefited from more frequent sample collection from multiple sites distributed throughout the watershed. Since there is only monthly *E. coli* data, collected from a single site within the watershed, comparison of simulated and measured *E. coli* loading within the watershed is not possible, and the evaluation of the distribution of *E. coli* loading within sub-watersheds is much less certain than if there had been more frequent data from more locations. For the Raccoon River watershed, the R^2 and E values for simulated and measured *E. coli* loading were 0.26 and 0.15 for the annual averages and 0.33 and 0.14 for the monthly averages during the modeling period.

After the Raccoon River watershed model was calibrated for streamflow, calibration for *E. coli* was achieved by varying several SWAT bacteria parameters within their acceptable ranges to match simulated annual and monthly pathogen loads with measured values from the monitoring site at the Des Moines Water Works. The calibration parameters that were varied include the following:

- die-off rate in solution – 0.1 day^{-1},
- die-off rate in soil – 0.03 day^{-1},
- bacteria partition coefficient – 1,
- bacteria temperature factor – 1.07, and
- fraction of manure with CFUs – 0.99.

For the 1997-2004 Raccoon River calibration period, the modeled average annual *E. coli* load was 1.81E + 16 CFU, as compared with the measured average annual load of 5.84E + 16 CFU. In general, the modeled annual loads did not show as much variation as the measured annual loads, with modeled annual loads varying from 1.18E + 16 to 3.48E + 16 CFU, while measured annual loads varied from 4.56E + 15 to 1.20E + 17 CFU. The modeled monthly loads also exhibited less variation than those measured, with modeled monthly loads varying from 1.54E + 12 to 1.47E + 16 CFU, while the measured monthly loads varied from 9.76E + 11 to 8.24E + 16 CFU. The average modeled monthly *E. coli* load was 1.50E + 15 CFU, which was slightly lower than the average measured monthly load of 4.86E + 15 CFU.

After the East Fork Des Moines River watershed model was calibrated for streamflow, calibration for *E. coli* was achieved by setting the bacteria parameters to the values obtained in calibrating the Raccoon River watershed model. The East Fork Des Moines River watershed model was then ran for the same 20 year period as the Raccoon River watershed model. For the period, the modeled average annual *E. coli* load from the watershed was 4.26E + 15 CFU, with a range of 1.70E + 15 CFU to 1.38E + 16 CFU, while the modeled monthly average load was 3.55E + 14 CFU, with a range of 3.19E + 12 CFU to 1.06E + 16 CFU (figures D6 and D7).

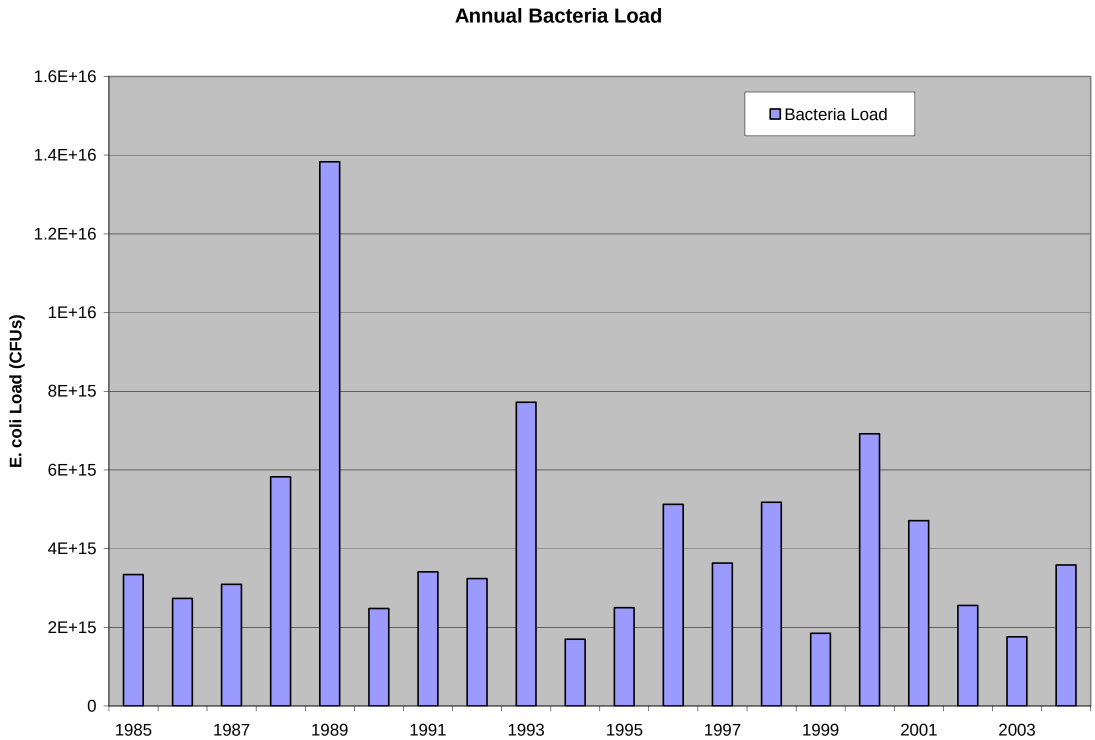

Figure D6. Modeled annual *E. coli* loads from the East Fork Des Moines River at Dakota City from 1985 through 2004.

For the East Fork Des Moines River watershed, the greatest annual *E. coli* loading and smallest annual streamflow both occurred during 1989. The greater *E. coli* loading in the watershed, during a period of very low streamflow, may be due to the timing and intensity of rainfall events, and the dry antecedent conditions. On July 12^{th} and 13^{th}, southern Minnesota received consecutive 4 and 3 inch rainfalls, which led to July accounting for 20 percent of the local annual precipitation for 1989. It is possible that the runoff from these intense rainfall events transported pathogens that had accumulated on and near the land surface earlier in the year.

Based on results from the Raccoon River, the SWAT model generally overestimated the smaller *E. coli* loads that typically occur during the fall and winter months, and underestimated the greater loads that usually occur during spring and summer. This discrepancy may be related the way that SWAT models delivery of bacteria to the streams. The model only considers *E. coli* coming from surface runoff and point sources. It does not consider any potential groundwater sources of bacteria to streams, such as drainage tiles.

A drainage tile system is a direct small-scale analogy of a karst groundwater system (Libra et al., 1984). Subsurface tile lines collect groundwater and route it directly to streams. Tile lines with surface inlets allow surface water through the inlets into the flow system during runoff, much like a sinkhole. Within the Bugenhagen sub-basin in northeast Iowa, it was found that during dry periods, tiles with surface inlets yielded shallow groundwater, but following significant precipitation, the tile intakes directed surface water carrying contaminants into the tiles (Rowden et al., 2000). In a different study, using field plots, Cook and Baker (2001) documented *E. coli* losses from surface applied manure to tile effluent.

As discussed, manure is stored in basins and land applied throughout the East Fork Des Moines River watershed. Furthermore, drainage tiles, with and without surface inlets, are used throughout the watershed and north-central Iowa. It is highly probable that drainage tiles are contributing significant *E. coli* loading within the watershed, especially during and following precipitation and snowmelt events. To better account for pathogen loading, TMDLs should consider pathogen inputs from groundwater sources as well as surface-water sources, especially in areas that have extensive tile systems and/or karst.

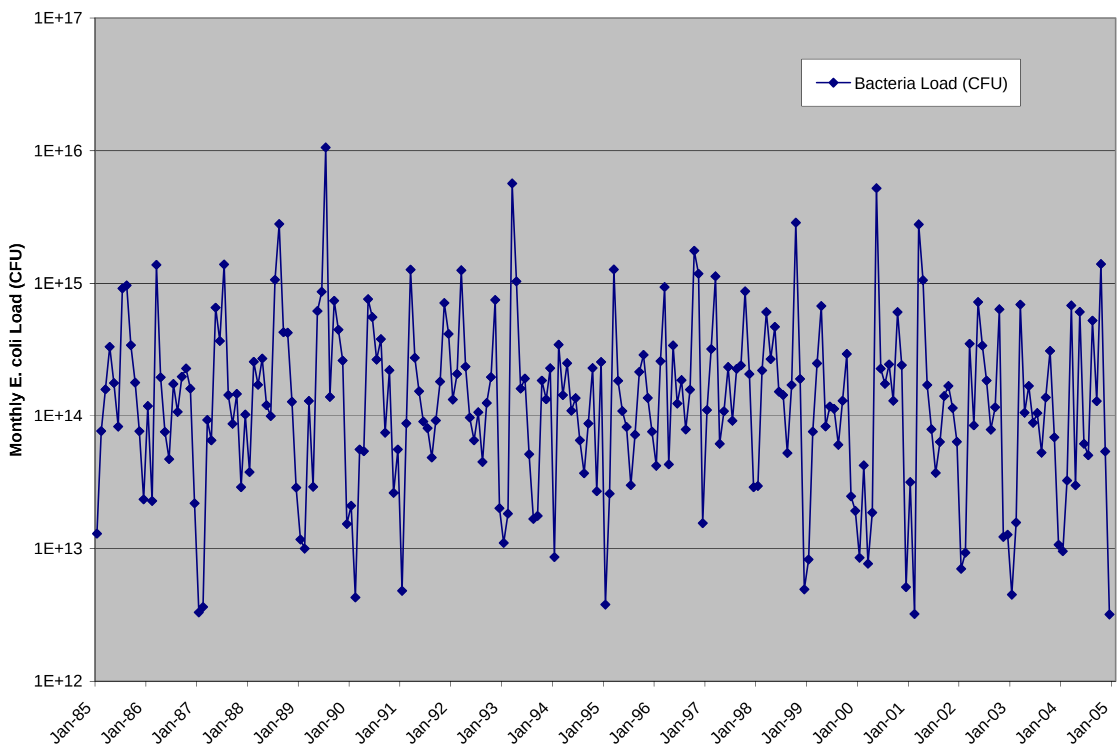

Figure D7. Modeled monthly *E. coli* loads from the East Fork Des Moines River at Dakota City from January 1985 through December 2004.

E. coli Loads: Figure D8 shows average annual *E. coli* loading exported from subbasins expressed as CFU/year, and figures 16 through 18 show average annual *E. coli* loading divided by the land area within the subbasins of the East Fork Des Moines River watershed expressed as CFU/ha during 1985 through 2004. As discussed, within a subbasin, the model first sums nonpoint source loads and then adds the point source contribution before exporting the total load to the next subbasin downstream. The results show the progression of *E. coli* loading as the pathogens are transported downstream by surface water from the headwaters to the watershed outlet. Unlike the duration curve method, the SWAT model includes the effects of instream bacteria decay and die-off, so

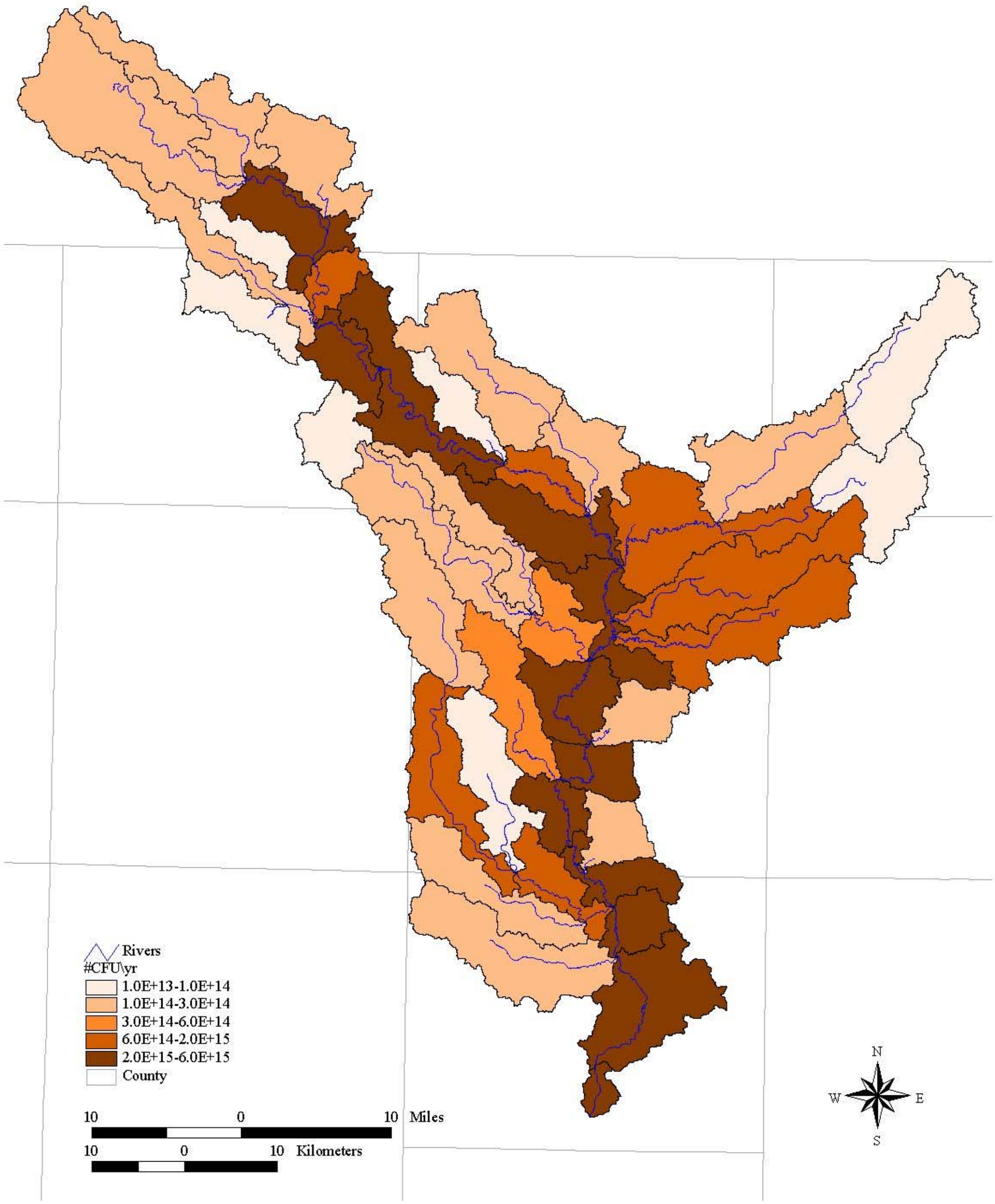

Figure D8. Average annual E. coli loads exported from subbasins within the East Fork Des Moines River watershed from 1985 through 2004.

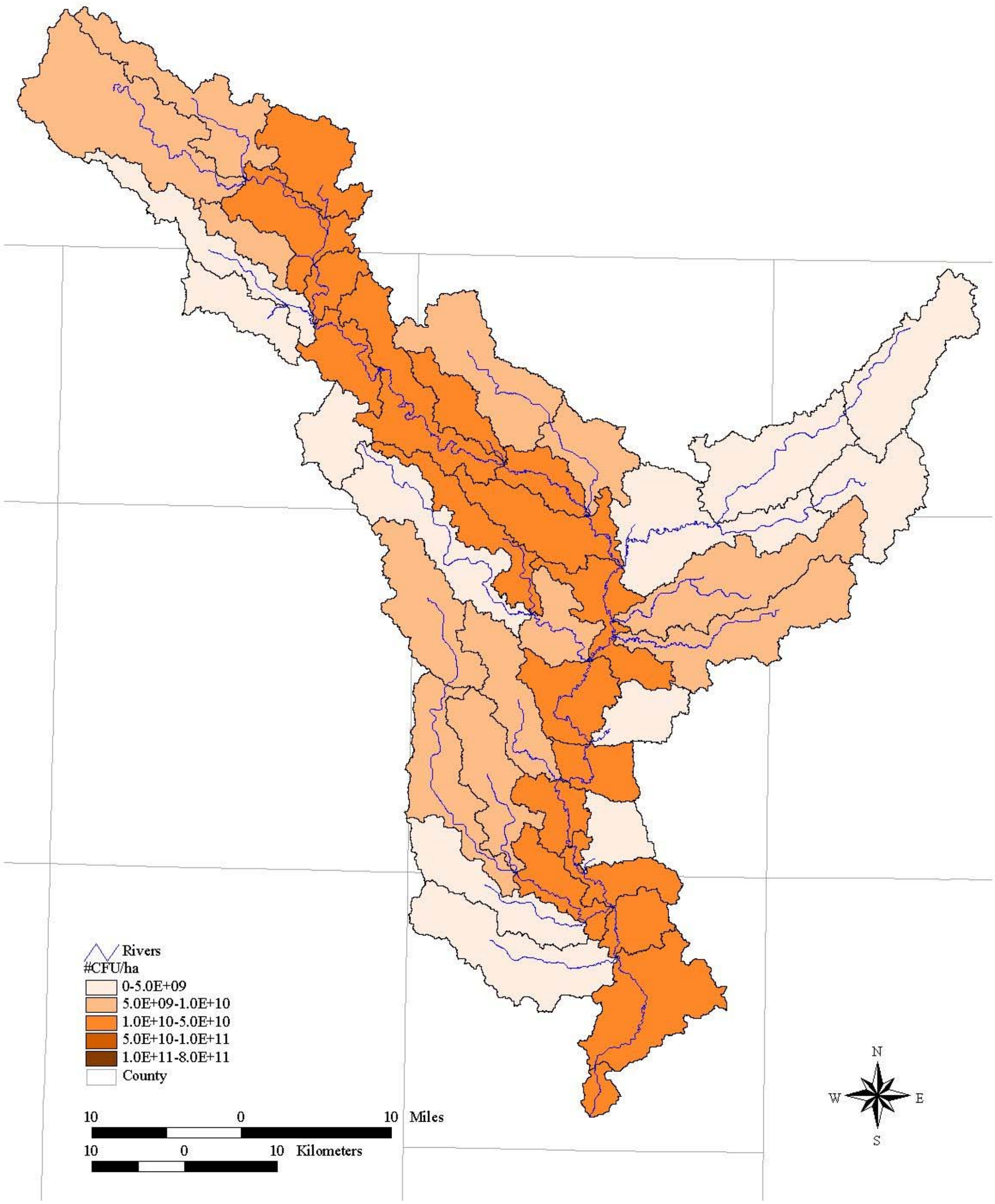

Figure D9. Average annual *E. coli* loads expressed as CFU/ha, within subbasins in the East Fork Des Moines River watershed from 1985 through 2004.

for loading to increase downstream, the number of pathogens coming into the stream network must exceed the number of pathogens that are expiring. Annual pathogen loads can also be expressed as CFU/ha within each subbasin in order to show differences in loading rates within the subasins of the watershed (Figure D9). The greatest annual loading occurred in the northwest portion of the watershed and along the

main stem of the East Fork Des Moines River. It should be recalled that the annual water yields were greatest in the northeast portion of the watershed. The reason for the greater *E. coli* loading in the northwest part of the watershed, in spite of the lower water yields, is probably due to having a higher concentration of AFOs in this part of the watershed.

When measured as pathogen loads generated within each subbasin, rather than as loads accumulated downstream, it appears that *E. coli* are distributed throughout the watershed, and that pathogen loading rates are greatest in the subbasins within the northwest portion of the watershed and along the main stem of the East Fork Des Moines River.

Point and Nonpoint Loading: As discussed, SWAT considers pathogen contributions from cattle in streams, WWTPs and septic systems to be point sources. Since the model first sums nonpoint source loads, then adds the point source contribution before exporting the total load downstream, the model can be used to distinguish contributions from point and nonpoint sources in terms of CFU/ha. Figures D10 and D11 show the distribution of average annual point and nonpoint source loads within the subbasins of the watershed from 1985 through 2004. The same scale is used for both figures to facilitate comparison of point and nonpoint source loading. The relative proportion of *E. coli* that is contributed from the various point sources that comprise the wasteload allocation will be discussed in Section 3.5

Point source loading of *E. coli* is generally greater along the tributaries, than along the main stem of the East Fork Des Moines River within the watershed. The greatest point source *E. coli* loading occurs in subbasins containing areas where cattle have access to streams, and areas with higher numbers of septic systems and WWTPs. Within the subbasins, point source loading ranged from 5.1E + 7 to 6.0E + 10 CFU/ha.

Nonpoint source loading of *E. coli* is also generally greater along the tributaries than along the main stem of the East Fork Des Moines River within the watershed. The greatest nonpoint source *E. coli* loading occurs in subbasins containing greater concentrations of CAFOs and cattle feedlots, and areas where manure is applied. Comparison of figures 17 and 18 shows that within the watershed, the contribution of *E. coli* bacteria from nonpoint sources is much greater than that from point sources. As discussed, the greatest nonpoint source of *E. coli* bacteria within the watershed is land applied livestock manure from CAFOs and cattle feedlots. According to the SWAT model, the existing pathogen load is 1.17E + 13 CFU/day, and nonpoint sources account for 99.5 percent, and point sources 0.5 percent of *E. coli* loading within the East Fork Des Moines River watershed. Using the moist hydrologic condition from the duration curve method, the load allocation, comprised of nonpoint sources, accounts for 99.8 percent of *E. coli* loading within the watershed, while the wasteload allocation, comprised of point source discharge from wastewater treatment facilities, accounts for 0.2 percent of the *E. coli* loading. The different proportions of nonpoint and point source allocations produced by the duration curve and SWAT model may result because the duration curve uses only WWTP discharge as a point source input, while the model considers contributions of pathogens from cattle in streams, septic system discharge, and WWTP discharge as point source inputs.

The use of relatively long-term daily discharge and *E. coli* concentrations to calibrate the East Fork Des Moines River watershed model should help to insure that the SWAT modeling results are representative of pathogen loading over a wide range of land-use management and environmental conditions. Precise calibration is necessary in order to determine the impacts of alternative management scenarios, and predict the effects of short-lived and long-term changes in climate, vegetation, land-use management, groundwater withdrawals, and water transfer, on water, pathogen, sediment and other various types of chemical loading within large watersheds.

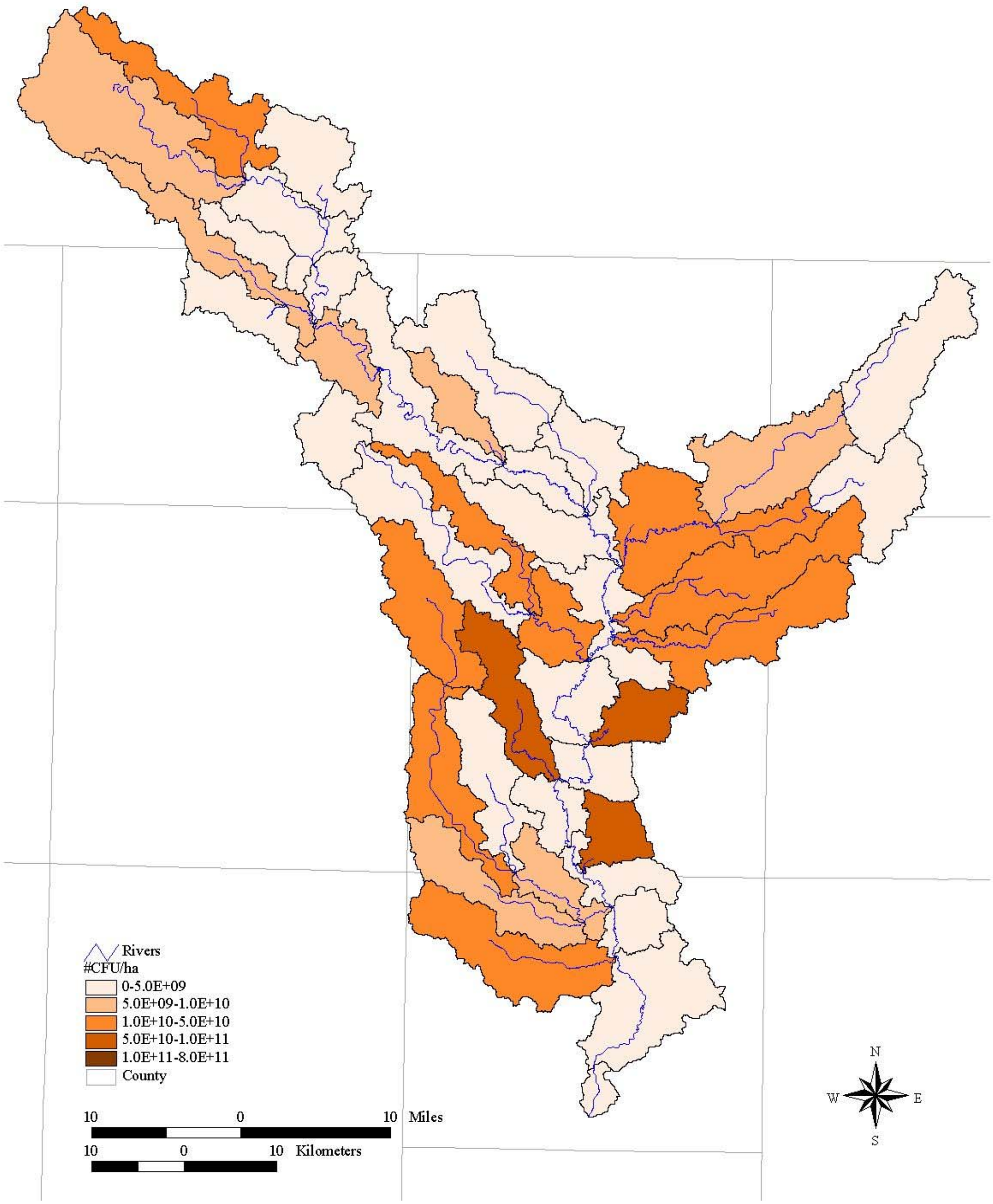

Figure D10. Average annual *E. coli* loads from point sources, expressed as CFU/ha, within subbasins in the East Fork Des Moines River watershed from 1985 through 2004.

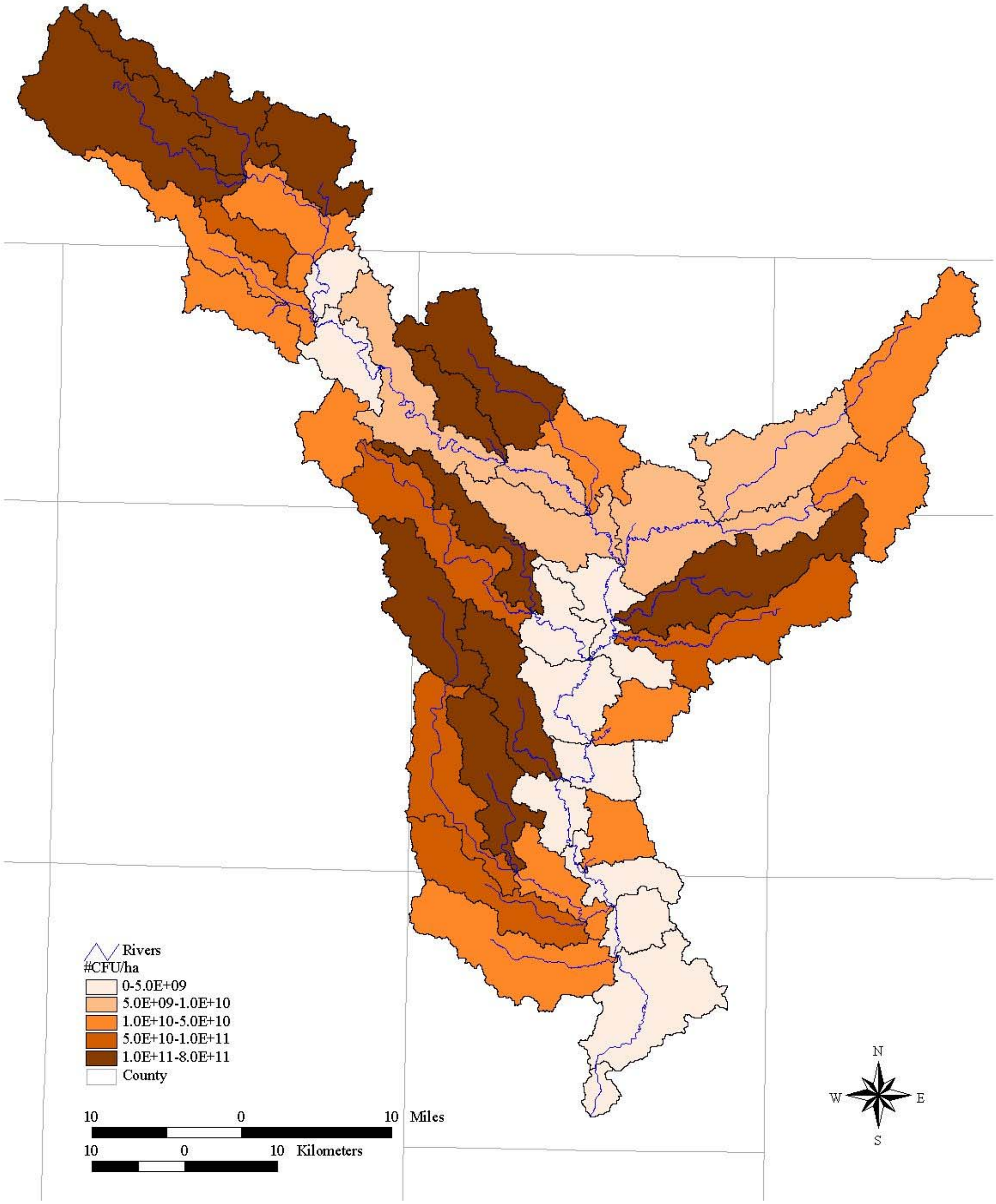

Figure D11. Average annual *E. coli* loads from nonpoint sources, expressed as CFU/ha, within subbasins in the East Fork Des Moines River watershed from 1985 through 2004.

Appendix E --- Public Comment

IOWA FARM BUREAU
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March 17, 2008

Mr. Allen Bonini
Watershed Quality Improvement Section
Iowa Department of Natural Resources
502 E. 9th Street, Des Moines, IA 50319-0034

RE: East Fork Des Moines River Total maximum Daily Load

Dear Mr. Bonini:

The Iowa Farm Bureau Federation (IFBF), the state's largest general farm organization with more than 153,000 members, would like to provide these comments regarding the draft Total Maximum Daily Load for the East Fork of the Des Moines River and its bacteria impairment.

Problem Identification

Section 3.1 on page 12 contains confusing language that is hard to follow. The first paragraph is long and jumps back and forth between evaluated versus monitored date, designated uses and bacteria standards. It is not clear what the basis of the impairment is and whether it is monitored or evaluated data. This paragraph needs revision.

SWAT Modeling Methodology

For Soil & Water Assessment Tool (SWAT) model set-up, it was necessary to use daily pathogen data from the Raccoon River near the Des Moines Water Works facility because the monthly *E. coli* data from the St. Joseph monitoring site were not adequate for model calibration. As discussed in Appendix D, instream pathogen concentrations exhibit great variability, due to changes in source behavior, changes from climatic and seasonal effects, and great temporal and spatial variability within the water column at monitoring sites due to natural and/or methodological causes. Because of this variability, precise calibration of the SWAT model for *E. coli* loading was not possible without daily *E. coli* concentrations and daily stream discharge data. This discussion needs to be included in the Data Source Section on Page 14.

This also calls into question the appropriateness of the use of data from one location to represent the conditions of another. This seems to undermine the validity of the entire TMDL.

The validity of the TMDL is important when considering the locations of it in the context of the Implementation section. This section says an 86 percent reduction in pathogen loading is needed within the watershed, based on the moist hydrologic condition of the duration curve. It also says:

- Nonpoint sources (from croplands, pastures, and other areas) account for 99.5 to 99.8 percent of *E. coli* loading within the watershed.
- The greatest nonpoint source loading occurs in subbasins containing greater concentrations of CAFOs and cattle feedlots, and areas where manure is applied.
- The greatest point source loading occurs in subbasins containing areas where cattle have access to streams, and areas with higher numbers of septic systems and WWTPs.
- Pathogen loading from cattle delivering manure directly into streams is much more significant than loading from septic systems and WWTPs.

It seems logical that these assumptions would most likely be incorrect when considering the use of data from a different river and location (the Raccoon River near the Des Moines Water Works, obviously more of an urban influence).

Also, following are a number of questions about other modeling aspects of this TMDL that seem unanswered or incomplete, and that need to be addressed in the final draft submitted to EPA:

- The load duration curves (LDC) only applies to points in the stream at which the samples were taken. Any variability with this LDC is even more amplified because data from another watershed was used to calibrate the model. This was a scheduled TMDL, so it seems that scheduled monitoring to meet the requirements should have been completed.

- Since the TMDL duration and frequency targets cannot be compared directly to the LDC, how do natural resource program managers in the watershed assess implementation scenarios?

- The TMDL should explain how the SWAT model accounts for stream bed re-suspension.

- Page 68: The SWAT model does not handle drainage tiles. Couldn't this be a significant issue with septic systems that are connected to tile lines, thus delivering raw sewage each day to streams?

- Do we understand the loading rates in this model between surface applied bacteria and injected bacteria? Do we understand the proportion in the assumed runoff rates? If we understand the sources, then we should be able to apply these to the modeling efforts and explain how that is done.

- Unsewered communities and septic systems that are connected to tile lines should be considered point sources.

- Is there a seasonal correlation with bacteria besides flow? Is there a correlation with nutrients and algae? That is, shouldn't the data be looked at as if to answer questions rather than to seemingly just support a hypothesis?

- The most significant research in Minnesota related to assessing fecal coliform transport to tile drainage was two separate studies conducted by Dr. Gyles Randall at the University of Minnesota Southern Experiment Station in Waseca. The first study (Randall, 2000) conducted from 1995-1997 involved collection of tile water samples from a series of thirteen and a half by fifteen meter plots that had received moldboard incorporation of fall applied dairy manure. The following spring samples were collected within three days of precipitation events that caused significant drainage. The study found 100 percent of the samples tested positive for fecal coliform bacteria, yet *E.* coli was only detected in five of the 30 samples over the three-year period. Fecal coliform concentrations were implied to be low and the authors speculated that significant winter die-off may have occurred.

- The second study (Randall, 2003) involved spring tile monitoring of fall applied (2002-03) injected swine manure. The study involved comparing field plots with applied manure vs. urea treatments. The authors found the number of fecal coliform bacteria to be similar in both urea-treated and manure treated plots. They suggested organisms did not survive over winter in the added manure and that levels seen during the six-week drainage sampling period were probably background concentrations. (Fecal Coliform and Turbidity TMDL Assessment for Rock River Draft Report, State of Minnesota, October 2007).

- Human contributions have been significantly underestimated in this watershed for bacteria. On page 23, for example, what is the pathogen concentration reduction based on? How many failing septics are attached to tile drains? This does not appear to be accounted for in modeling, nor is there a calculation for distribution of how human waste is handled throughout watershed.

- Waste water treatment plants (WWTPs) in the area discharge bacteria daily to these streams that are not A1 and A2 streams, and the contributions were underestimated. Additionally, based on recent reviews of NPDES permit compliance, loading rate calculations may have overestimated bacteria reductions that are occurring at each of the facilities in this watershed.

- Loading rates from the failing septic tanks is underestimated, especially those that may be discharging directly to streams through tiles. The loading rates from the failing septic tanks would occur daily and therefore would be an issue during low flows and high flows.

- Wildlife loading: We recall that Dr. Tom Moorman Iowa State University said at a recent stakeholder meeting that wildlife contributions could be up to as much as 30 percent. These contributions again seem to be underestimated.

Other Issues

- This was a scheduled TMDL, so sampling could have been targeted to it accordingly. Additionally, sourced microbial sampling is available and there are some university labs doing it now. Some sub-watershed studies or sampling could have completed to make this issue more resolvable.

- The TMDL does not begin to identify sub-watersheds that are contributing more or less loading. How do watershed managers effectively begin to target limited resources?

- It would be helpful to have those that completed this TMDL be identified in the document.

- What are the procedures for Iowa TMDLs? Do all bacteria TMDLs now follow the same protocols? Are these protocols contained in a document that is available to the public?

- The TMDL notes that unsewered communities are present but it doesn't state where they are or in which sub-watershed. This needs to be better defined for natural resource managers. Also, septic system issues are identifiable and funds are available to deal with these issues.

- A higher priority should be placed on preventing human waste in all bacteria TMDLS as human pathogens are vectors of highly communicable disease.

- No WWTP bypasses or violations were noted. These can be easily obtained by a review of DNR records and should be included in the TMDL.

- In Figure 7 on page 22, manure applied is in terms of tons of nitrogen per facility. Why is this unit used? This is not a nitrogen TMDL.

- It should be more clearly stated that there are several contributors to NPS rather than the NPS "lumped" into one group. The problem with this is that the larger community receiving this document sees the NPS number as the responsibility of the Ag community to reduce the bacteria and nitrogen numbers. NPS is actually a combination of communities, it is actually *everything that isn't a point source*. For this size of a watershed, the list of NPS contributors is fairly extensive. There are urban and rural storm water contributions, wildlife, drainage tiles (where illegal and illicit point source discharges are occurring), unidentified septic dischargers, etc.

Implementation

In the Implementation section on page 30, there is a reference to, "The greatest point source loading occurs in subbasins containing areas where cattle have access to streams, and areas with higher numbers of septic systems and WWTPs." This reference seems to be attempting to categorize cattle in a stream as a point source. Although it may appear to be a minor distinction, it is critical in the context of potential regulatory action. This is incorrect and needs to be clarified.

The federal Clean Water Act does not define point source or nonpoint source. Various EPA sources define point sources as any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock concentrated animal feeding operation (CAFO), landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

Nonpoint source pollution is defined by EPA as originating from diffuse areas (land surface or atmosphere) having no well-defined source[1].

In addition, the Iowa DNR defines NPSs as that pollution that happens when rainfall, snowmelt or irrigation water runs over land or through the ground and picks up pollutants and deposits them into streams, lakes or groundwater[2]. Those pollutants include excess soil, bacteria and nutrients (from farm fertilizers and manure). Nonpoint source (NPS) pollution occurs when rainfall, snow melt or irrigation water runs over land or through the ground, picking up pollutants and depositing them into lakes, rivers and groundwater. Nonpoint pollutants and sources that threaten or impair designated uses in waterbodies include:

- Excess fertilizer (nutrients), herbicides and insecticides from agricultural, residential and urban areas.
- Sediment (siltation, suspended solids), pesticides, pathogens (animal waste), from agricultural, residential and urban areas.
- Oil, grease and toxic chemicals from urban runoff and energy production.
- Sediment from improperly managed construction sites, crop and forest lands and eroding streambanks.
- Bacteria and nutrients from livestock operations, pet wastes and faulty septic systems.

These definitions would indicate that cattle in a stream are consistent with the definitions, practices and programs of the federal government and the state of Iowa.

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1 - National Management Measures to Control Nonpoint Source Pollution from Agriculture, EPA 841-B-03-004, July 2003.
2 - Iowa *Nonpoint Source Management Program*, Chapter 2, p. 5, September 2000.

Also with respect to implementation, the previous concerns discussed with data and model calibration cause a reasonable person to question the likelihood of success in achieve the TMDL goal with the best management practices listed. At least one Nature Resources Conservation Service district conservationist says they do not consider the pathogen loading reduction goal feasible even if all BMPs suggested are implemented.

In addition, this district conservationist does not recall being contacted by the DNR regarding the draft TMDL for the East Fork. The department needs to communicate directly with these resource processionals on these matters to get the best possible, most realistic implementation plan or BMP suggestions possible.

The complexity causes this professional to wonder where they should start to work on the issue. They acknowledge there is a lot of work that can be done to improve the watershed, but many farmers think they are doing a good job. Outreach and education is the key to addressing this, but professional staff and financial and technical resources are limited. They must focus on those that request assistance and have limited time to spend on outreach.

Local Watershed Advisory Committee

This TMDL does not discuss the formation of a local watershed advisory committee, as did other TMDLs such as the Big Sioux River TMDL. Should adequate monitoring someday become available, creation of a local watershed advisory committee will help ensure that solutions identified will not place livestock farmers at a competitive disadvantage. In addition, such a committee can help prioritize the best management practices and funding sources for implementation.

For the urban point source needs, the IFBF would support expanded use of a variety of urban storm water best management practices that are being used in the region, but with limited monitoring data, it will be difficult to target where to begin. The IFBF commits to working with the county Farm Bureaus in the basin and their partners in any way we can to secure the funding and expertise necessary to expand the voluntary use and adoption of these BMPs. The IFBF has grants that can be used to support voluntary watershed education and demonstration efforts. We would also support application to other funding sources if a plan can be developed that is consistent with IFBF voluntary watershed education and demonstration policy.

Farm Bureau Policy & Related Issues

Farm Bureau emphasizes our support for the funding of incentive programs that assist farmers in achieving water quality goals. Farm Bureau policy supports voluntary incentive-based approaches based on sound scientific information, technical assistance to landowners and site-specific flexibility. We support a TMDL program that would require:

- The use of monitoring data (not just evaluated data) in determining impairments and sources of impairment;

- The determination, allocation and inclusion of background, natural and/or legacy levels in impairments;
- Use attainability analysis on all waters before initial listing and/or implementation of TMDLs;
- Complete agricultural participation in the listing, assessment, development and implementation of a TMDL;
- Good general public participation;
- Quantitative long-term data to evaluate success;
- A comprehensive watershed and source water monitoring program;
- Acknowledgement of previously adopted conservation measures; and
- Implementation strategies targeted at all sources.

Also, other IFBF programs may be useful in this effort. The IFBF supports the work of Trees Forever, a private nonprofit based in Marion, Iowa. Part of what they do is work with rural and urban partners to demonstrate and place trees, grasses and shrubs in locations that can benefit conditions and needs of the Big Sioux basin.

Another program that may be useful to promote is the availability of Farm*A*Syst. This is a farmstead and rural resident assessment system developed to protect water resources. Each of the 12 units available free online gives you a brief background on the subject, such as on-farm septic tanks and private well conditions, and an assessment worksheet to evaluate their affect on local water quality. Also included are references to Iowa environmental laws and contact information for technical advice. In the past, the IFBF has also sponsored local training session for those local professionals who may want to use these or promote their use to others. More information on this program can be found at Iowafarmasyst.com.

Longer-term, the IFBF is working at the state level to secure additional funding for voluntary conservation programs that may need to be used here. The IFBF wass also a member of the Watershed Quality Planning Task Force that made recommendations to the Iowa Legislature regarding ways to improve watershed efforts like the one needed in the East Fork of the Des Moines River.

We continue to have concerns about general issues that may have serious long-term impacts on draft TMDLs, the IDNR's TMDL program and the ability of agriculture to successfully deal with these issues in a voluntary fashion. Our overall concerns continue to remain that there is not a clear plan for initial field assessment, long-term monitoring, and model calibration with TMDLs in Iowa. These are critical questions that need to be considered and resolved.

Other concerns have been documented in detail in our previous recent comments, including: Use of the trophic state index in lieu of approved state water quality standards and approved numeric criteria; establishment of arbitrary endpoints that result in defacto water quality standards; a lack of a comprehensive cost-benefit analysis for each TMDL; and no apparent consideration of the useful life of the waterbody and other physical features of impaired waters.

In addition, the nonpoint source TMDLs we have previously commented on need to include more specific assurances in the Implementation Plan sections that load allocations will be achieved using incentive-based, non-regulatory approaches. As stated in other previous TMDLs with NPS contributions, these sections should also include specific assurances from DNR that TMDL implementation is dependent on application of available technology as much as is practicable by landowners and farmers in the watersheds, and availability of financial resources from the Clean Water Act Section 319 Nonpoint Source Management Program, Iowa Department of Agriculture and Land Stewardship cost-share programs, and USDA-NRCS cost-share programs.

The Implementation Plan sections should also explicitly state that load allocations should be recognized as planning and implementation guides and are not subject to EPA approval.

The IFBF again thanks you for the opportunity to comment and asks for your serious consideration of these issues so that long-term success is ensured for the citizens of Iowa and the agricultural nonpoint source community. If you have any questions, please contact me at 225-5432.

Sincerely,

Rick Robinson
Environmental Policy Advisor

Cc: John Askew, EPA Region 7 Administrator

May 20, 2008

Rick Robinson
Iowa Farm Bureau Federation
5400 University Ave
West Des Moines, IA 50266

Dear Mr. Robinson:

Thank you for your comments submitted on March 17, 2008 regarding the draft TMDL for the East Fork Des Moines River. Below are IDNR responses to your comment letter.

Problem Identification

We have revised the text in Section 3.1 to improve its clarity. Also, the basis for the impairment is discussed in the General Report Summary under the heading *What's Wrong with the East Fork Des Moines River?* as well as the new text included in the *Problem Statement* portion of Section 3.1.

SWAT Modeling Methodology and **Other Issues**

Your comments in these sections of your letter can be summarized into the following items:

1) accounting for raw human sewage bacteria levels,
2) using a SWAT model calibrated to data from the Raccoon River,
3) accounting for stream bed re-suspension of bacteria,
4) accounting for raw sewage seen coming out of drain tiles,
5) accounting for unsewered communities,
6) estimating the loading rates from septic systems,
7) estimating current WWTP bacteria discharges to streams that are not currently A1 or A2,
8) estimating wildlife loading,
9) identifying sub-watersheds that are contributing to loading,
10) identifying protocols available to the public,
11) accounting for WWTP bypasses,
12) the use of units within Figure 7, on page 23, and
13) aggregating nonpoint sources into one group.

Our response to each one of these follows:

Item 1): For *E.coli* bacteria, very few wastewater treatment facilities monitor for bacteria in their effluent. Therefore, bacteria estimates were derived from conservative assumptions based on type of treatment, quantity and quality of influent wastewater, and per capita pollutant generation. For *E.coli*, virtually all NPDES associated documentation and records use fecal coliforms as the standard for measuring pathogen indicators and not *E.coli*. Thus, all assessment and calculations of bacteria loadings from point sources apply to fecal coliform only. However, the use of fecal coliform as surrogates for *E.coli* is treated as a conservative estimate in this TMDL. Because *E.coli* is a subset of fecal coliform (recall that FC * 0.92 = EC in surface water), use of fecal coliform in estimating point source discharges will overestimate *E.coli* losses to streams. Thus estimates of *E.coli* point source loads from WWTPs provide a worst-case estimate of their inputs to East Fork Des Moines River receiving waters.

The amount of bacteria discharged into a stream was estimated using a three-tiered approach. If a facility had bacteria monitoring data, then the monitoring data were used (Estimate Type 1). If the facility had no monitoring data available, an estimated discharge amount was assumed based on the population estimate (Estimate Type 2). The total bacteria amount produced by the population was then reduced by 99.9 percent from the wastewater treatment process. For controlled discharge facilities, the same rate of bacteria generation by population was used but the reduction rate varied depending on the length of time the wastewater was in storage (Estimate Type 3).

Item 2): The TMDL is based on the duration curve, not the modeling results. The model was calibrated for bacteria using data from the Raccoon, and calibrated for flow using data from the East Fork. The model uses input data from the sub-basins surrounding the East Fork. We used 6,310 water samples collected in Iowa to come up with a relationship between fecal and E. coli bacteria.

Item 3): The comments on bacteria in streambeds are consistent with what we are learning from the beach monitoring program. If sediments are disturbed, bacteria may be released into the water column. However, there is no evidence that bacteria can reproduce in stream sediments, therefore the bacteria populations in the streambed would need to be constantly replenished (through watershed sources) to continue to be a source. If the sources identified in the TMDL were reduced or removed, any contribution from the streambed would decrease as a result.

Items 4) and 6): Raw sewage coming out of tiles is an enforcement issue with the local IDNR Field Office or local County Sanitarian. Septic systems are addressed in section 3.3 pg. 24. For the duration curve, we assumed a 100 percent failure rate for all septic systems within the watershed. For the model, this resulted in overestimating the amount of bacteria at low flow conditions. Therefore we used a reduction factor to bring the model results closer to measured results. As shown by the Load Duration Curve, there are no issues with bacteria at low flows, so therefore the failing septic systems do not seem to be a major issue at the St. Joseph monitoring site.

Item 5): Unsewered communities were included in the TMDL calculations through the calculations for septic systems and the assumption that all septic systems in the watershed have failed. The unsewered communities would be those that are not included in tables 4a and 4b. SWAT treats unsewered communities and septic systems as point sources for modeling purposes.

Item 7): In the development of the bacteria TMDL for the East Fork Des Moines River basin, the rebuttable presumption was assumed where all perennially flowing waters are protected for primary contact recreation and aquatic life. This results in all permitted facilities discharging to a Class A stream being required to meet water quality standards at the end of pipe. These permits will be updated as use attainability analysis are completed and approved.

For the duration curve, we assumed all treatment plants were discharging at maximum rates, and assumed zero bacteria die off. However for the model this overestimated the amount of bacteria at low flow conditions. Therefore, a reduction factor was used so that the results for low flow conditions were closer to measured values.

Item 8): As stated in section 3.3 pg. 24 and 25, deer population density was assumed to be 100 deer per square mile of forested area. We then doubled that to account for other wildlife. We believe that inputs from all wildlife are minor in comparison to those from livestock within the watershed.

Item 9): Figure D8 shows average annual loading of E. coli by sub-basin within the East Fork Des Moines River watershed. Sub watershed loading is discussed at length in section 3.

Item 10): This information is available at:
http://www.iowadnr.gov/water/watershed/tmdl/index.html

Item 11): Bypasses tend to occur during high flows, when the effects would be minimized. Also, the model was run using average daily loading by month and therefore cannot incorporate individual events.

Item 12): This unit was used because that is how the model allocates manure applications. The model then has bacteria factors to calculate how much bacteria is applied with the manure.

Item 13): Your letter suggests that nonpoint sources should be more clearly stated, rather than "lumped" into one group. On page 21 Section 3.3, the document notes that nonpoint source contributions are from land application of livestock manure, grazing livestock, cattle contributions deposited directly in the stream, failing septic systems and unsewered communities, urban areas and wildlife.

Implementation

While the SWAT model deals with cattle in the streams as a point source, this does not mean that cattle in the stream are categorized as a point source – they are simply modeled that way in order for them to be properly accounted for in the model. For TMDL purposes cattle in the stream are included in the nonpoint source loads.

Local Watershed Advisory Committee

Additional language has been added to section 4 to emphasize the importance of forming a local watershed advisory group.

Farm Bureau Policy & Related Issues

Your letter indicates that Iowa Farm Bureau Federation (IFBF) continues to have concerns over initial field assessments, long term monitoring, and model calibration. As a general rule, the TMDL program obtains field level data for each watershed that is being addressed. Clearly this has not occurred on the much larger scale of the East Fork Des Moines River, but this type of data is collected for smaller watersheds. Data that is collected includes land use, management practices, conservation structures, condition of pasture, and livestock access to streams. This past year the NPS 319 Program and DSC have begun to accept development grant applications on a continual basis. These grants are often used for field and stream assessments and identification of priority areas and needed practices prior to submitting grant applications. With the EPA Consent Decree ending in the near future, the TMDL program has been able to align more with areas of local support and interest and with the priorities of other agency programs. Your concern over long-term monitoring is shared by the DNR. There simply are not the resources available to conduct the needed ambient monitoring, targeted monitoring for TMDL development, and follow-up monitoring upon the completion of the TMDLs. Section 5 of the TMDL tries to highlight this issue and present a comprehensive monitoring plan should resources become available. Model calibration is, of course, based on the available data. Obviously the more data available, the better the modeling effort will be. Our annual monitoring plans take into account the data needed for modeling so that we can collect the data most valuable to the model. This is a continually improving process, but one we feel is headed in the right direction and has been making progress over the past several years.

The IFBF comment letters continue to raise such issues as the use of the trophic state index (which was not used in this TMDL), the need for a cost-benefit analysis for each TMDL, and the belief that there is a need to consider the useful life of a waterbody. IDNR believes that these issues have been adequately addressed in previous replies, and refer you to those previous responses for further clarification.

In closing, we feel it is important to again address one comment that is near the end of your letter and which has appeared in many of your previous comment letters related to TMDLs with nonpoint source components. In your letter you request that the implementation section should state that the load allocations are not subject to EPA approval. EPA's regulations for total maximum daily loads and individual water quality-based effluent limitations are found in 40 CFR §130.7. This regulation states that "All TMDLs established under paragraph [130.7](c) for water quality limited segments shall continue to be submitted to EPA for review and approval".[1]

[1] In 57 FR 33040-01, EPA made it clear that the deletion of WLAs and LAs from 40 CFR 130,7(d) was a non-substantive change. The relevant portion of that Federal Register reads as follows:

> EPA is today making *non-substantive clarifying corrections* to its regulations in part 130 to amend repeated references to 'WLAs/LAs and TMDLs' to read 'TMDLs.' EPA had clearly stated in its definition of WLAs, LAs and TMDLs, and in the preamble to the 1985 final rule establishing part 130, that WLAs and LAs are part of a TMDL. See 50 FR 1775. Accordingly, the references to WLAs and LAs in these passages are not necessary. Since these changes are not substantive, and serve only to clarify existing requirements, EPA finds that notice and comment proceedings regarding these changes are unnecessary. Furthermore, the changes are in the nature of interpretive amendments to EPA rules, which are exempt from notice and comment requirements.

57 FR 33040-01 (emphasis added).

WLAs and LAs are part of TMDLs, therefore including a statement as you have suggested would be inaccurate and violate federal regulations. (See 57 FR 33040-01)

Thank you again for taking the time to comment on the draft TMDL for the East Fork Des Moines River. Your comments and this response will be included with the finalized TMDL submitted to the EPA Region VII office in Kansas City for approval.

Sincerely,

Allen P. Bonini, Supervisor
Watershed Improvement Section