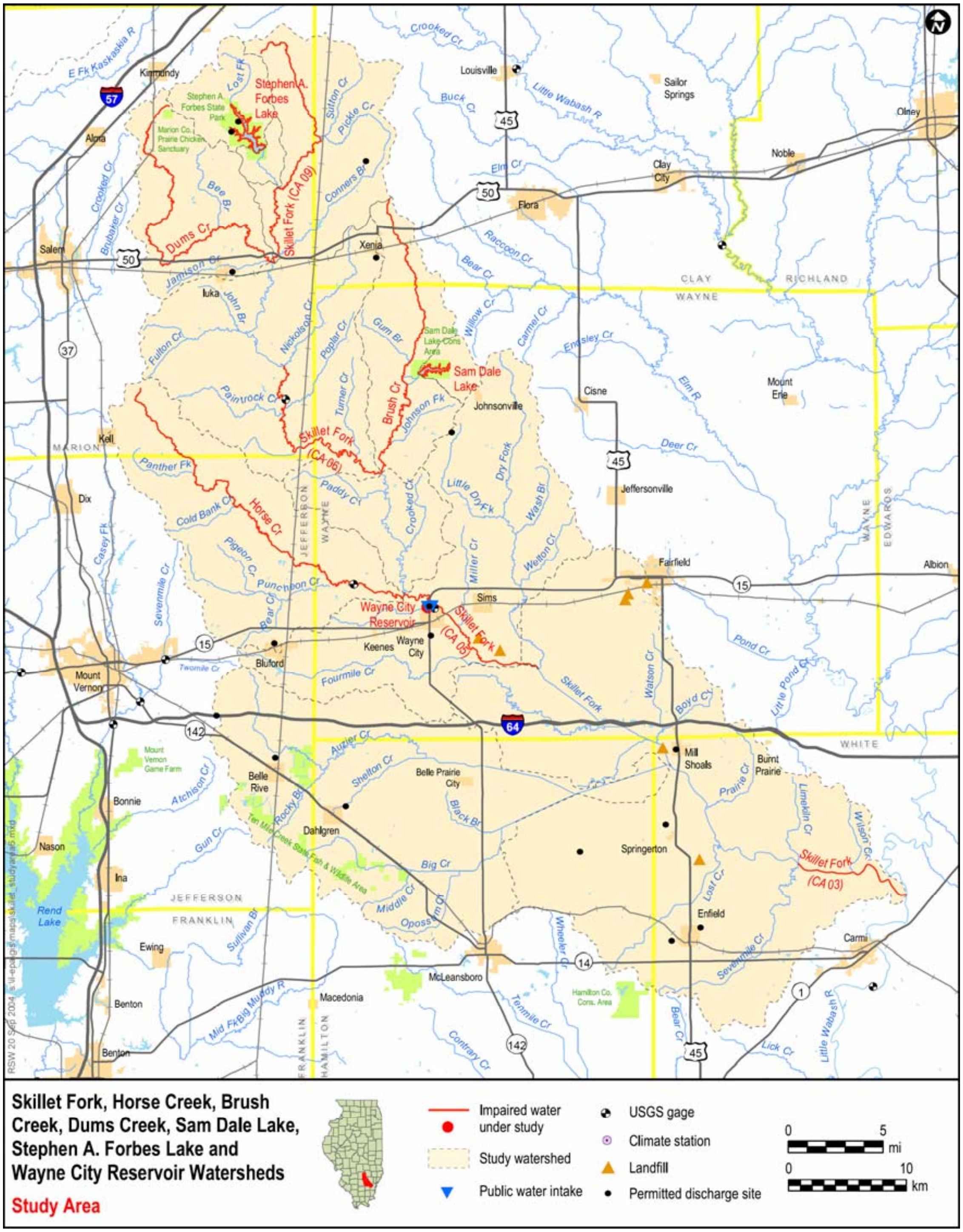
Illinois
Environmental
Protection Agency

Bureau of Water
P. O. Box 19276
Springfield, IL 62794-9276

August 2007

IEPA/BOW/07-009

Skillet Fork Watershed TMDL Report



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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF

WW-16J

DEC 08 2006

Marcia T. Willhite, Chief
Bureau of Water
Illinois Environmental Protection Agency
P.O. Box 19276
Springfield, IL 62794-9276

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Loads (TMDLs) from the Illinois Environmental Protection Agency (IEPA) for the Skillet Fork Watershed in Illinois. The TMDLs are for fecal coliform and phosphorus that impair the Primary Contact and Aquatic Life uses.

Based on this review, U.S. EPA has determined that Illinois' TMDLs for fecal coliform and phosphorus meet the requirements of Section 303(d) of the Clean Water Act and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves the fecal coliform and phosphorus TMDLs addressing seven impairments (see Table 5 of the Enclosure). The statutory and regulatory requirements, and U.S. EPA's review of Illinois' compliance with each requirement, are described in the enclosed decision document.

We wish to acknowledge Illinois' effort in submitting this TMDL and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Mr. Kevin Pierard, Chief of the Watersheds and Wetlands Branch at 312-886-4448.

Sincerely yours,

for Jo Lynn Traub
Director, Water Division

RECEIVED
DEC 14 2006
Watershed Management Section
BUREAU OF WATER

Enclosure

cc: Bruce Yurdin, IEPA

Skillet

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF:

WW-16J

SEP 20 2007

Marcia Willhite, Chief
Bureau of Water
Illinois Environmental Protection Agency
P.O. Box 19276
Springfield, IL 62794-9276

RECEIVED
SEP 27 2007
Watershed Management Section
BUREAU OF WATER

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Loads (TMDL) from the Illinois Environmental Protection Agency (IEPA) for Skillet Fork (CA-03, CA-05, and CA-06), for Brush Creek (CAR-01), and Horse Creek (CAN-01) in Illinois. The TMDLs are for fecal coliform and manganese, and address several impairments in these waterbodies.

Based on this review, U.S. EPA has determined that Illinois' TMDLs for fecal coliform and manganese meet the requirements of Section 303(d) of the Clean Water Act and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves seven TMDLs for thirteen impairments for Skillet Fork (CA-03, CA-05, and CA-06), for Brush Creek (CAR-01), and Horse Creek (CAN-01) in Illinois. The statutory and regulatory requirements, and U.S. EPA's review of Illinois' compliance with each requirement, are described in the enclosed decision document.

We wish to acknowledge Illinois' effort in submitting this TMDL and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Dean Maraldo, TMDL Program Manager, at 312-353-2098.

Sincerely yours,

Kevin M. Pierard
Acting Director, Water Division

Enclosure

cc: Jennifer Clarke, IEPA

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Final Stage 1 Progress Report

Prepared for Illinois Environmental Protection Agency

April 2005

Skillet Fork Watershed

Skillet Fork (CA03, CA05, CA06, CA09),
Horse Creek (CAN 01), Brush Creek (CAR 01),
Dums Creek (CAW 01), Sam Dale Lake (RBF),
Stephen A. Forbes Lake (RCD), and
Wayne City Side Channel Reservoir (RCT)

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First Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

October 2004

Skillet Fork Watershed

Skillet Fork (CA03, CA05, CA06, CA09),
Horse Creek (CAN01), Brush Creek (CAR01),
Dums Creek (CAW01), Sam Dale Lake (RBF),
Stephen A. Forbes Lake (RCD), and
Wayne City Side Channel Reservoir (RCT)

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EXECUTIVE SUMMARY

This is the first in a series of quarterly status reports documenting work completed on the Skillet Fork project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list, which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a TMDL be completed for each pollutant listed for an impaired waterbody. A TMDL is a report that is submitted by the States to the EPA. In the TMDL report, a determination is made of the greatest amount of a given pollutant that a waterbody can receive without violating water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review are presented in this first quarterly status report.

Next, the Illinois EPA, with assistance from consultants, will recommend an approach for the TMDL, including an assessment of whether additional data are needed to develop a defensible TMDL.

Finally, Illinois EPA and consultants will conduct the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

Methods

The effort completed in the first quarter included: 1) two site visits and collection of information to complete a detailed watershed characterization; 2) development of a water quality database and data analyses; and 3) synthesis of the watershed characterization information and the data analysis results to confirm the sufficiency of the data to support both the listing decision and the sources of impairment that are included on the draft 2004 303(d) list.

Results

Based on Stage 1 work, the project team has concluded that TMDLs are warranted for all ten impaired waterbodies in this targeted watershed, for all listed pollutants. Specifically:

- For **Skillet Fork (Segment CA 03)**, data are considered sufficient to support the causes listed on the draft 2004 303(d) list, and dissolved oxygen (DO), manganese, fecal coliform, pH, and atrazine TMDLs are warranted. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and algal respiration. A review of ammonia and dissolved oxygen data suggest that ammonia is not a significant source and that there are other factors besides ammonia that are contributing to the low observed dissolved oxygen. There were insufficient data to assess the relationship between sediment oxygen demand (SOD) and DO, carbonaceous biochemical oxygen demand (CBOD) and DO, and chlorophyll and DO. Based on the watershed characterization, it was determined that potential sources of nutrients, ammonia and BOD may include: municipal point sources, failing private sewage disposal systems, runoff from agricultural land (fertilized cropland and agricultural land with livestock) and intensive animal feeding operations. Low flows and high temperatures also appear to contribute to the low dissolved oxygen concentrations in this segment.

  The observed manganese concentrations in the lake likely reflect natural background conditions (soils in the watershed are naturally high in manganese), although brine from oil wells may also contribute to the elevated concentrations. Because of the naturally high levels of manganese in the soils, the general use criterion may be difficult to attain.

  Potential sources of fecal coliform include farms with livestock and intensive agricultural livestock operations, sewage treatment plants, and failing septic systems. Elevated fecal concentrations were identified in upstream segments and therefore the fecal sources are not all specific to this segment.

  Potential sources contributing to the pH excursions are unclear from the data, but the naturally acidic nature of the soils is suspected of contributing to the problem.

  The primary source of atrazine is non-irrigated cropland.

- For **Skillet Fork (Segment CA 05)**, data are considered sufficient to support the causes listed on the draft 2004 303(d) list, and dissolved oxygen, manganese, pH, and atrazine TMDLs are warranted. The discussion of sources contributing to low dissolved oxygen, manganese, pH and atrazine in Skillet Fork Segment CA 03 also applies to Segment CA 05, with two exceptions: algal respiration and ammonia nitrification are not thought to be significant factors contributing to low dissolved oxygen in this segment (CA 05). Because of the naturally high levels of manganese in the soils, the general use and public water supply criteria may be difficult to attain.

- For **Skillet Fork (Segment CA 06)**, data are considered sufficient to support the causes listed on the draft 2004 303(d) list, and dissolved oxygen, manganese, pH, and atrazine TMDLs are warranted. The discussion of sources contributing to low dissolved oxygen, manganese, pH and atrazine in Skillet Fork Segment CA 03 also applies to Segment CA 06. Because of the naturally high levels of manganese in the soils, the general use criterion may be difficult to attain.

- For **Skillet Fork (Segment CA 09)**, data are considered sufficient to support the cause listed on the draft 2004 303(d) list, and a dissolved oxygen TMDL is warranted.

It should be noted that the listing, while warranted, is based on only three dissolved oxygen measurements, with two of the three measurements being approximately 2 mg/l below the criteria of 5 mg/l. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Although there were insufficient data to assess the relationship between ammonia and dissolved oxygen, SOD and DO, CBOD and DO, and chlorophyll and DO, potential sources in this watershed were identified through the watershed characterization. These sources may include runoff from agricultural land (fertilized cropland and agricultural land with livestock) and failing private sewage disposal systems (lesser extent). There are no point sources in this watershed. Similar to what was observed farther downstream of this segment, low flows and high temperatures may also exacerbate low dissolved oxygen concentrations in this segment.

- For **Horse Creek (Segment CAN 01)**, data are considered sufficient to support the listing of this segment for dissolved oxygen; however, the data were extremely limited. Only two of the four measurements were below the DO criterion. The data are also sufficient to support the listing of this segment for manganese with one of five samples exceeding the general use criteria for manganese. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Potential sources contributing to one or more of these causes include failing private sewage disposal systems (lesser extent), runoff from agricultural land (fertilized cropland and agricultural land with livestock), a permitted point source discharger, and an intensive animal feeding operation. The observed manganese concentrations likely reflect natural background conditions (soils in the watershed are naturally high in manganese), although brine from oil wells may also contribute to the elevated concentrations. Because of the naturally high levels of manganese in the soils, the general use criterion may be difficult to attain.

- For **Brush Creek (Segment CAR 01)**, the data, though extremely limited, are considered sufficient to support the listing of this segment for dissolved oxygen and manganese. The observed manganese concentrations likely reflect natural background conditions (soils in the watershed are naturally high in manganese), although brine from oil wells may also contribute to the elevated concentrations. Because of the naturally high levels of manganese in the soils, the general use criterion may be difficult to attain. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Low dissolved oxygen can be exacerbated by low flow and/or high temperature conditions, similar to what was observed in Skillet Fork. Although the data were not available to determine the primary causes of low dissolved oxygen, potential sources of nutrients, ammonia and BOD include failing private sewage disposal systems (lesser extent), and runoff from agricultural land (fertilized cropland and agricultural land with livestock).

- For **Dums Creek (Segment CAW 01)**, data are considered sufficient to support the listing of this segment for dissolved oxygen with four of the five values less than the criterion. Because there are no point sources in this watershed, low DO is likely caused by nonpoint sources. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Low dissolved oxygen can be exacerbated by low flow and/or high temperature conditions, similar to what was observed in Skillet Fork. Although the data were not available to determine the primary causes of low dissolved oxygen, potential sources of nutrients, ammonia and BOD include failing private sewage disposal systems (lesser extent), and runoff from agricultural land (fertilized cropland and agricultural land with livestock).

- For **Sam Dale Lake (Segment RBF)**, data are considered sufficient to support the listing of this segment for total phosphorus. Phosphorus concentrations appear to be increasing over time in this lake. Potential phosphorus sources include sediment phosphorus release from the lake bottom sediments under anoxic conditions and watershed runoff from agricultural lands.
- For **Stephen A. Forbes Lake (Segment RCD)**, data are considered sufficient to support the listing of this segment for total phosphorus. Potential phosphorus sources include sediment phosphorus release from the lake bottom sediments under anoxic conditions and watershed runoff from agricultural lands. Because of the low discharge flows, the two treatment facilities in this watershed are not suspected of being significant sources of phosphorus.
- For **Wayne City Side Channel Reservoir (Segment RCT)**, data are considered sufficient to support the listing of this segment for manganese. The manganese concentrations exceed the public water supply criterion, but not the general use criterion. Potential sources of manganese include release of manganese from lake bottom sediments during summer anoxic conditions, and natural watershed sources (soils are naturally high in manganese). Because of the naturally high levels of manganese in the soils, the public water supply criterion may be difficult to attain.

INTRODUCTION

This Stage 1 report describes initial activities related to the development of TMDLs for impaired waterbodies in the Skillet Fork watershed. Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed. This section provides some background information on the TMDL process, and Illinois assessment and listing procedures. The specific impairments in waterbodies of the Skillet Fork watershed are also described.

TMDL Process

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is called the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA 2004), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review are presented in this first quarterly status report.

Next, the Illinois EPA, with assistance from consultants, will recommend an approach for the TMDL, including an assessment of whether additional data are needed to develop a defensible TMDL.

Finally, Illinois EPA and consultants will conduct the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

Illinois Assessment and Listing Procedures

Water quality assessments in Illinois are based on a combination of chemical (water, sediment and fish tissue), physical (habitat and flow discharge), and biological (macroinvertebrate and fish) data. Illinois EPA conducts its assessment of water bodies using a set of five generic designated use categories: public water supply, aquatic life, primary contact (swimming), secondary contact (recreation), and fish consumption (IEPA, 2004). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of three possible "use-support" levels:

- Fully supporting (the water body attains the designated use);
- Partially supporting (the water body attains the designated use at a reduced level); or
- Not supporting (the water body does not attain the designated use).

All water bodies assessed as partial or nonsupport attainment for any designated use are identified as "impaired." Waters identified as impaired based on biological (macroinvertebrate, macrophyte, algal and fish), chemical (water, sediment and fish tissue), and/or physical (habitat and flow discharge) monitoring data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters.

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized on a watershed basis. Illinois EPA watershed boundaries are based on the USGS ten-digit hydrologic units, to provide the state with the ability to address watershed issues at a manageable level and document improvements to a watershed's health (IEPA, 2004).

List of Identified Watershed Impairments

The impaired waterbody segments included in the project watershed are listed in Table 1, along with the parameters they are listed for, and the use impairments as identified in the draft 2004 303(d) list (IEPA, 2004). TMDLs are currently only being developed for pollutants that have numerical water quality standards. These pollutants are indicated in Table 1 in boldface type. Sources that are listed for pollutants that exceed statistical guidelines or have non-numeric criteria are not subject to TMDL development at this time (IEPA, 2004). Table 1 provides information on the targeted waterbodies, including size, causes of impairment, and use support (partial support, full support, nonsupport). Those impairments that are the focus of this report are shown in bold font.

The remaining sections of this report include:

- Watershed characterization: *discussion of methods for information compilation and a detailed characterization of the watershed*
- Database development and data analysis: *discussion of data sources and methods of data analysis*
- Confirmation of causes and sources of impairment: *assessment of sufficiency of data to support the listing and identification of potential sources contributing to the impairment*
- Conclusions

Table 1. Impaired Waterbodies in the Skillet Fork Watershed

Waterbody Segment	Waterbody Name	Size (miles/acres)	Year Listed	Listed for[1]	Use Support[2,3]
CA03	Skillet Fork	7.13	1998	**Manganese, pH, dissolved oxygen, fecal coliform, atrazine**, total suspended solids, habitat alteration, sedimentation/siltation, total phosphorus (statistical guideline), PCBs	Aquatic life (P), fish consumption (P), primary contact (N)
CA05	Skillet Fork	10.96	2002	**Manganese, pH, dissolved oxygen, atrazine**, total suspended solids, habitat alteration, sedimentation/siltation, PCBs	Aquatic life (P), fish consumption (P), primary contact (F), public water supply (P)
CA06	Skillet Fork	16.63	2002	**Manganese, pH, dissolved oxygen, atrazine**, total suspended solids, sedimentation/siltation, PCBs	Aquatic life (P), fish consumption (P), primary contact (F)
CA09	Skillet Fork	19.77	2002	**Dissolved oxygen**, PCBs	Aquatic life (P), Fish consumption (P)
CAN01	Horse Creek	28.21	2002	**Manganese, dissolved oxygen**	Aquatic life (P) Fish consumption (F)
CAR01	Brush Creek	21.27	1998	**Manganese, dissolved oxygen**	Aquatic life (P)
CAW01	Dums Creek	25.38	2002	**Dissolved oxygen**	Aquatic life (P)
RBF	Sam Dale Lake	194	1998	**Phosphorus**, total suspended solids, excess algae growth, total phosphorus (statistical guideline)	Aquatic life (F), fish consumption (X), overall use (P), primary contact (N), public water supply (X), secondary contact (P)
RCD	Stephen A. Forbes Lake	525	2004	**Phosphorus**, total suspended solids, excess algae growth, total phosphorus (statistical guideline)	Aquatic life (F), fish consumption (F), overall use (P), primary contact (P), public water supply (X), secondary contact (P)
RCT	Wayne City Side Channel Reservoir	8	2004	**Manganese**, total suspended solids, excess algae growth, total phosphorus (statistical guideline)	Aquatic life (F), overall use (P), primary contact (P), public water supply (P), secondary contact (P)

[1] Bold font indicates cause will be addressed in this report. Other potential causes of impairment listed for these waterbodies do not have numeric Water Quality Standards and are not subject to TMDL development at this time.
[2]F = Full, P = Partial, N = Nonsupport, X = Not evaluated
[3]The aquatic life use support for SA Forbes Lake may need to be revisited. The phosphorus criteria is the same for both the aquatic life and secondary contact use, however it was observed that the aquatic life use is stated as being fully supported and the secondary contact use is stated as being partially supported.

WATERSHED CHARACTERIZATION

The purpose of watershed characterization was to obtain information describing the watershed to support the identification of sources contributing to manganese, pH, total phosphorus, dissolved oxygen, fecal coliform and atrazine impairments. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including geology and soils, climate, hydrology, land cover, urbanization and growth, and point source discharges and septic systems. The methods used to characterize the watershed, and the findings are described below.

Methods

Watershed characterization was conducted by compiling and analyzing data and information from various sources. Where available, data were obtained in electronic or Geographic Information System (GIS) format to facilitate mapping and analysis. To develop a better understanding of land management practices in the watershed, calls were placed to local agencies to obtain information on crops, pesticide and fertilizer application practices, tillage practices and best management practices employed. Additionally, a meeting was held on December 11, 2003 with Regional and State-level IEPA staff and a site visit was conducted the following day. A second site visit was conducted on June 24, 2004.

The first step in watershed characterization was to delineate the watershed boundaries for the impaired waterbodies (Table 1) in GIS using topographic and stream network (hydrography) information. Other relevant information obtained and processed for mapping and analysis purposes included:

- current land cover;
- current cropland;
- State and Federal lands;
- soils;
- point source dischargers;
- public water supply intakes;
- roads;
- railroads;
- state, county and municipal boundaries;
- landfills;
- oil wells;
- coal mines;
- dams;
- data collection locations; and
- location of 303(d) listed lakes and streams.

To better describe the watershed and obtain information related to active local watershed groups, data collection efforts, agricultural practices, and septic systems, calls were placed to county-level officials at the Natural Resources Conservation District (NRCS), Agricultural Extension Office, Soil and Water Conservation District (SWCD), Health Department, and Farm Services Agency (FSA). A valuable resource used in this effort was *An Intensive Survey of the Skillet Fork Basin: Data Summary* (IEPA, 2002), an in-depth report prepared by the Illinois EPA in 2002. The report entitled *Diagnostic and Feasibility Study, Stephen A. Forbes Lake*, prepared by the Illinois Department of Conservation under the Clean Lakes Program (ca. 1993) was also useful for the Stephen A. Forbes Lake subwatershed. Other information compiled for this task related to climate, population growth and urbanization. A list of data sources and calls is included in Appendix A. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including geology and soils, land cover and uses, climate, and population growth. The methods used to characterize the watershed, and the findings are described below.

Skillet Fork Watershed Characterization

The impaired waterbodies addressed in this report are all located within the Skillet Fork watershed. This watershed is located in Southeastern Illinois, approximately 10 miles east of the city of Mount Vernon and the intersection of Interstates 57 and 64. Skillet Fork is a tributary to the Little Wabash River, with its confluence located three miles northeast of Carmi, Illinois, near river mile 39. Portions of the Skillet Fork watershed lie in Clay, Marion, Wayne, Jefferson, White and Hamilton counties. The watershed is approximately 672,425 acres (1,051 square miles) in size, and there are about 1,720 miles of streams in the watershed. The main stem of the Skillet Fork River is approximately 97 miles long (54 miles are listed as being impaired). Major tributaries in the watershed include Horse Creek, Auxier Ditch, Dry Fork, Big Creek, Brush Creek, Dums Creek and Sevenmile Creek. Seven of the eight impaired segments that are addressed in this report are located in the upper two thirds of the watershed. Figure 1 shows a map of the watershed, and includes some key features such as waterways, impaired waterbodies, public water intakes and other key features. The map also shows the locations of point source discharges that have a permit to discharge under the National Permit Discharge Elimination System (NPDES).

The following sections provide a broad overview of the characteristics of the Skillet Fork watershed, as delineated in Figure 1. Specific information about the smaller subwatersheds for impaired waterbodies follows the general overview.

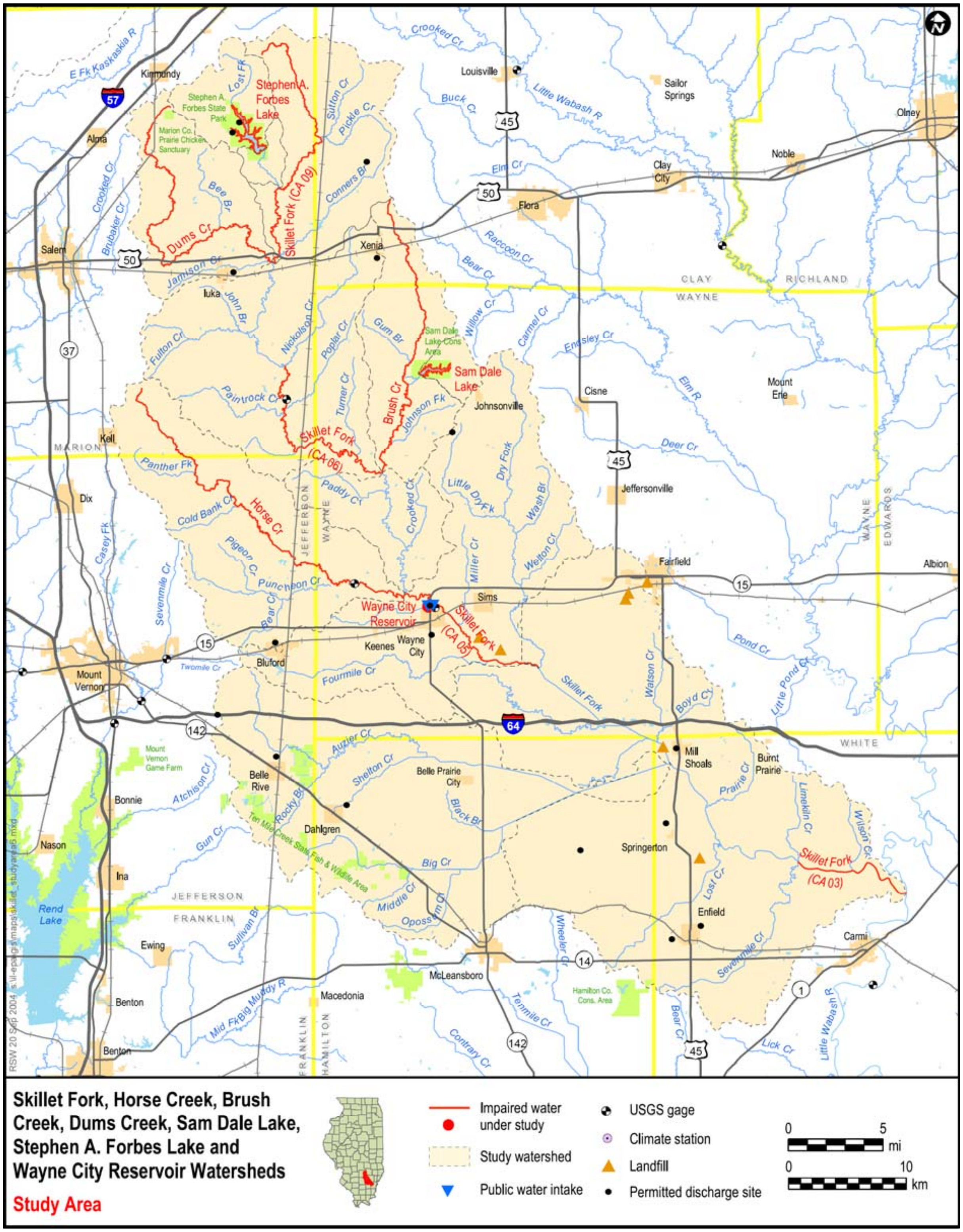

Figure 1. Base Map of Skillet Fork Watershed.

Geology and Soils

Information on geology and soils was compiled to understand whether the soils are a potential source of manganese and/or phosphorus. The Skillet Fork watershed lies in the Till Plains physiographic division and has been primarily been shaped by glaciers. These glaciers smoothed the landscape resulting in less pronounced relief. Elevation in the watershed ranges from 650 feet above mean sea level (AMSL) at the highest point in the watershed, just south of the town of Kinmundy, to 370 feet at the Skillet Fork's confluence with the Little Wabash River.

Figure 2 shows the major soil associations in the Skillet Fork watershed. Each association has a distinctive pattern of soils, relief, and drainage. Typically, an association consists of one or more major soils and some minor soils (Miles, 1996). Glacial drift covers portions of the watershed, with a thin layer of loess overlying the till in most areas. The drift thickness ranges from 2 to 30 feet while the loess cap overlying the drift is approximately 30-40 inches thick (Preloger, 2003; Currie, 1986). Other areas of the watershed are composed of soils that formed in water-deposited sediment. These soils can be alluvial soils formed in silty areas along streams or more clayey soils that formed in slackwater glacial lakes. These soils are naturally poorly drained and in many cases, drainage ditches have been dug to reduce wetness and reduce the potential of flooding (Currie, 1986). Soils on the more sloped portions of the watershed tend to be moderately well drained (Miles, 1996). Detail on the geology and soils in the Skillet Fork watershed can be found in the USDA Soil Surveys produced for Clay, Marion, Wayne, Jefferson, White and Hamilton counties.

The STATSGO soils information was used to identify the predominant soil associations in the Skillet Fork watershed (shown in Figure 2) and the available county soil surveys were used to describe the soils (Wayne County was out of soil surveys).

The Skillet Fork watershed is comprised primarily of soils from six soil associations, with four of these comprising over 90% of the watershed area. The frequency of occurrence of these associations is presented in Table 2. Characteristics of the four primary soil associations are discussed in additional detail below. As this overview of the soils shows, many of the soils in the Skillet Fork watershed contain manganese and iron oxide concretions or accumulations and are also acidic. This could result in manganese and iron moving into solution and being transported in base flow and/or runoff, as discussed in later sections of this report.

Table 2. Watershed soils (Source: STATSGO)

Soil Map Units (MUID)	Acres	Percentage
Cisne-Hoyleton-Darmstadt (IL006)	74,246	11%
Patton-Marissa-Montgomery (IL020)	18,465	3%
Bluford-Ava-Hickory (IL038)	341,615	51%
Hurst-Reesville-Patton (IL051)	19,496	3%
Grantsburg-Zanesville-Wellston (IL064)	84,447	12%
Bonnie-Belknap-Piopolis (IL069)	134,057	20%

Fifty-one percent of the Skillet Fork watershed is underlain by the Bluford-Ava-Hickory association. The soil series comprising this association are described as follows in the Marion County soil survey (Miles, 1996). The Bluford series consists of somewhat poorly drained, slowly permeable soils on low ridges, broad ridgetops or short side slopes along drainageways. Slopes range from 0 to 7 percent. Rounded dark nodules or iron and manganese oxide are noted at all depths in the Bluford series, with these soils described as being extremely acid to neutral in pH. The Ava series consists of moderately well drained soils on side slopes, the crest of prominent ridges and narrow ridgetops on the Illinoian till plain. Slopes range from 1 to 10 percent. Fine and medium rounded nodules or irregular dark accumulations of iron and manganese oxide are noted at all depths of the Ava series. These soils are described as being slightly to very strongly acid. The Hickory series consists of well-drained, moderately permeable soils on side slopes along drainageways in strongly dissected areas on the Illinoian till plain. These soils were formed in glacial till and have slopes ranging from 10 to 50 percent. Common to many medium accumulations of iron and manganese oxide are noted at depths of 14 to 45 inches and the Hickory series is described as being slightly to very strongly acid at depths to 45 inches.

Twenty percent of the Skillet Fork watershed is underlain by the Bonnie-Belknap-Piopolis association. The soil series comprising this association are described as follows in the Hamilton County soil survey (Currie, 1986). The Bonnie, Belknap and Piopolis series consist of poorly drained, moderately slowly to slowly permeable soils on flood plains. These soils were formed in silty alluvial deposits and slopes are less than 2 percent. In the Bonnie series, few to common rounded nodules (iron and manganese oxides) are found throughout the soil horizon at depths to 60 inches below the surface. These soils are described as medium to very strongly acid to 14 inches deep and very strongly to extremely acid at depths between 14 and 60 inches. The Belknap series is acidic, with the acidity varying from slightly to strongly acid depending on the depth. Few to common rounded nodules or iron and manganese oxides are found at depths between 16 and 60 inches. The Piopolis series is slightly to strongly acid, depending on the depth. Few to common rounded accumulations or nodules of iron and manganese oxides are found at depths between 14 and 37 inches.

Twelve percent of the Skillet Fork watershed is underlain by the Grantsburg-Zanesville-Wellston association. The soil series comprising this association are described as follows in the Franklin and Jefferson County soil survey (Preloger, 2003). The Grantsburg series consists of moderately well drained, very slowly permeable soils on uplands. The parent material for these soils is loess and silty sediments over bedrock. Slopes range from 2 to 10 percent. These soils are strongly to extremely acid and, at depths of 19 to 60 inches, iron-manganese concretions are found. The Zanesville series consists of moderately well drained, slowly permeable soils on uplands. The parent material for these soils is loess and loamy residuum over bedrock. Slopes range from 10 to 18 percent. These soils are described as being neutral in the surface layers (0 to 8 inches) and very strongly acid at depths between 8 and 60 inches. At depths between 8 and 50 inches common rounded iron-manganese concretions are found. The Wellston series consists of well-drained, moderately slowly permeable soils on uplands with slopes of 10 to 18 percent. The parent material for these soils is loess and silty residuum over bedrock. These soils are moderately to very strongly acid at all depths (to 48 inches) and there is no mention of iron or manganese nodules or concretions at any depth.

Eleven percent of the Skillet Fork watershed is underlain by the Cisne-Hoyleton-Darmstadt association. The soil series comprising this association are described as follows in the Marion County soil survey (Miles, 1996). The Cisne series consists of poorly drained, very slowly permeable soils on the broad, nearly level parts of the Illinoian till plain. These soils formed in loess and in the underlying loaming sediments, with slopes ranging from 0 to 2 percent. At depths of 8 to 30 and 50 to 60 inches, medium and fine rounded dark accumulations of iron and manganese oxide are noted. The Cisne soil series is also described as being strongly to very strongly acid. The Hoyleton series consists of somewhat poorly drained, slowly permeable soils on knolls and low ridges or on short side slopes along drainageways on the Illinoian till plain. Slopes range from 0 to 7 percent. Common medium irregular dark stains of iron and manganese oxide are noted at depths of 30-50 inches and these soils are neutral to very strongly acid. The Darmstadt series consists of somewhat poorly drained, very slowly permeable soils on low ridges or on short side slopes along drainageways on the Illinoian till plain. Slope ranges from 0 to 6 percent. Common fine and medium rounded dark nodules of iron and manganese oxide are noted at all depths of the Darmstadt series and the pH in these soils varies from strongly alkaline to medium acid.

Both coal and oil have been extracted throughout this portion of Illinois. These activities peaked between 1940 and 1980. Coal was only mined near the headwaters of the Auxier Ditch in the southwestern part of the watershed. Information from IEPA GIS files indicates there were approximately 10 coal mines in this area, although the timing of their operations rarely overlapped. Both shaft and strip-mining techniques were used. However, coal is no longer actively mined in the watershed with the last mine closing around 1974 (based on GIS information obtained from the Illinois Natural Resources Geospatial Data Clearinghouse).

Figure 3 shows the locations of active oil wells in the Skillet Fork watershed. The Illinois EPA estimates the average active oil well density in the watershed at two wells per square mile (IEPA, 2002). According to the White County SWCD, most oil wells on the map are active and many landowners lease out their land to oil companies. The oil companies then contract out disposal of the brine water withdrawn during the oil extraction process. During wet weather, the contractors frequently dump saltwater into an adjoining ditch (White County SWCD). Because the soils contain manganese this brine water may be a source of manganese. The Clay County NRCS also mentioned the pumping of brine water as a potential cause of increased erosion and possibly lower pH. According to the Clay County NRCS, some sections of Clay County and Marion Co. soils have been damaged from pumping of salt water into oil wells to increase production. When brine water reaches the surface, it prevents vegetation from growing, and increased erosion results.

Oil wells may also be a nuisance for other reasons. According to the Jefferson County NRCS, many oil wells are abandoned and are often not properly capped. Sometimes the tanks will rust out and leak. The White County SWCD noted that they get a fair number of complaints about how to reclaim cropland after an oil spill (usually when a pipe bursts).

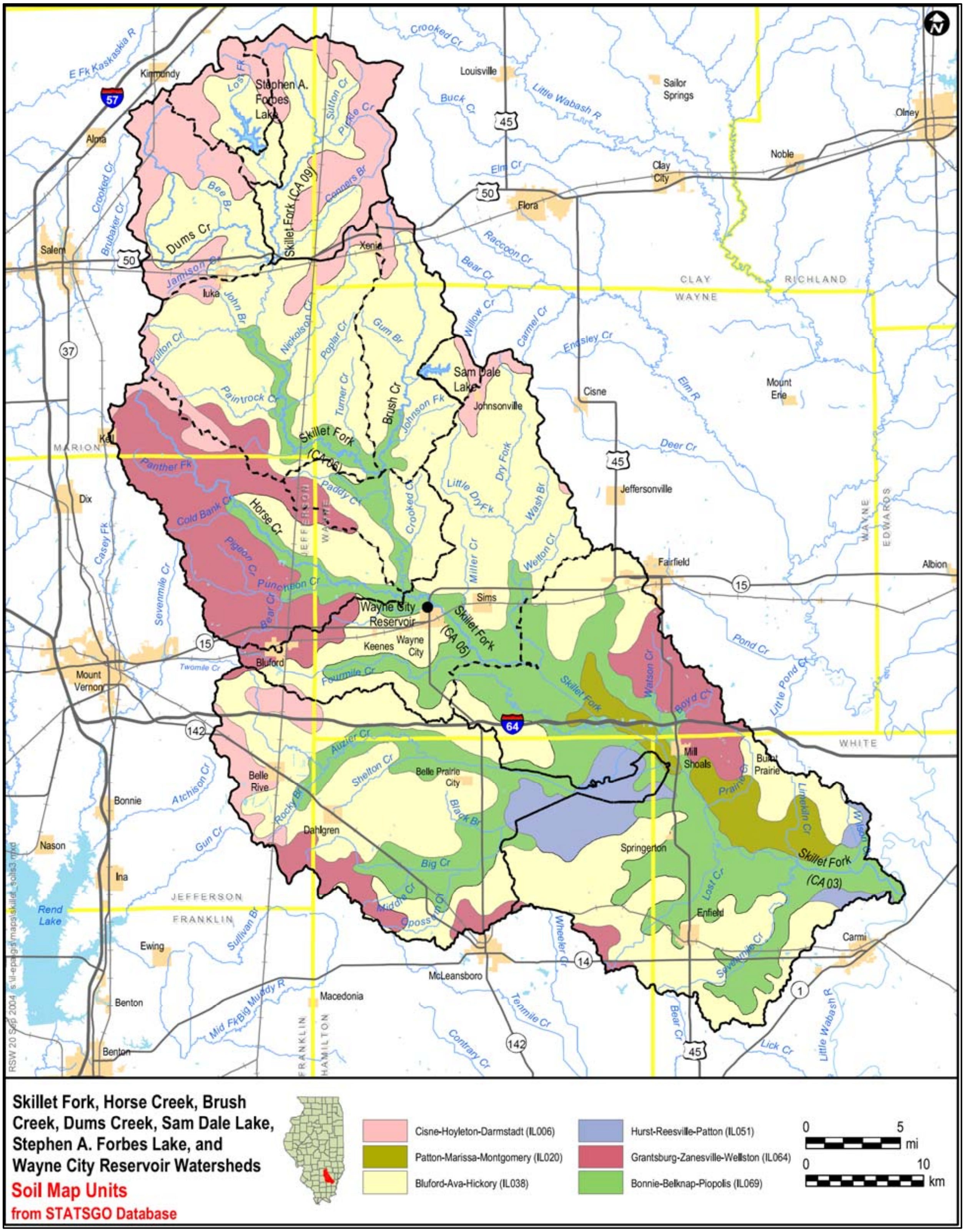

Figure 2. Soil Associations in Skillet Fork Watershed

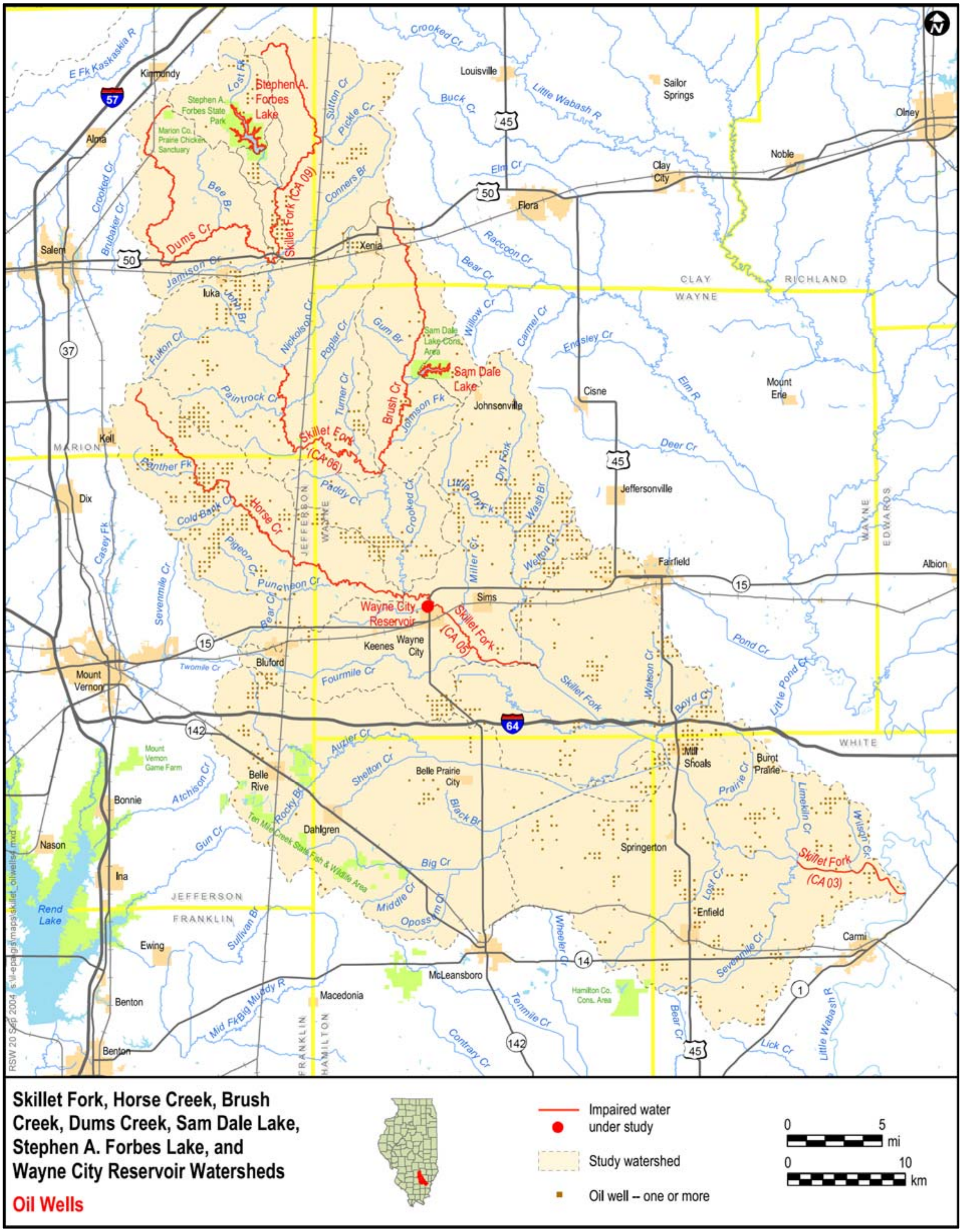

Figure 3. Oil Wells in the Skillet Fork Watershed

Climate

Climate information was obtained and summarized to support the watershed characterization and gain an understanding of runoff characteristics for this study area. The Skillet Fork watershed has a temperate climate with cold, snowy winters and hot summers. The National Weather Service (NWS) maintains two weather stations in the watershed; one is located in Wayne City (in the middle of the watershed) and a second is near Carmi (near the Skillet Fork mouth). Nearby stations located just outside the watershed include: Kinmundy (near the river headwaters), Salem (northwest of the watershed), Flora (northeast of the watershed), Dix (west of the watershed), Mount Vernon (west of the watershed), Fairfield (east of the watershed), McLeansboro (south of the watershed) and Carmi (just south of the Skillet Fork confluence with the Little Wabash River). These are maintained through the Cooperative Observer Program (COOP). Climate data are archived at the National Climatic Data Center (NCDC) and summaries are available on the web page of the Illinois State Climatologist Office (Illinois Water Survey, 2004).

Because of variations noted between the Wayne City (119040) and Carmi (111296) stations, climate summaries are presented for both of these stations. Summaries are based on data collected between 1971 and 2000. The annual average long-term precipitation recorded in the watershed ranges from 40.53 inches at Wayne City to 42.58 inches at Carmi. Maximum annual precipitation amounts of 57.13 inches (1957) and 65.78 inches (1950) were recorded at Wayne City and Carmi, respectively. The minimum annual precipitation at these two stations was recorded in 1953 and was 26.78 and 26.82 at Wayne City and Carmi. On average, a measurable amount of precipitation (0.01 inches) is recorded on 22% to 27 % of the days in a year. Of the days with measurable precipitation, approximately 10% have rainfall amounts of at least an inch. Average snowfall ranges between 10.3 and 13.1 inches per year at Wayne City and Carmi, respectively.

Temperature data are not available for either the Wayne City or Carmi stations. However, temperature summaries for the 1971-2000 period are available for six stations located near the Skillet Fork watershed. Based on these nearby stations, monthly average temperatures in the watershed are typically below freezing during the coldest part of the year (January) and average in the upper 70s (Fahrenheit) during the warmest part of the year (July). Temperatures can reach 90^{o}F in the summer. Temperature averages are consistent within 1-2 degrees across the watershed. Summaries of station data are provided in Table 3.

Table 3. Summary of precipitation and temperature data in and near the Skillet Fork watershed

Station[1]	Description	Period of Record	Precipitation					Snowfall	Temperatures (°F)					
			Annual statistics (in)			# days > threshold (in)		Inches	January			July		
			Avg[2]	Min (yr)	Max (yr)	> 0.01	> 1.00	Avg[2]	Avg[2]	Min	Max	Avg[2]	Min	Max
115943	Mt. Vernon	1895-2001	42.19	23.39 (1980)	63.07 (1945)	112	11	17.7	27.9	18.8	37.0	77.1	66.4	87.8
119040	**Wayne City**	**1948-2001**	**40.53**	**26.78 (1953)**	**57.13 (1957)**	**82**	**12**	**10.3**	***Temperature data are not available for this station***					
112931	Fairfield	1887-2001	45.00	24.31 (1908)	63.81 (1927)	115	11	15.3	28.4	19.7	37.0	76.7	65.1	88.2
111296	**Carmi 6**	**1923-2001**	**42.58**	**26.82 (1953)**	**65.78 (1950)**	**99**	**11**	**13.1**	***Temperature data are not available for this station***					
111302	Carmi 3	1987-2001	46.38	36.54 (1987)	59.72 (1990)	109	13	14.4	31.3	22.3	40.2	78.0	67.0	88.9
112344	Dix	1990-2001	42.10	34.29 (1997)	57.02 (1993)	95	11	11.3	*Temperature data are not available for this station*					
115515	McLeansboro	1892-2001	43.90	19.48 (1914)	63.38 (1945)	121	10	15.9	29.6	20.3	38.9	77.5	65.8	88.0
114756	Kinmundy	1990-2001	41.23	34.55 (1991)	54.65 (1993)	102	11	16.6	*Temperature data are not available for this station*					

Station[1]	Description	Period of Record	Precipitation					Snowfall	Temperatures (°F)					
			Annual statistics (in)			# days > threshold (in)		Inches	January			July		
			Avg[2]	Min (yr)	Max (yr)	> 0.01	> 1.00	Avg[2]	Avg[2]	Min	Max	Avg[2]	Min	Max
117636	Salem	1915-2001	42.53	27.54 (1947)	61.14 (1957)	112	11	14.4	27.5	18.1	36.8	78.2	68.1	88.2
113109	Flora	1893-2001	42.94	22.23 (1958)	60.48 (1993)	99	11	8.4	29.4	20.7	38.1	77.0	65.4	88.6

[1] Stations in the watershed are shown in boldface type.
[2] Average is based on 1971-2000 data.

Hydrology

An understanding of hydrology helps with understanding the importance of different watershed transport and instream processes. The Skillet Fork watershed has one active USGS streamflow gage, located in Wayne City, IL (gage 03380500) approximately 35 miles upstream of the mouth. The drainage area at this gage is 464 square miles (296,960 acres) or approximately half of the watershed area. Daily discharge measurements are available from October of 1908 to the present. These data were used to calculate return periods for given floods, as shown in Table 4.

Table 4. Estimated discharges for select return periods at Skillet Fork River near Wayne City, IL.

Return Period (years)	Discharge (cfs)
1	420
2	8,500
5	15,200
10	19,000

Figure 4 is a flow duration curve, indicating median flows around 40 ft^3/s. According to Singh et al. (1988), the 7-day, 10-year low flow (7Q10) is 0.05 ft^3/s for this stream at the gage location.

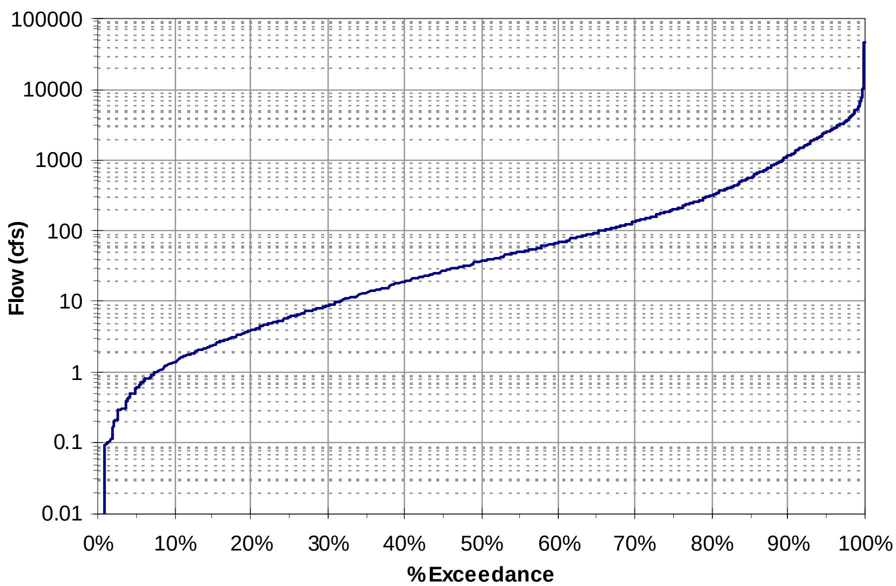

Figure 4. Flow-Duration Curve, Skillet Fork River Near Wayne City, IL.

Significant portions of Skillet Fork and its tributaries have undergone hydrological alteration, primarily to address the poor drainage characteristics of the soils in the watershed. IEPA indicates that channelization in the lower reaches of Skillet Fork (below the USGS gage) and in Auxier Ditch is one of the most prominent influences on habitat quality (IEPA, 2002).

Land Cover

Runoff from the land surface contributes pollutants to nearby receiving waters. To understand sources contributing to receiving water impairments, it was necessary to characterize land cover in the watershed. Land cover in the Skillet Fork watershed is shown in Figure 5, and listed in Table 5. The predominant land cover in the watershed is agriculture, shown in yellow on the map. Approximately 65% of the watershed is cropland. Grassland (e.g., pasture) constitutes 12% of the watershed area. The second highest land cover is forest, which covers approximately 16% of the watershed.

Agricultural practices in the Skillet Fork watershed were documented by conducting phone interviews with the local Natural Resources Conservation Service (NRCS), Farm Service Agency (FSA) and Soil and Water Conservation District (SWCS) officials in the counties that the watershed spans. Contact information for these officials is provided in Appendix A.

Based on calls to the county SWCD, NRCS, agricultural extension and FSA offices, it was confirmed that the majority of the crops grown are corn and soybeans, with lesser amounts of other grains such as wheat and sorghum, as well as some milo and sunflowers. The rotation of these crops varies depending on the field location in the landscape (lowland vs. upland areas), but generally follows some alternating corn-soybean rotation.

Tillage practices in the watershed range from no-till to conventional tillage, which is done mainly in the lowlands of the watershed. A recent report by the Illinois Department of Agriculture reports tillage practices by crop type and county for 98 of the 102 counties in the state. In general the information obtained on tillage practices agreed with the county transect survey results (Illinois Department of Agriculture, 2002). The statistics for the Skillet Fork watershed, shown below in Table 6, are an area-weighted average of the data from the counties in the watershed (note: 2002 data were not available for Wayne County so data from 2000 were used in the calculation). It was noted by the Hamilton County SWCD that no-till is not typically used in lowland areas because of issues related to drainage. This was consistent with information obtained from the Hamilton County FSA and Wayne County NRCS, which reported a higher percentage use of conventional till in lowland areas and a higher percentage farmers using no-till for crops grown on highland areas. The Clay County NRCS noted that more than 50% of the soybeans are no-till and the rest of the crops have at least 25-30% residual, even using conventional methods. Tile drains are not commonly used in Marion, Clay or Jefferson Counties due to the high clay content of the soils (Jefferson, Clay and Marion County NRCS), but are becoming more popular in some portions of the watershed in the last few years (White Co. SWCD, Hamilton Co. SWCD and FSA, Wayne Co. NRCS). Tile drains are primarily used in lowland and former wetland areas (Hamilton Co. SWCD, Wayne Co. NRCS).

Figure 5. Land Cover In Skillet Fork Watershed 1999-2000

Table 5. Land Cover in Skillet Fork Watershed

Land Cover Type	Area (acres)	Percent of Watershed Area
Agriculture[1]	438,980	65.3
Forest	107,874	16.0
Grassland	79,867	11.9
Urban	7,351	1.1
Water	3,981	0.6
Wetland	33,987	5.1
Barren Land	318	<0.1
Totals	**672,358**	**100**

Source: Illinois Department of Agriculture, 1999-2000 land cover
[1]The primary crops are soybeans (51%), corn (32%) and winter wheat, other small grains and hay (17%)

Table 6. Percent of Fields, by Crop, with Indicated Tillage Practice[1]

	Conventional Till[2]	Reduced-Till[3]	Mulch-Till[4]	No-Till[4]
Corn	56	2	3	40
Soybean	30	4	7	59
Small grain	18	1	27	54

Source: Illinois Department of Agriculture (2002)
[1]Total percentage for each crop may not equal 100% due to rounding.
[2] Residue level 0 – 15%
[3] Residue level 16-30%
[4] Residue level > 30%

The amount of grassland and/or forest may be higher than shown in Table 5, due to participation of local farmers in the Conservation Reserve Program (CRP). This program pays farmers to plant highly erodible land used for crop fields with permanent vegetation for a ten-year period, thereby reducing erosion and sediment yield. Information on participation in the conservation reserve program was obtained through calls to county agencies. It was estimated that there are:

- 20,000-30,000 acres in Jefferson County in the CRP (Jefferson County NRCS);
- 13,000 acres in White County (White County FSA);
- 33,000 acres in Hamilton County in the CRP (Hamilton County FSA), with most of these located in the northwest part of the county;
- 50,000 acres in Wayne County in the CRP (Wayne Co. NRCS); and
- many CRP acres in Marion County, especially in the Skillet Fork watershed due to the poorer soils in the county (Marion County SWCD).

Note that these area estimates are for the entire county rather than the portion of the county that was in the Skillet Fork watershed. Watershed-specific estimates were not available.

Best management practices (BMPs) are employed by farmers in the watershed to reduce soil erosion. These BMPs include the tillage practices described above that leave more residue on the soil before and after harvesting and the use of vegetation as filter strips near stream banks and along the edges of their fields (Wayne County NRCS, Clay County NRCS). Although not possible to quantify, it was reported that there are many buffer strips in the watershed (White County FSA, SWCD and NRCS, Hamilton County FSA, Wayne County NRCS, Marion Co. NRCS and SWCD, Clay County NRCS). These consist of riparian buffer zones, grassed waterways and filter strips. The Clay County NRCS also noted that some grade stabilization projects have been completed in the Skillet Fork watershed and some sediment basins have also been built. Additionally, the Clay County NRCS noted that there is a large storage basin located north of Xenia.

Pesticide and Fertilizer Application

Based on conversations with the county SWCD, NRCS and FSA offices, pesticide application appears to be very common throughout the watershed. Atrazine is primarily used on corn and milo, and roundup is used on soybeans. These pesticides are applied by tank/truck, generally in the spring and sometimes in June (White Co. FSA and NRCS, Hamilton County FSA, Wayne Co. NRCS, Marion Co. NRCS). It was noted that the application is farmer-dependent (Hamilton Co. SWCD).

Most of the fertilizers applied in the watershed are commercial fertilizers (potash and nitrogen). Manure is also applied, but not very commonly. The timing and application rates vary by farmer, but most counties noted a spring fertilizer application (Marion Co. NRCS, Jefferson Co. NRCS, Hamilton Co. FSA, and Wayne Co. NRCS). The Clay County NRCS noted that most farmers test the soil prior to fertilizing.

Livestock

Livestock operations are a potential source of both nutrients and fecal coliform. The yellow areas in Figure 5 indicate agricultural land cover and also include livestock operations. IEPA estimated that there were 76 livestock facilities in the watershed in 1998 (IEPA, 2002). County-level livestock statistics for 2002 were available through the Census of Agriculture (USDA NASS, 2002), and are summarized in Table 7. Recent, watershed-specific information on livestock operations was obtained by contacting county agencies. Through these calls, turkey, hog and cattle operations were identified in the Skillet Fork watershed, although it was not possible to identify the exact location of all facilities mentioned. In Jefferson County, a turkey operation was noted in the Horse Creek watershed. Manure from this operation is broadcast spread and tilled into the soil. In White County one or two hog operations (CAFOs) and one small cattle operation (pasture) were identified. The White County SWCD noted that the cattle operation farm had applied for EQIP funding. In Hamilton County three hog operations with about 15,000 hog head were identified in the Skillet Fork watershed, with all three located in the southern portion of the watershed, upstream of Skillet Fork segment CA03 (Hamilton County FSA). The waste from these operations is stored in pits. This manure is also tank-applied or it is mixed into slurry and knifed into the ground. In Wayne County there are approximately 25 significant hog farms and ten turkey operations. There is one dairy operation with approximately 50 cows. According to the Wayne County NRCS, IEPA has been regularly checking on this dairy operation for approximately the past two years. Manure from this operation is disposed of in in-ground tanks. In Marion County, there are several small beef operations with just a few head, up to 40 head. Most of these cattle are free range and only about a quarter to a third of the operations fence the cows away from local waterways. In Clay County there are one or two medium size hog CAFOs in the watershed, with less than 1,000 head each (Clay County NRCS).

Table 7. 2002 Animal Statistics by County for the Skillet Fork Watershed

County	Percent of County within Watershed	Number of Head in County (rounded to nearest 100)		
		Hogs & Pigs	Cattle and Calves	Any poultry - layers ≥ 20 weeks
Clay	12.25%	34,400	3,900	400
Hamilton	42.37%	24,200	4,300	100
Jefferson	21.72%	10,000	16,100	400
Marion	34.96%	8,600	11,300	(D)
Wayne	49.51%	60,000	15,900	500
White	27.41%	14,000	6,400	400

Source: 2002 Census of Agriculture
(D) – withheld to avoid disclosing data for individual farms

The green areas on Figure 5 show forested lands (approximately 16% of the watershed), which are both upland (generally oak-hickory) and floodplain (mixed composition). Also shown on the map (in red) are areas of low/medium and high-density development (approximately 1% of the watershed). These areas indicate the locations of the towns and residential communities in the watershed. Wayne City is the largest urban area in the Skillet Fork watershed.

Urbanization and Growth

Urbanization and growth are two factors that can affect the amount and quality of runoff from land surfaces and which also affect the demand on water and sewage treatment facilities. The Skillet Fork watershed encompasses portions of six counties (Clay, Hamilton, Jefferson, Marion, Wayne and White) and thirteen small communities. These communities are: Belle Prairie City, Belle River, Bluford, Dahlgren, Enfield, Iuka, Johnsonville, Keenes, Mill Shoals, Springerton, Sims, Wayne City, and Xenia. Portions of the communities of Fairfield, Kell and Burnt Prairie also lie within the watershed. The city of Wayne City is the largest urbanized area entirely within the watershed with 1,089 residents and Fairfield is the largest urbanized area partially within the watershed with 5,421 residents. (Census 2000 website, http://factfinder.census.gov/home/saff/main.html?_lang=en). Population data are shown by county in Table 8.

The State of Illinois Population Trends Report (State of Illinois, 1997) provides projected population trends by county. Illinois Population Trends (State of Illinois, 1997) predicts declining population growth in the watershed in all six counties.

Table 8. Population Summary

County	1990[1]	2000[1]	2010[2]	2020[2]	% of County in Watershed	% of Watershed in County
Clay	14,460	14,560	12,878	12,319	12.25%	5.4%
Hamilton	8,499	8,621	7,570	7,262	42.37%	17.4%
Jefferson	37,020	40,045	37,324	35,943	21.72%	11.9%
Marion	41,561	41,691	39,328	38,261	34.96%	19.0%
Wayne	17,241	17,151	16,551	16,518	49.51%	33.4%
White	16,522	15,371	14,459	13,842	27.41%	13.0%

[1]U.S. Census Bureau
[2]State of Illinois, 1997

Point Source Discharges and Septic Systems

Seventeen entities were identified that are permitted to discharge treated wastewater to Skillet Fork or its tributaries. Ten of these are municipal discharges, one is a water treatment plant, two are gas or oil company operations, two serve the Stephen A. Forbes State Park facilities, one is a rest area, and one serves a school. Figure 1 shows the locations of these discharges, and Table 9 provides a list of permittees, parameters that are discharged from these outfalls and the permit expiration date.

Two other NPDES-permitted dischargers were also identified, however, there are not data available for these two dischargers (Little Wabash Voc and New Hope Elementary School) and their permits expired in 1994 and 2001, respectively. These two dischargers are not included in the table below, because they are not thought to be currently active. However, if information showing otherwise becomes available, then they will be included in later stages of this project.

All county health departments serving the Skillet Fork watershed were contacted. Based on calls made to the county health departments, it was determined that most of the urbanized areas are served by public sewer, with areas outside municipal boundaries served primarily by private septic systems. None of the county health officials contacted were able to estimate the percent of septic systems that are failing, and many noted that they only inspect a system if a complaint is made about it. Very few complaints (1-2 per year at most) have been received by the health departments. Several county health departments mentioned that there might be straight pipes in the watershed (Marion, Jefferson/Wayne, and Egyptian (White)), however, none had an estimate of how many were in existence. None of the health departments contacted had any programs in place to test groundwater quality.

Table 9. NPDES Discharges and Parameters

NPDES ID	Facility Name	Average design flow (MGD)	Permitted to Discharge	Permit expiration date
IL0004294	Trunkline Gas Co.-Johnsonville	0.0013	BOD_5, Flow, Total Ammonia Nitrogen, pH, Total Suspended Solids (TSS)	4-30-02
IL0024643	Beaver Creek School STP	0.0125	$CBOD_5$, Flow, Total Ammonia Nitrogen, TSS	12-31-04
IL0046957	Bluford STP	0.06	BOD_5, $CBOD_5$, Flow, Total Ammonia Nitrogen, pH, TSS	11-30-05
IL0050814	Wayne City WTP		Flow, pH, TSS	2-29-04
IL0054496	Springerton STP	0.02	BOD_5, $CBOD_5$, Flow, Total Ammonia Nitrogen, pH, TSS	11-30-07
IL0068977	IL DNR-S.A. Forbes State Park	0.004	Fecal Coliform, BOD_5, $CBOD_5$, Flow, Total Ammonia Nitrogen, pH, TSS	10-31-04
IL0073903	IL DNR Stephen Forbes State Park	0.0034	Fecal Coliform, BOD_5, $CBOD_5$, Flow, Total Ammonia Nitrogen, pH, TSS	5-31-05
IL0074314	Prosise Oil Company	0.25	Flow	11-30-04
ILG580029	Xenia STP	0.055	BOD_5, $CBOD_5$, Flow, pH, TSS	12-31-07
ILG580080	Dahlgren STP	0.05	BOD_5, $CBOD_5$, Flow, pH, TSS	12-31-07
ILG580105	Enfield West STP	0.025	BOD_5, $CBOD_5$, Flow, pH, TSS	12-31-07
ILG580108	Enfield East STP	0.05	BOD_5, $CBOD_5$, Flow, pH, TSS	12-31-07
ILG580129	Belle Rive STP	0.048	BOD_5, $CBOD_5$, Flow, pH, TSS	12-31-07
ILG580146	Iuka STP	0.043	BOD_5, $CBOD_5$, Flow, pH, TSS	12-31-07
ILG580195	Mill Shoals STP	0.0382	BOD_5, $CBOD_5$, Flow, pH, TSS	12-31-07
ILG580220	Wayne City South STP	0.19	BOD_5, $CBOD_5$, Flow, pH, TSS	12-31-07
IL006889	IL DOT-I64 Jefferson Co West STD (Goshen Rd West Rest Area)	0.006	$CBOD_5$, Flow, pH, TSS, Dissolved Oxygen	2-28-09

Water intakes

There are two drinking water intakes located in the Skillet Fork watershed. Both of these are in Wayne City and are shown in Figure 1. One intake draws water from Skillet Fork and the other from the Wayne City Reservoir. It was noted by the Jefferson/Wayne and Egyptian (White Co.) Health Departments that many people have public water, even if they don't have public sewer.

Watershed Activities

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. State agencies currently active in the Skillet Fork watershed are Illinois Department of Agriculture (IDA), Illinois

Department of Natural Resources (IDNR), and the Illinois Environmental Protection Agency (IEPA). The USDA/NRCS in conjunction with the various county Soil and Water Conservation Districts offers landowners programs to cost-share for conservation plans and best management practices. These include programs such as the Conservation Reserve Program (CRP) and the Environmental Quality Incentives Program (EQIP). The following Resource Conservation & Development Councils (RC&D's) serve counties in the Skillet Fork watershed: Wabash Valley RC&D, Shawnee RC&D, and the Post Oaks Flats RC&D. Recent RC&D activities are outlined in the July 2004 Quarterly News Briefs (Illinois Association of RC&D's, 2004) and are discussed as follows. The Post Oaks Flats RC&D received federal authorization in July 2003. Since January 2004, the Post Oak Flats RC&D has held a GIS Workshop and assisted with an Energy Efficient Codes Workshop. More workshops are planned for this summer to include Marketing, Prairie Walks, Wildlife Management and Grazing Land. Post Oak Flats has also assisted several organizations with grant searches, and grant writing information. The Wabash Valley RC&D recently held a hunting workshop. One topic covered during this workshop that is relevant to this Stage 1 work was "conservation programs available to help landowners attract more wildlife to their land." The Shawnee RC&D has been focusing its efforts most recently in the Cache River watershed and not in the Skillet Fork watershed. All three of these RC&Ds may be good partners for TMDL implementation.

Volunteer programs currently active in the area include:

- RiverWatch (IDNR): Auxier Creek, Crooked Creek, and Paddy Creek are monitored
- Volunteer Lake Monitoring Program (IEPA)
- Illinois EcoWatch Network: Volunteers conduct monitoring of Horse Creek as part of the Critical Trends Assessment Program (CTAP)
- Upper Little Wabash Ecosystem Partnership

Skillet Fork (Segment CA 03) Watershed Characterization

Skillet Fork Segment CA 03 is 7.13 miles in length and its watershed is 672,425 acres in size. This segment is located within the following 10-digit HUC: 0512011506. This segment of the creek flows through forestland and open agricultural areas. It receives water from upstream sections of the Skillet Fork, as well as Sevenmile Creek and Limekiln Creek, and flows downstream to the confluence with the Little Wabash River. Segment CA 03 is located entirely within White County. The subwatershed for CA 03 is the entire Skillet Fork watershed and the previous general discussion of the project study area applies to this segment of Skillet Fork. Land cover, population and point source information was provided previously in Table 5 (land cover), Table 8 (population) and Table 9 (permitted point source dischargers). Photos are provided in Appendix B.

Skillet Fork (Segment CA 05) Watershed Characterization

Skillet Fork Segment CA 05 is 10.96 miles in length and its subwatershed is 372,134 acres in size. This segment is located within the following 10-digit HUC: 0512011506. It is in the center of the watershed, originating at the confluence of Horse Creek with the main stem Skillet Fork just upstream of Wayne City. It ends at the confluence of Dry Creek with the main stem of Skillet Fork. Other tributaries draining to this segment include Fourmile Creek and Miller Creek. This segment is entirely within Wayne County and flows through Wayne City, open agricultural areas and some forested lands. A portion of the subwatershed lies within Jefferson County. The communities of Bluford, Johnsonville, Sims and Keene are also in this subwatershed. The primary soil associations in this subwatershed are the Bluford-Ava-Hickory (57%) and Cisne-Hoyleton-Darmstadt (17%). These soil associations were described in detail previously in this report. Land cover for the Skillet Fork CA 05 subwatershed is listed in Table 10. Approximately 58% of the land is used for agriculture, and approximately 23% is forested. Point sources in this segments subwatershed include: Wayne City South STP, Wayne City WTP, Bluford STP, Trunkline Gas Co.-Johnsonville, IL DNR S. A. Forbes State Park, IL DNR Stephen Forbes State Park, Xenia STP, Iuka STP and Prosise Oil Co. Photos are provided in Appendix B.

Table 10. Land Cover in Segment CA 05 Skillet Fork Subwatershed

Land Cover	Area (acres)	Percent
Agriculture	215,582	58%
Forest	87,336	23%
Grassland	47,164	13%
Wetland	17,618	5%
Urban	2,587	1%
Water	1,660	0%
Barren	186	0%
Total	**372,134**	**100%**

Skillet Fork (Segment CA 06) Watershed Characterization

Skillet Fork Segment CA 06 is 16.63 miles in length and its subwatershed is 166,494 acres in size. This segment is located within the following 10-digit HUC: 0512011502. It is in the upper portion of the watershed, originating at the confluence of Nickolson Creek with the main stem Skillet Fork and ending at the confluence of Brush Creek with the main stem. Other tributaries draining to this segment include Turner Creek, Poplar Creek and Paintrock Creek. This segment begins in Marion County and ends in Wayne County with approximately half of the segment in each county. Portions of the subwatershed lie within Clay and Jefferson counties. The stream flows through open agricultural areas and some forested lands. The primary soil associations in this subwatershed are the Bluford-Ava-Hickory (60%) and Cisne-Hoyleton-Darmstadt (33%). These soil associations were described in detail previously in this report. Portions of the communities of Xenia and Iuka are in this subwatershed. Point sources in this segment's subwatershed include: IL DNR S. A. Forbes State Park, IL DNR Stephen Forbes State Park, Iuka STP, Xenia STP and Prosise Oil Co. Land cover for the Skillet Fork CA 06 subwatershed is listed in Table 11. Approximately 57% of the land is used for agriculture, and approximately 26% is forested.

Table 11. Land Cover in Segment CA 06 Skillet Fork Subwatershed

Land Cover Type	Area (acres)	Percent
Agriculture	94,703	57%
Forest	42,911	26%
Grassland	16,633	10%
Wetland	10,589	6%
Urban	809	0%
Water	763	0%
Barren	87	0%
Total	**166,494**	**100%**

Skillet Fork (Segment CA 09) Watershed Characterization

Skillet Fork Segment CA 09 is 19.77 miles in length and its subwatershed is 60,263 acres in size. This segment is located within the following 10-digit HUC: 0512011502. It is the most upstream segment of the main stem, originating at the headwaters and extending downstream to the confluence with Dums Creek. Other tributaries draining to this segment include Lost Fork (which includes Stephen A. Forbes Lake), Sutton Creek and Pickle Creek. This segment itself is entirely within Marion County but a portion of the subwatershed is in Clay County. The stream flows through open agricultural areas and some forested lands. The primary soil associations in this subwatershed are the Bluford-Ava-Hickory (53%) and Cisne-Hoyleton-Darmstadt (47%). These soil associations were described in detail previously in this report. There are no incorporated municipalities within the subwatershed. Land cover for the Skillet Fork CA 09 subwatershed is listed in Table 12. Approximately 64% of the land is used for agriculture, and approximately 18% is forested. Point source dischargers located within this subwatershed include: the Prosise Oil Company, IL DNR S. A. Forbes State Park, IL DNR Stephen Forbes State Park, and the Iuka STP (discharge enters the most downstream end of this segment).

Table 12. Land Cover in Segment CA 09 Skillet Fork Subwatershed

Land Cover Type	Area (acres)	Percent
Agriculture	38,668	64%
Forest	13,303	22%
Grassland	4,859	8%
Wetland	2,672	4%
Water	541	1%
Urban	192	0%
Barren	28	0%
Total	**60,263**	**100%**

Horse Creek (Segment CAN 01) Watershed Characterization

Horse Creek Segment CAN 01 is 28.21 miles in length and its subwatershed is 64,040 acres in size. This segment is located within the following 10-digit HUC: 0512011503. The entire creek length is included in the segment, which drains to Skillet Fork just upstream of Wayne City. Horse Creek has several smaller tributaries and ditches that drain to it. The larger tributaries include Panther Fork, Cold Bank Creek, and Puncheon

Creek. Portions of the segment and subwatershed are in Marion (headwaters), Jefferson (middle) and Wayne (downstream) counties. The stream flows through open agricultural areas and some forested and grass lands. Very small areas of the communities of Kell and Bluford are in the subwatershed. The primary soil associations in this subwatershed are the Grantsburg-Zanesville-Wellston (70%) and the Bluford-Ava-Hickory (14%). These soil associations were described in detail previously in this report. Land cover for the Horse Creek CAN 01 subwatershed is listed in Table 13. Approximately 41% of the land is used for agriculture, approximately 30% is forested and approximately 22% is grassland. The water in the creek was observed to be coffee-colored and very slow moving during a site visit on June 24, 2004. Deeply incised, steep stream banks and sediment islands were also observed. Also noted (by smell) during the site visit was a hog operation just north of Horse Creek. The riparian zone was heavily wooded with many trees and shrubs that shade the creek very well. The point source discharger in this watershed is the Bluford STP. A photos is provided in Appendix B.

Table 13. Land Cover in Segment CAN 01 Horse Creek Subwatershed

Land Cover Type	Area (acres)	Percent
Agriculture	26,374	41%
Forest	18,971	30%
Grassland	14,147	22%
Wetland	3,806	6%
Urban	542	1%
Water	139	0%
Barren	62	0%
Total	**64,040**	**100%**

Brush Creek (Segment CAR 01) Watershed Characterization

Brush Creek Segment CAR 01 is 21.27 miles in length and its subwatershed is 35,834 acres in size. This segment is located within the following 10-digit HUC: 0512011502. The entire creek length is included in the segment, which drains to Skillet Fork at the terminus of Skillet Fork segment CA 06. Brush Creek has several smaller tributaries and ditches that drain to it. The largest of the tributaries include Johnson Fork and Gum Branch. The outlet for Sam Dale Lake also drains to Brush Creek. The headwaters of the creek are in Clay County but the majority of the stream and subwatershed are in Wayne County. There are no incorporated municipalities within the subwatershed boundaries. The stream flows through open agricultural areas and some forested lands. The primary soil associations in this subwatershed are the Bluford-Ava-Hickory (83%) and Cisne-Hoyleton-Darmstadt (11%). These soil associations were described in detail previously in this report. Land cover for the Brush Creek CAR 01 subwatershed is listed in Table 14. Approximately 57% of the land is used for agriculture and approximately 28% is forested. There are no point source discharges located within the Brush Creek subwatershed.

Table 14. Land Cover in Segment CAR 01 Brush Creek Subwatershed

Land Cover Type	Area (acres)	Percent
Agriculture	20,361	57%
Forest	10,130	28%
Grassland	4,366	12%
Wetland	545	2%
Water	342	1%
Urban	91	0%
Barren	0	0%
Total	**35,834**	**100%**

Dums Creek (Segment CAW 01) Watershed Characterization

Dums Creek Segment CAW 01 is 25.38 miles in length and its subwatershed is 33,727 acres in size. This segment is located within the following 10-digit HUC: 0512011502. The entire creek length is included in the segment, which drains to Skillet Fork at the terminus of Skillet Fork segment CA 09 near the Highway 50 bridge. Bee Branch is the only significant tributary to Dums Creek but there are several smaller tributaries and ditches that drain to it. Dums Creek is located entirely within Marion County. The Marion County Prairie Chicken Sanctuary is located near the headwaters of the creek. The community of Iuka is the only incorporated municipality within the subwatershed boundaries. The stream flows through open agricultural areas and some forested lands. The primary soil associations in this subwatershed are the Cisne-Hoyleton-Darmstadt (51%) and the Bluford-Ava-Hickory (49%). These soil associations were described in detail previously in this report. Land cover for the Dums Creek CAW 01 subwatershed is listed in Table 15. Approximately 67% of the land is used for agriculture and approximately 18% is forested. During a site visit on June 24, 2004, much bank incision was observed at Omega Road, with many trees undercut and falling (or fallen) into the creek. This suggests that stream bank erosion is a concern. There are no point source dischargers located within this subwatershed.

Table 15. Land Cover in Segment CAW 01 Dums Creek Subwatershed

Land Cover Type	Area (acres)	Percent
Agriculture	22,634	67%
Forest	5,949	18%
Grassland	3,130	9%
Wetland	1,606	5%
Urban	332	1%
Water	53	0%
Barren	22	0%
Total	**33,727**	**100%**

Sam Dale Lake (Segment RBF) Watershed Characterization

Sam Dale Lake is located in Wayne County and is 194 acres in size. Its subwatershed is 4,342 acres in size. This segment is located within the following 10-digit HUC: 0512011502. Water enters the lake through direct drainage from the subwatershed. The outlet, at the western end of the lake, drains to a small tributary of Brush Creek. The Sam Dale Lake Conservation Area surrounds the lake and is largely forested. The primary soil associations in this subwatershed are the Bluford-Ava-Hickory (74%) and the Cisne-Hoyleton-Darmstadt (26%). These soil associations were described in detail previously in this report. A phone interview with the Conservation Area superintendent, Denny Massie, indicates that the lake is generally clear compared to the surrounding creeks. Excessive algae problems tend to occur in the Trout Pond, rather than in the lake itself. The Trout Pond is a small pond that drains through a ditch into Sam Dale Lake. Land use upstream of the conservation area is primarily cropland, corn and soybeans. The fields closest to the lake are fallow. Land use in the Sam Dale Lake watershed is shown in Table 16. There are no point source dischargers located within this subwatershed. Photos are provided in Appendix B.

Table 16. Land Cover in Segment RBF Sam Dale Lake Subwatershed

Land Cover Type	Area (acres)	Percent
Agriculture	2,573	59%
Forest	1,096	25%
Grassland	428	10%
Water	240	6%
Urban	6	0%
Wetland	0	0%
Barren	0	0%
Total	**4,342**	**100%**

Stephen A. Forbes Lake (Segment RCD) Watershed Characterization

Stephen A. Forbes Lake is located in Marion County and is 525 acres in size. This lake was completed in 1963 and has 18 miles of shoreline. Its subwatershed is 13,628 acres in size. This segment is located within the following 10-digit HUC: 0512011502. The lake is an impoundment of Lost Fork, a tributary to the Skillet Fork segment CA 09 in the upper portion of the watershed. Lost Fork and an unnamed tributary provide flow to the upper end of the lake. Several smaller tributaries, including Philips Branch, Mountain Branch and Rocky Branch, also flow to the lake. The primary soil associations in this subwatershed are the Cisne-Hoyleton-Darmstadt (51%) and the Bluford-Ava-Hickory (49%). These soil associations were described in detail previously in this report.

A comprehensive report prepared in mid-90s under the Illinois Clean Lakes Program (Illinois Department of Conservation, ca. 1993) provides valuable information on the area, including detailed information on land uses, nonpoint source loadings, and water quality problems in the lake. It should be noted, however, that a marina at the lake was recently constructed (~four years ago), and therefore was not mentioned in the Clean Lakes Study report. Furthermore, based on a call with the site superintendent, Gary Weggner, it was determined that the site superintendent’s residence has only a septic system and not a discharge that requires a permit. The report includes a Feasibility Study directed at development of a restoration plan for the lake.

The lake is the centerpiece of the Stephen A. Forbes State Recreation Area, which is currently 3,103 acres in size (including the lake area). Of this total, 1,150 acres are forests of oak and hickory (IDNR website). Based on a conversation with the site superintendent, the lake has algae blooms and the general condition is murky and unclear, especially in the upstream, shallower areas. After a period of low rainfall, the lake becomes somewhat clearer, perhaps to a Secchi depth of 3 ft.

According to the Clean Lakes Study report, topography in the lake's subwatershed is very gentle, with elevations ranging from 513 feet to 656 feet. There is little to no discharge of groundwater to the lakes or their tributaries due to the presence of impermeable loess deposits that are typically located in the upper five feet of the stratigraphic column. There are no municipalities in the lake's subwatershed. Outside of the park, land use is primarily for cropland. Land use is summarized in Table 17. Photos are provided in Appendix B.

Table 17. Land Cover in Segment RCD Stephen A. Forbes Lake Subwatershed

Land Cover Type	Area (acres)	Percent
Agriculture	8,178	60%
Forest	3,494	26%
Grassland	985	7%
Wetland	461	3%
Water	460	3%
Urban	46	0%
Barren	5	0%
Total	**13,628**	**100%**

Activities within the state park include hiking, picnicking, horseback riding, camping and hunting. The lake is used for boating, fishing and swimming. It had served as the park's potable water supply until 1989 when the city of Kinmundy began providing water to the park. The Illinois Natural History Survey maintains a station for fisheries and aquatic biology research (the Sam Parr lab) just south of the lake. At the time of publication (ca. 1993) of the Clean Lakes Program study, recreation on the lake had decreased because of siltation and excessive vegetation that have negatively impacted boating and fishing. During a site visit on June 24, 2004, it was noted that the lake was opaque and there was low usage of the marina and lake (despite good weather).

Point sources to the lake include the park's wastewater treatment facilities. There are separate systems for the park's campground (including the shower house) and the park office & visitor center, which also services the marina that is downhill from there on the lake. These are very small facilities, discharging less than 0.01 million gallons per day (see Table 9). Other buildings in the park rely on septic tanks, leaching fields and holding tanks for waste handling and/or treatment.

Nonpoint sources include runoff from agriculture and shoreline bank erosion. The authors of the Clean Lakes Study estimate that 12% of the original lake capacity has been lost due to accumulated sediment in the lake. A Feasibility Study and Lake Restoration Program was developed under the Clean Lakes Program to address the water quality issues in the lake and to improve the recreational and aesthetic qualities of the lake. However, the plan was never implemented (SA Forbes Park Superintendent-personal communication) so water quality remains an issue and the lake was listed in the IEPA's 2004 303(d) list for phosphorus.

Wayne City Side Channel Reservoir (Segment RCT) Watershed Characterization

The Wayne City Side Channel Reservoir (Wayne City SCR) is located just north of Wayne City near Skillet Fork segment CA 05 and Shoe Creek. It is an 8-acre reservoir created by diverting a portion of the flow from Skillet Fork and is used as a drinking water source for the residents of Wayne City. It is contained entirely within the subwatershed for Skillet Fork segment CA 05. This segment is located within the following 10-digit HUC: 0512011506. The reservoir does not have a subwatershed per se, since it is an artificially constructed water body surrounded by a constructed berm and thus, receives little to no runoff from direct drainage. However, since the water in the reservoir is from the portion of Skillet Fork comprising segment CA 05, the land cover for this stream segment, which is provided in Table 10, is likely to reflect potential sources affecting water quality in the reservoir. Refer to the discussion of soils and other watershed features for segment CA 05 for a description of the watershed contributing to the Wayne City Side Channel Reservoir. Photos of the reservoir are provided in Appendix B.

DATABASE DEVELOPMENT AND DATA ANALYSIS

A water quality database was developed and the data were analyzed to confirm the sufficiency of the data to support both the listing decision and the sources of impairment that are included on the draft 2004 303(d) list.

Data Sources and Methods

All readily available existing data to describe water quality in the impaired waterbodies were obtained. IEPA data included IEPA ambient water quality monitoring data, IEPA Intensive Basin Survey data, IEPA Voluntary Lake Monitoring Data, and IEPA NPDES monitoring data. Data collected by the United States Geological Survey (USGS) through their routine monitoring program were also obtained. All available and relevant data were then compiled in electronic format along with sample location and collection information, in a project database. A list of data sources is included in Appendix A.

The water quality data were analyzed to confirm the cause of impairment for each waterbody and, in combination with the watershed characterization data, an assessment was made to confirm the sufficiency of the data to support the listing decision and the sources of impairment that are included on the draft 2004 303(d) list. Data were first compiled and basic statistics for each parameter were computed. The data were then compared to relevant water quality standards based on beneficial use. Related parameters were also analyzed to understand sources of impairment (e.g., total phosphorus data were reviewed for waterbodies with dissolved oxygen impairments).

A summary of readily available water quality data for the watershed, the period of record and date ranges is presented in Table 18 below. Sampling station locations are shown in Figure 6.

Table 18. Water quality data summary for the Skillet Fork watershed.

Waterbody Segment	Parameter	Sampling Station	Period of Record (#)	Minimum	Maximum	Average
Skillet Fork CA 03	Dissolved Oxygen (mg/L)	CA 02[a]	5/2001-9/2001 (3 samples)	7.60	11.20	9.03
		CA 03	1/1994-4/2003 (80 samples)	0.80	15.90	8.13
		CAGC01[a]	7/1998-9/2001 (5 samples)	5.80	12.30	8.32
		CAJ 01[a]	7/1998-9/2001 (5 samples)	4.40	11.90	7.20
	Manganese (ug/L)	CA 02[a]	5/2001-9/2001 (3 samples)	180	390	270
		CA 03	1/1994-4/2003 (82 samples)	78	1,700	577
		CAGC01[a]	7/1998-9/2001 (5 samples)	120	620	268
		CAJ 01[a]	7/1998-9/2001 (5 samples)	120	290	192
	pH (S.U.)	CA 02[a]	5/2001-9/2001 (3 samples)	8.10	8.40	8.20
		CA 03	1/1994-4/2003 (82 samples)	6.10	8.57	7.26
		CAGC01[a]	7/1998-9/2001 (5 samples)	7.60	7.90	7.72
		CAJ 01[a]	7/1998-9/2001 (5 samples)	6.80	7.70	7.32
	Atrazine (ug/L)	CA 03	4/1998-7/2001 (5 samples)	<0.10	15.00	4.22
	Fecal coliform (cfu/100 ml)	CA 03	1/1994-9/2001 (48 samples)	<2	5,700	484
Skillet Fork CA 05	Dissolved Oxygen (mg/L)	CA 05	1/1994-6/2003 (81 samples)	3.20	12.90	7.42
		CA 07[a]	8/1998-9/2001 (6 samples)	3.80	10.40	5.37
	Manganese (ug/L)	CA 05	1/1994-6/2003 (81 samples)	97	1,600	511
		CA 07[a]	8/1998-9/2001 (6 samples)	270	980	507
	pH (S.U.)	CA 05	1/1994-6/2003 (81 samples)	6.10	8.90	7.28
		CA 07[a]	8/1998-9/2001 (6 samples)	7.00	7.40	7.15
	Atrazine (ug/L)	CA 05	4/1996-6/2001 (11 samples)	<0.10	14.00	4.82
Skillet Fork CA 06	Dissolved Oxygen (mg/L)	CA 06	1/1994-4/2003 (79 samples)	2.20	12.70	7.48
		CA 08[a]	8/1998-9/2001 (3 samples)	4.40	10.90	6.67
	Manganese (ug/L)	CA 06	1/1994-4/2003 (80 samples)	96	7,000	612
		CA 08[a]	8/1998-9/2001 (4 samples)	230	610	415

Waterbody Segment	Parameter	Sampling Station	Period of Record (#)	Minimum	Maximum	Average
	pH (S.U.)	CA 06	1/1994-4/2003 (80 samples)	6.00	8.20	7.10
		CA 08[a]	8/1998-9/2001 (4 samples)	7.10	7.70	7.30
	Atrazine (ug/L)	CA 06	4/1998-6/2001 (5 samples)	0.16	16.00	5.06
Skillet Fork CA 09	Dissolved Oxygen (mg/L)	CA 09	7/1998-7/2001 (3 samples)	2.80	12.30	6.00
Horse Creek CAN 01	Dissolved Oxygen (mg/L)	CAN 01	7/1998-7/2001 (4 samples)	3.10	12.90	6.43
	Manganese (ug/L)	CAN 01	7/1998-9/2001 (5 samples)	230	1500	552
Brush Creek CAR 01	Dissolved Oxygen (mg/L)	CAR 01	7/1998-9/2001 (5 samples)	2.30	11.90	6.62
	Manganese (ug/L)	CAR 01	7/1998-9/2001 (5 samples)	260	1,600	950
Dums Creek CAW 01	Dissolved Oxygen (mg/L)	CAW 01	8/1998-9/2001 (5 samples)	2.2	14.5	5.38
Sam Dale Lake RBF	Total Phosphorus (mg/L)	RBF-1	4/1992-10/2002 (30 samples)	0.05	1.45	0.23
		RBF-2	4/1992-10/2002 (15 samples)	0.05	0.34	0.20
		RBF-3	4/1992-10/2002 (15 samples)	0.06	0.74	0.26
Stephen A. Forbes Lake RCD	Total Phosphorus (mg/L)	RCD-1	1/1994-10/2001 (23 samples)	0.04	0.78	0.15
		RCD-2	4/1998-10/2001 (10 samples)	0.05	0.12	0.08
		RCD-3	4/1998-10/2001 (10 samples)	0.08	0.38	0.16
Wayne City Side Channel Reservoir RCT	Manganese (ug/L)	RCT-1	4/2001-10/2001 (5 samples)	120	330	196

[a] Indicates monitoring station is located upstream of assessed segment. These stations were not located within the listed segment. Data collected at these stations were used to help identify sources, but were not used in determining whether the data support the segment listing.

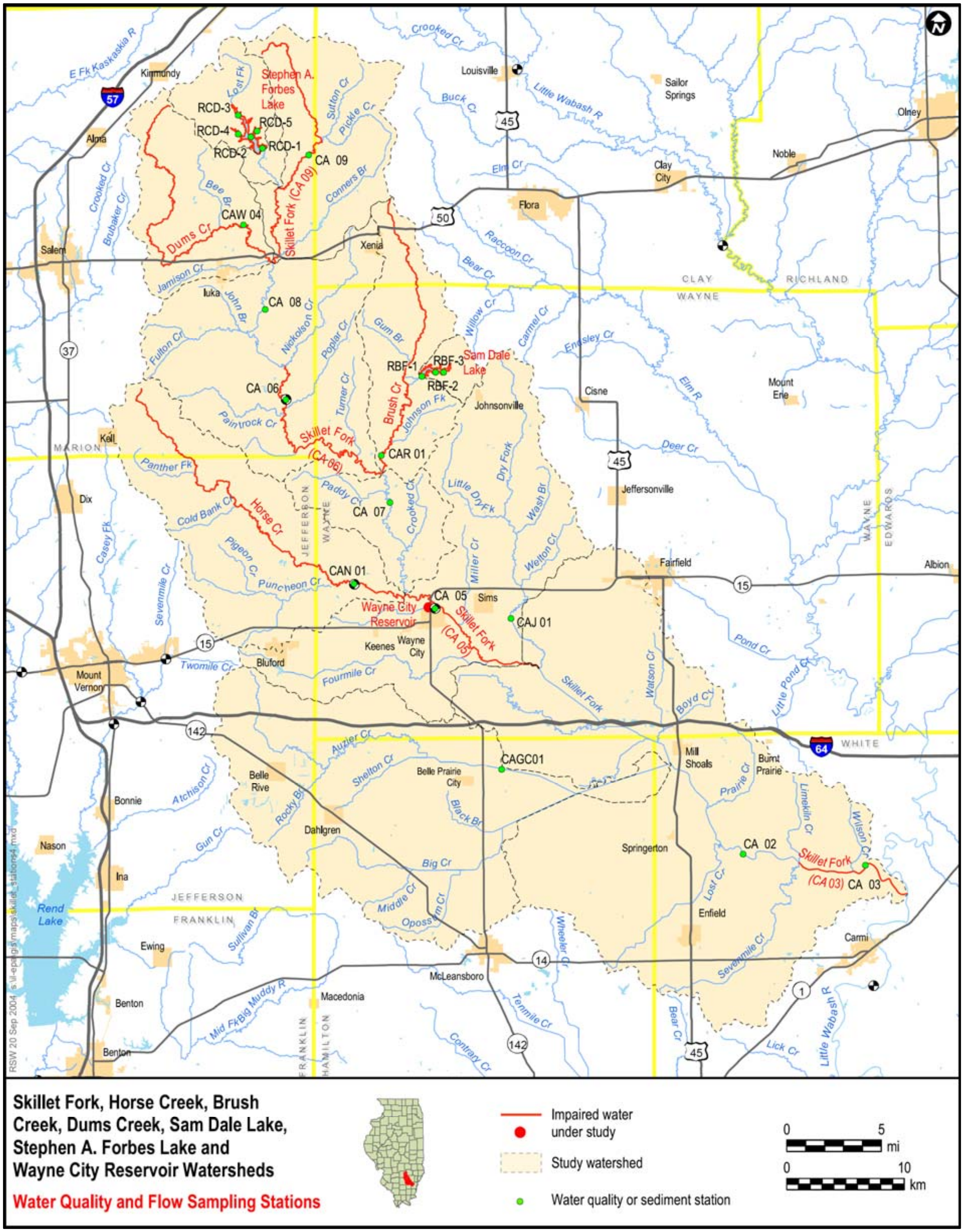

Figure 6. Sampling stations in the Skillet Fork watershed

CONFIRMATION OF CAUSES AND SOURCES OF IMPAIRMENT

Water quality data were evaluated to confirm the cause of impairment for each waterbody in the Skillet Fork watershed, and in combination with the watershed characterization data, the sufficiency of the data were assessed to support the listing decision and the sources of impairment that are included on the 2004 303(d) list. Table 19 lists the impaired waterbodies, the applicable water quality criteria, and the number of samples exceeding the criteria. Of the impairments identified in the Skillet Fork waterbodies, atrazine is the only constituent without a numeric criterion in the State's water quality standards specified in Part 302 of Title 35 in the Illinois Administrative Code (35 Ill. Adm. Code, 2002). The development of the atrazine criterion shown in Table 19 is discussed in the Illinois EPA's 2004 305(b) report as indicated in the footnote to the table. The results summarized in Table 19 are discussed by waterbody in the following sections.

Table 19. Water Quality Standards and Number of Exceedances

Sample Location/ Cause of Impairment	Applicable Illinois Nonspecific Use Designation	Water Quality Criterion[1]	Number of Samples Exceeding Criterion
Skillet Fork (CA 03)			
Manganese	General Use	1,000 ug/l	10 of 95 samples > criteria
Dissolved oxygen	General Use	5 mg/l minimum	17 of 80 samples < criteria
Fecal coliform	General Use	400 cfu/100ml in < 10% of samples Geomean < 200 cfu/100 ml	6 of 22 samples > criterion Geomean = 131 cfu/100 ml
pH	General Use	>6.5 and < 9.0 S.U.	3 of 95 samples < criteria
Atrazine	General Use	1 ug/L (avg. of 3 samples)	2 of 2 averages (3 samp/avg.) > criteria
Skillet Fork (CA 05)			
Manganese	General Use	1,000 ug/l	5 of 81 samples > criteria
	Public Water Supply	150 ug/l	34 of 36 samples > criteria
Dissolved oxygen	General Use	5 mg/l minimum	15 of 87 samples < criteria
pH	General Use	>6.5 and < 9.0 S.U.	7 of 81 samples < criteria
Atrazine	General Use	1 ug/L (avg. of 3 samples)	4 of 4 averages (3 samp/avg.) > criteria
Skillet Fork (CA 06)			
Manganese	General Use	1,000 ug/l	8 of 84 samples > criteria
Dissolved oxygen	General Use	5 mg/l minimum	19 of 82 samples < criteria
pH	General Use	>6.5 and < 9.0 S.U.	9 of 84 samples < criteria
Atrazine	General Use	1 ug/L (avg. of 3 samples)	2 of 2 averages > criteria (3 samp/avg.)
Skillet Fork (CA 09)			
Dissolved oxygen	General Use	5 mg/l minimum	2 of 3 samples < criteria

Sample Location/ Cause of Impairment	Applicable Illinois Nonspecific Use Designation	Water Quality Criterion[1]	Number of Samples Exceeding Criterion
Horse Creek (CAN 01)			
Manganese	General Use	1,000 ug/l	1 of 5 samples > criteria
Dissolved oxygen	General Use	5 mg/l minimum	2 of 4 samples < criteria
Brush Creek (CAR 01)			
Manganese	General Use	1,000 ug/L	2 of 5 samples > criteria
Dissolved oxygen	General Use	5 mg/l minimum	1 of 5 samples < criteria
Dums Creek (CAW 01)			
Dissolved oxygen	General Use	5 mg/l minimum	4 of 5 samples < criteria
Sam Dale Lake (RBF)			
Total Phosphorus	General Use	0.05 mg/l	44 of 45 surface samples > criteria
Stephen A. Forbes Lake (RCD)			
Total Phosphorus	General Use	0.05 mg/l	31 of 33 surface samples > criteria
Wayne City Side Channel Reservoir (RCT)			
Manganese	General Use	1,000 ug/l	No exceedances
	Public Water Supply	150 ug/l	2 of 5 samples > criteria

[1]Atrazine criterion is a preliminary water chemistry indicator (chronic value) derived in accordance with the procedures described in 35 Ill. Adm. Code 302.627 (2002). This value has not been peer-reviewed.

The following sections also discuss potential sources of impairments. The Illinois EPA (IEPA, 2004) defines potential sources as known or suspected activities, facilities, or conditions that may be contributing to impairment of a designated use. The impairments identified by IEPA in the 305(b) report are listed in Table 20. Potential sources identified through the Stage 1 work are summarized in Table 21. These potential sources were identified through the watershed characterization activities previously discussed and analysis of available data as described in the following section.

Table 20. Waterbody Impairment Causes and Sources (from IEPA, 2004) for the Skillet Fork Watershed.

Waterbody	Cause of impairments	Potential Sources (from 305(b) Report)
Skillet Fork (CA 03)		
	Manganese	Source unknown
	pH	Source unknown
	Dissolved oxygen	Source unknown
	Fecal coliform	Source unknown
	Atrazine	Nonirrigated crop production
Skillet Fork (CA 05)		
	Manganese	Source unknown
	pH	Source unknown
	Dissolved oxygen	Source unknown
	Atrazine	Source unknown
Skillet Fork (CA 06)		
	Manganese	Source unknown
	pH	Source unknown
	Dissolved oxygen	Source unknown
	Atrazine	Nonirrigated crop production
Skillet Fork (CA 09)		
	Dissolved oxygen	Source unknown
Horse Creek (CAN 01)		
	Manganese	Source unknown
	Dissolved oxygen	Intensive animal feeding operations
Brush Creek (CAR 01)		
	Manganese	Source unknown
	Dissolved oxygen	Intensive animal feeding operations
Dums Creek (CAW 04)		
	Dissolved oxygen	Grazing related sources; Pasture grazing-riparian and/or upland; Intensive animal feeding operations
Sam Dale Lake (RBF)		
	Phosphorus	Agriculture; Crop-related sources; Non-irrigated crop production; Habitat modification; Streambank mod/destabilization
Lake Stephen A. Forbes (RCD)		
	Phosphorus	Agriculture; Crop-related sources; Non-irrigated crop production; Habitat modification; Streambank mod/destabilization; Recreation and tourism activities; Forest/grassland/ parkland
Wayne City SCR (RCT)		
	Manganese	Agriculture; Crop-related sources; Non-irrigated crop production; Source unknown

Table 21. Other Impairment Causes and Sources in the Impaired Skillet Fork Waterbody Segments.

Waterbody	Cause of impairments	Potential Sources
Skillet Fork (CA 03)		
	Manganese	Natural background sources, oil well brine, streambank erosion
	pH	Natural background sources
	Dissolved oxygen	Algal respiration, sediment oxygen demand, degradation of CBOD, nitrification of ammonia (lesser extent), municipal point sources, failing septic systems, agricultural runoff, intensive animal feeding operations
	Fecal coliform	Municipal point sources, agricultural runoff, failing septic systems, intensive animal feeding operations
	Atrazine	Nonirrigated crop production
Skillet Fork (CA 05)		
	Manganese	Natural background sources, oil well brine, streambank erosion
	pH	Natural background sources
	Dissolved oxygen	Sediment oxygen demand, degradation of CBOD, municipal point sources, failing septic systems, agricultural runoff, intensive animal feeding operations
	Atrazine	Nonirrigated crop production
Skillet Fork (CA 06)		
	Manganese	Natural background sources, oil well brine, streambank erosion
	pH	Natural background sources
	Dissolved oxygen	Algal respiration, sediment oxygen demand, degradation of CBOD, nitrification of ammonia (lesser extent), municipal point sources, failing septic systems, agricultural runoff, intensive animal feeding operations
	Atrazine	Nonirrigated crop production
Skillet Fork (CA 09)		
	Dissolved oxygen	Algal respiration, sediment oxygen demand, degradation of CBOD, nitrification of ammonia, agricultural runoff, runoff from livestock operations, failing septic systems (lesser extent)
Horse Creek (CAN 01)		
	Manganese	Natural background sources, oil well brine, streambank erosion
	Dissolved oxygen	Algal respiration, sediment oxygen demand, degradation of CBOD, nitrification of ammonia, failing septic systems (lesser extent), agricultural runoff, municipal point source, intensive animal feeding operation

Waterbody	Cause of impairments	Potential Sources
Brush Creek (CAR 01)		
	Manganese	Natural background sources, oil well brine, streambank erosion
	Dissolved oxygen	Algal respiration, sediment oxygen demand, degradation of CBOD, nitrification of ammonia, agricultural runoff, runoff from livestock operations, failing septic systems (lesser extent)
Dums Creek (CAW 04)		
	Dissolved oxygen	Algal respiration, sediment oxygen demand, degradation of CBOD, nitrification of ammonia, agricultural runoff, runoff from livestock operations, failing septic systems (lesser extent)
Sam Dale Lake (RBF)		
	Phosphorus	Agricultural runoff, sediment phosphorus release during seasonal hypolimnetic anoxia, failing septic systems
Lake Stephen A. Forbes (RCD)		
	Phosphorus	Agricultural runoff, sediment phosphorus release during seasonal hypolimnetic anoxia, failing septic systems
Wayne City SCR (RCT)		
	Manganese	Natural background sources, sediment manganese release during seasonal hypolimnetic anoxia

Skillet Fork (Segment CA 03)

Listed for: Dissolved Oxygen, Manganese, Fecal Coliform, pH and Atrazine

Dissolved oxygen, fecal coliform, and manganese data were collected at one station (CA03) in the impaired segment and at one station (CA02) just upstream of the impaired segment. Almost all of the data were collected at station CA03, which is routinely monitored by the IEPA as part of their Ambient Water Quality Monitoring Program. These data were collected between 1994 and 2003, as shown in Table 18. Data at station CA02 are only available for the summer of 2001. Additional data are available at stations CAJ 01 and CAGC01 for two of the tributaries draining to Skillet Fork upstream of the impaired segment. These data are summarized in Table 18 but will be used primarily in the modeling portion of the TMDL development and so are not discussed in this report in detail.

Dissolved Oxygen

The IEPA guidelines (IEPA, 2004a) for identifying dissolved oxygen as a cause of impairment in streams state that the aquatic life use is not supported if there is at least one excursion of the applicable standard (5.0 mg/L) or known fish kill resulting from dissolved oxygen depletion. For the available data, 17 of 80 (21%) dissolved oxygen measurements were below the general use water quality criterion of 5 mg/L. Excursions ranged from 0.4 to 4.2 mg/L below the criterion and have occurred throughout the sampling record, with the most recent occurrence in 2003. There were no excursions of the water quality criterion in the three measurements at station CA02. The data compared to the general use criterion are shown in Figure 7. These data are considered representative of water quality in this segment, as the sampling station is located near the middle of the listed segment. Therefore the data are sufficient to support the listing of this segment of Skillet Fork for dissolved oxygen on the draft 2004 303(d) list.

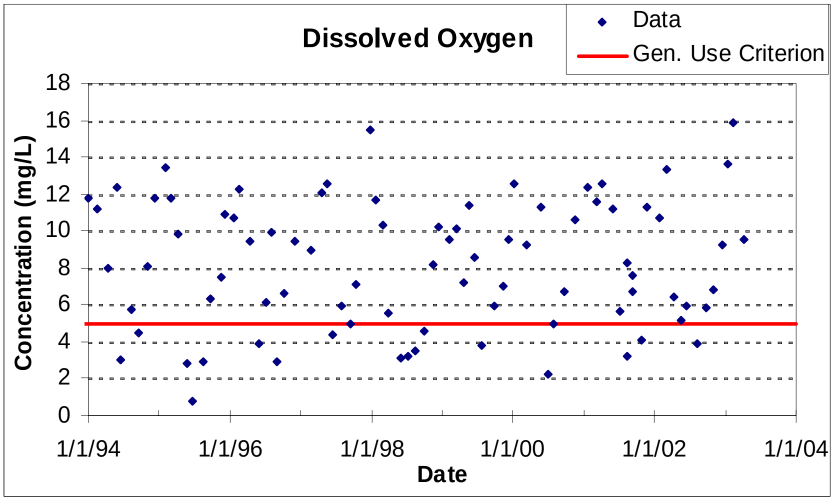

Figure 7. Skillet Fork (CA03) Dissolved Oxygen Data Compared to General Use Criterion

All but three of the excursions occurred between June and September, when water temperature was above 20°C. Two of the remaining excursions occurred in May and the other excursion occurred in October. The amount of dissolved oxygen that the stream is capable of maintaining under normal conditions decreases as the water temperature increases. Low flows in late summer months may exacerbate the low dissolved oxygen concentrations in this segment by reducing the velocity (e.g. turbulence) of the water, which reduces the amount of oxygen exchanged with the atmosphere. However, in-stream dissolved oxygen should meet the water quality criterion under unimpaired conditions, even at low stream velocities and temperatures above 20°C.

Typical causes of low dissolved oxygen include sediment oxygen demand (SOD), degradation of carbonaceous biochemical oxygen demand (CBOD), nitrification of ammonia and/or algal photosynthesis and respiration. These may all contribute to low dissolved oxygen in Skillet Fork. Most of the main stem of Skillet Fork is impaired for dissolved oxygen (as shown in Figure 1). Although not listed, it is highly likely that the segment just upstream of CA 03 also has occurrences of low dissolved oxygen but there were insufficient data to adequately characterize conditions in this segment.

Ammonia data were also collected on 13 of the 17 days when the dissolved oxygen concentration was below the water quality criterion. Ammonia concentrations on these days ranged from 0.09 mg/L to 0.76 mg/L. On the two days that the ammonia concentration exceeded 0.50 mg/L, the dissolved oxygen concentration was less than the criterion. However, there were many days when the ammonia concentration was between 0.09 mg/L and 0.50 mg/L and the dissolved oxygen concentration was greater than the criterion, suggesting that there are other factors besides ammonia that are contributing to the low observed dissolved oxygen. Data were not available to explore the relationship between dissolved oxygen and carbonaceous biochemical oxygen demand (CBOD), and dissolved oxygen and chlorophyll in this segment.

Although the monitoring data are insufficient to identify whether SOD, CBOD and/or chlorophyll are contributing to low dissolved oxygen, several potential sources of ammonia, nutrients, and biochemical oxygen demand were identified through a review of the watershed characterization discussion. Recall that the land use in this watershed is predominantly agricultural (65%), forest (16%) and grassland (12%). 1% of the watershed area is developed (~7,400 acres). Potential sources include fifteen municipal point sources, failing private sewage disposal systems (septic and surface discharge systems), runoff from agricultural lands and from pastureland with livestock as well as intensive animal feeding operations.

Manganese

The IEPA guidelines (IEPA, 2004a) for identifying manganese as a cause of impairment in streams state that the aquatic life use is not supported if there is at least one exceedance of applicable acute or chronic standards. For the available data at CA03, 10 of 95 manganese measurements exceeded the general use criterion. Exceedances ranged from 200 to 700 ug/l over the criterion, and these have occurred throughout the sampling record. These data are considered representative of water quality in this segment, both temporally and spatially, and therefore the data are sufficient to support the listing of this segment of Skillet Fork for manganese on the draft 2004 303(d) list.

Manganese is a naturally occurring element that is a component of over 100 minerals. Of the heavy metals, it is surpassed in abundance only by iron (Agency for Toxic Substances and Disease Registry (ATSDR) 1997). Because of the natural release of manganese into the environment by the weathering of manganese-rich rocks and sediments, manganese occurs ubiquitously at low levels in soil, water, air, and food (USEPA, 2003).

As described previously in the Watershed Characterization portion of this report, many of the soils in the Skillet Fork watershed contain naturally-occurring manganese concretions or accumulations and most soils in the watershed are also acidic (pH < 6.6). The low pH could result in the manganese moving into solution and being transported through baseflow and/or runoff. A data analysis found that dissolved manganese accounts for approximately 60% of the total manganese. Streambank erosion of manganese-containing soils has been documented upstream on the main stem of the Skillet Fork and its tributaries and is also a likely source of manganese in the creek. Another potential source of manganese are oil well operations. The Skillet Fork watershed has over 200 active oil wells. In the past, the process of extracting the oil included pumping out brine water, which is typically high in manganese, and dumping it on the surface or storing it in lagoons that drained to surface waters. Though not as common as in the past, dumping this saltwater into ditches during wet weather still occurs (White County SWCD) and thus, oil well operations may also be a source of manganese.

The observed levels of manganese are likely due to the natural geochemical environment and most likely reflect natural background conditions. For this reason, the general use standard may be difficult to attain. Manganese does not present any human health hazards, but may be responsible for offensive tastes and appearances in drinking water, as well as staining laundry and fixtures.

Fecal Coliform

The IEPA guidelines (IEPA, 2006) for identifying fecal coliform as a cause of impairment in streams state that fecal coliform is a potential cause of impairment of the primary contact use if the geometric mean of all samples collected during May through October (minimum five samples) is greater than 200/100 ml, or if greater than 10% of all samples exceed 400/100 ml. Between January 1994 and September 2001, 48 fecal coliform measurements were collected. Of these samples, 22 were collected between May and October. 6 of these 22 samples (27%) were greater than 400 cfu/100 ml. The geometric mean of the samples from this data set is 131 cfu/100 ml). These data are considered representative of water quality in this segment, and the data are considered sufficient to support the listing of this segment of Skillet Fork for fecal

High fecal coliform counts are not limited to this segment of Skillet Fork. Approximately 35% of the fecal data in upstream segment CA 05 and 39% of the fecal data in upstream segment CA 06 collected between May and October exceeded the 400 cfu/100 ml criterion. These data suggest that there are sources of bacteria upstream of segment CA 03. Table 22 presents a comparison of the fecal data in segment CA 03 and in upstream segments.

Table 22. Comparison of Fecal coliform Data in the Skillet Fork Mainstem

Station	Period of Record	Max. Fecal Concentration (cfu/100 ml)	Count of Fecal Data	% of May-Oct samples > 400 cfu/100 ml
CA 03	1994-2001	5,700	48	27%
CA 05	1994-2004	14,200	63	36%
CA 06	1994-2004	30,800	59	39%

A comparison with total suspended solids (TSS) data indicates a positive relationship between fecal coliform and TSS (see Figure 8), suggesting there may be wet weather sources of fecal coliform, including runoff from agricultural operations. As noted in Table 7, the 2002 Census of Agriculture indicates there are several thousand livestock head in the counties comprising the Skillet Fork watershed, including in the vicinity of this segment of Skillet Fork and upstream in the watershed. Several hog confined animal feeding operations (CAFOs) are located in White County (White County FSA). Potential sources include nonpoint sources such as farms with livestock and intensive agricultural livestock operations. In addition, there are twelve sewage treatment operations (STPs) that treat fecal coliform in the watershed upstream of the Segment CA 03 sampling stations (see Table 9). Only two of these STPs have a permit limit specified for fecal coliform but all are potential sources. Another potential source of fecal coliform is failing septic systems. As discussed previously, most developed areas located outside municipal boundaries are served by septic systems. Although estimates of failing systems and straight pipes were not readily available, failing systems are a potential source of bacteria. Fecal coliform concentrations in failed septic systems range from 10,000 to 1,000,000 cfu/100 mL (Center for Watershed Protection, 1999).

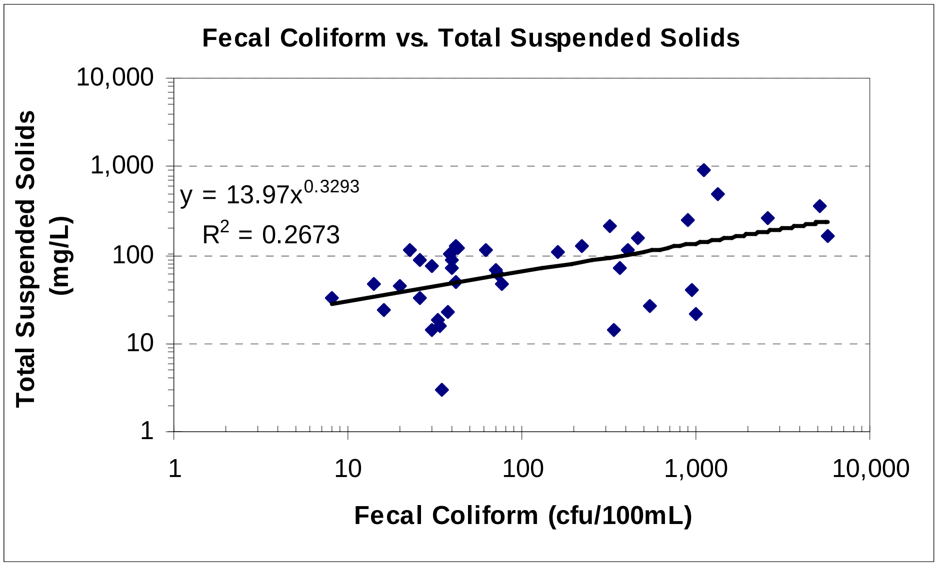

Figure 8. Relationship between Fecal Coliform and Total Suspended Solids in Segment CA 03

pH

The IEPA guidelines (IEPA, 2004a) for identifying pH as a cause of impairment in streams state that the general use is not supported if there is at least one exceedance of the applicable standards (greater than 6.5 and less than 9.0 S.U.). Three of the 95 samples measured at CA03 between 1994 and 2003 were less than the 6.5 criterion. Excursions ranged from 0.1 to 0.4 S.U. below the criterion and have occurred throughout the sampling record, with the most recent occurrence in 2000. The data compared to the general use criterion are shown in Figure 9. Excursions occurred at all times of the year (summer, winter and spring). These data are considered representative of water quality in this segment and are considered sufficient to support the listing of this segment of Skillet Fork for pH on the draft 2004 303(d) list.

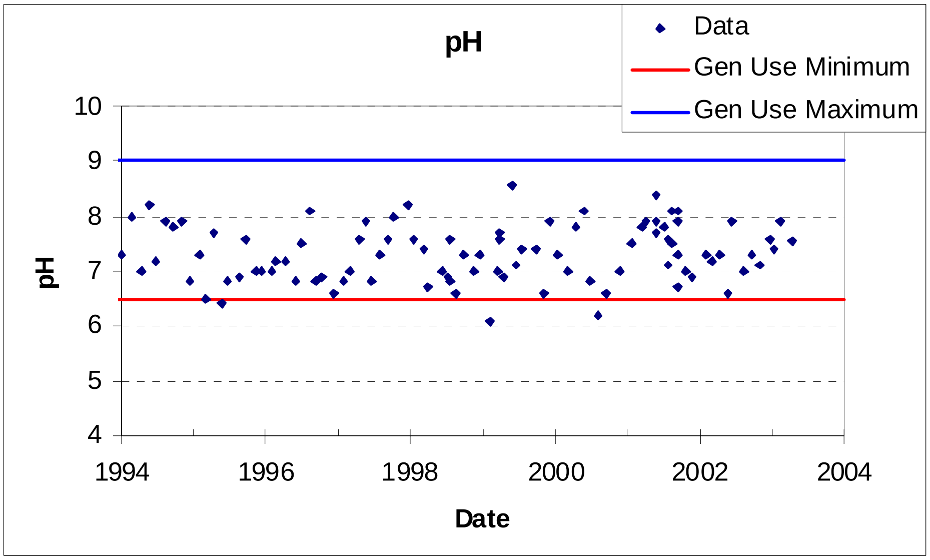

Figure 9. Skillet Fork (CA03) pH Data Compared to General Use Criterion.

Relationships between pH and other parameters were examined and there does not appear to be a direct relationship between pH and dissolved oxygen, flow, total nitrogen, nitrate + nitrite, ammonia, dissolved phosphorus or total phosphorus. The relationship between pH and nutrients was examined because the respiration of algae can be a source of low pH. When algae grow, they consume carbon dioxide and raise the pH. When the algae respire, they release carbon dioxide and lower the pH. Because there are only infrequent violations of pH below 6.5 and because there aren't corresponding periods where the pH is significantly higher, it is not suspected that the algae are causing the pH violations. Potential reasons for the three low pH values were not clear from the data.

One potential source contributing to the low observed instream pH is the acidic nature of the soils in this watershed. As described in the Geology and Soils portion of the Watershed Characterization, all of the soils in the watershed have acidic properties, though the severity of their acidic nature varies by soil group association.

Although coal mining was conducted in the Auxier Ditch watershed, just upstream of this segment of Skillet Fork, these activities ended approximately 30 years ago. On-going acid mine drainage from abandoned mines has the potential to alter the pH in receiving waters. However, Auxier Ditch itself is not listed as impaired for pH and therefore, it is unlikely that pH excursions further downstream would be due to this source. Nevertheless, the data support the listing of this segment on the 303(d) list for this parameter. However, additional data/reconnaissance is needed to better identify potential sources in the watershed.

Atrazine

The IEPA guidelines (IEPA, 2004a) for identifying atrazine as a cause of impairment in streams state that the aquatic life use is not supported if there is at least one exceedance of the applicable guideline (1.0 ug/L) in the average of three samples. There were three samples collected during the summer of 1998 and during the summer of 2001 at station CA03. Since each year had at least three atrazine measurements, an average concentration for each year was calculated and compared to the criterion. The average concentration in each year was greater than the criterion (1998 average = 5.5 ug/L, 2001 average = 1.6 ug/L). The data are limited but consistent and support the listing for this cause and the sources.

Atrazine is used as an herbicide, primarily for corn, to control grass and broadleaf weeds. It is usually applied to fields by tank just before or just after corn has emerged (Illinois Department of Public Health). According to several county Farm Service Agency (FSA) personnel interviewed for the watershed characterization, application can extend into June (White County FSA, Hamilton County FSA). The highest concentration in this segment was observed in June (1998). Several studies have indicated that atrazine causes hermaphroditic effects in frogs (Proceedings, National Academy of Science, 2002). There are several pathways that atrazine can be transported from a field to a stream, including surface runoff (transport of the soil particles from the field to the river during a rain event), and migration to groundwater and subsequent outflow to a receiving water. In addition, atrazine transport from the corn fields to the surface waters may be accelerated by the use of tile drains, particularly in the lowland areas of the watershed.

Skillet Fork (Segment CA 05)

Listed for: Dissolved Oxygen, Manganese, pH, and Atrazine

Dissolved oxygen, manganese and pH data were measured approximately once per month from 1994-2003 at station CA05 (Table 18), which is located in the center of segment CA 05. This station is routinely monitored by the IEPA as part of their Ambient Water Quality Monitoring Program. These parameters were monitored less frequently at station CA07, which is in the segment of Skillet Fork immediately upstream of segment CA 05. Atrazine was collected in CA 05 once per month in April, May and June between 1996 and 1998 and in 2001. Atrazine has not been monitored at station CA07.

Dissolved Oxygen

Dissolved oxygen data collected in this segment are compared to the general use water quality criterion in Figure 10. Fifteen of the 87 measurements are below the general use criterion of 5 mg/l. Eleven excursions were measured at station CA05 and four were measured at station CA07. Excursions ranged from 0.1 to 1.8 mg/L below the 5 mg/L criterion. As stated previously, one excursion of the dissolved oxygen criterion is sufficient to list dissolved oxygen as a cause for impairment of the aquatic life use (IEPA, 2004a). Therefore, the data support the listing of this segment on the draft 2004 303(d) list for dissolved oxygen.

High ammonia concentrations (> 0.50 mg/L) in this segment are associated with both high and low dissolved oxygen concentrations, though none of the DO measurements are below the criterion. Ammonia nitrification does not appear to have a significant effect on dissolved oxygen. Chlorophyll has been measured in this segment since 2001 and concentrations range from 5 to 55 ug/L. There are 17 days since 2001 that chlorophyll a and dissolved oxygen were both measured at station CA05. There does not appear to be a relationship between algae (as indicated by chlorophyll concentration) and dissolved oxygen, suggesting the respiration of algae is also not a significant cause of dissolved oxygen depletion in this segment.

DO is inversely related to water temperature and thirteen of the fifteen excursions occurred when the temperature was greater than 20°C. As shown in Figure 11, a comparison of DO excursions to the flow in the segment (also measured at station CA05) indicated that excursions occurred over a wide range of flows (0.2 cfs to 933 cfs). However, nine of the fifteen excursions occurred when the flow was less than 10 cfs. As shown in Figure 4, 70% of the historical flows are greater than 10 cfs. The water temperature was greater than 20°C on seven of the nine days where the flow was less than 10 cfs and the dissolved oxygen was less than 5 mg/L. This combination of high temperature and low flow appears to reduce the assimilative capacity of the stream for oxygen-demanding loads from the potential sources described in the next paragraph.

Recall that land use in this watershed is predominantly agricultural (58%), forest (23%) and grassland (13%). Only 1% (2,587 acres) of the watershed is developed. Based on the site characterization and available data, potential sources contributing to low dissolved oxygen in this segment include point sources (8), runoff from agricultural areas, livestock operations, failing septic systems, sediment oxygen demand, and CBOD degradation. Additional data collection will be needed to confirm any potential sources.

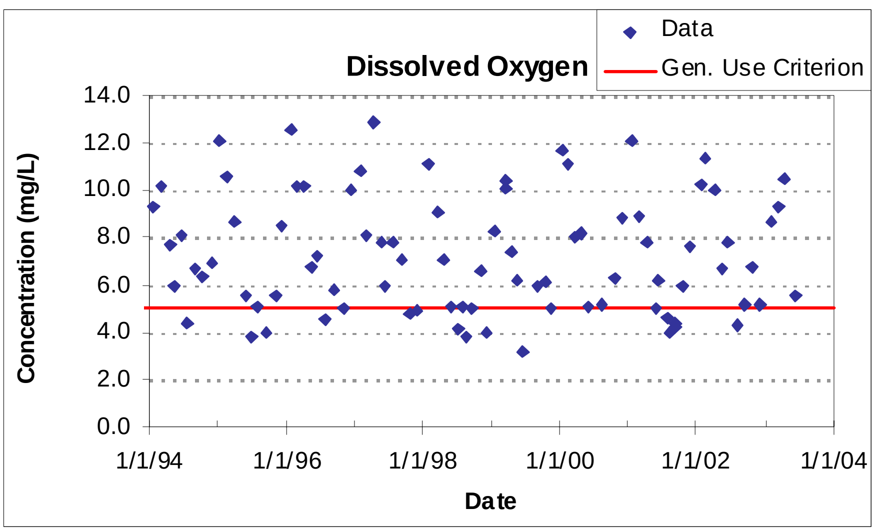

Figure 10. Skillet Fork (CA05 and CA07) Dissolved Oxygen Data Compared to General Use Criterion

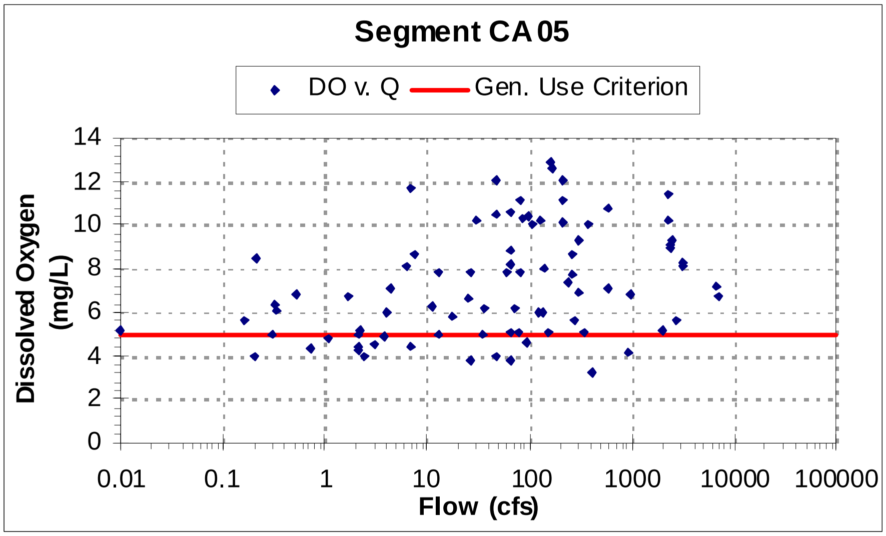

Figure 11. Skillet Fork (CA05 and CA07) Dissolved Oxygen Relationship to Flow

Manganese

81 measurements are available for manganese for Segment CA 05 of Skillet Fork. Five of the 81 samples exceed the general use criterion of 1,000 ug/L by 100-600 ug/L. An additional six manganese results are available at station CA07, in the reach just upstream of segment CA 05. None of these measurements exceeded the general use criterion.

This segment of Skillet Fork is used as a public water supply so the more restrictive public water supply criterion is applicable to this segment. This guideline indicates impairment if more than 10% of the observations measured since 1999 exceed 150 ug/L. At both monitoring locations (CA05 and CA07), more than 10% of the observations exceeded the numeric criterion. At station CA05, 34 of the 36 observations (94%) were greater than 150 ug/L. At station CA07, all five observations (100%) made since 1999 were greater than the criterion.

Because the IEPA guidelines state that one exceedance of the manganese criterion is sufficient to identify manganese as a cause of impairment, the data are considered sufficient to support manganese being listed on the draft 2004 303(d) list.

A discussion of background sources of manganese is provided above under Segment CA 03 of Skillet Fork. As manganese is ubiquitous in this region, the general use and public water supply standards may be difficult to obtain.

pH

81 measurements are available for pH for Segment CA 05 of Skillet Fork. Seven of the 81 samples do not comply with the general use lower limit criterion of 6.5 S. U. by 0.1-0.4 S.U. An additional six pH results are available at station CA07, in the reach just upstream of segment CA 05. None of these measurements exceeded the general use criteria. The comparison of these data to the pH general use criteria is shown in Figure 12. The most recent excursion occurred in May 2002. Because the IEPA guidelines state

that one excursion of either pH criterion is sufficient to identify pH as a cause of impairment, the data are considered sufficient to support the listing of this segment of Skillet Fork for pH on the draft 2004 303(d) list.

Excursions were observed during all seasons suggesting that pH does not show a seasonal correlation. As with Segment CA 03, relationships between pH and other parameters were examined, particularly nutrients because the respiration of algae can be a source of low pH. There does not appear to be a direct relationship between pH and dissolved oxygen, flow, total nitrogen, nitrate+nitrite, ammonia, dissolved phosphorus or total phosphorus. As with Segment CA 03, reasons for the low pH values in this segment were not clear from the data. Additional discussion of potential sources of pH is provided above under Segment CA 03 of Skillet Fork.

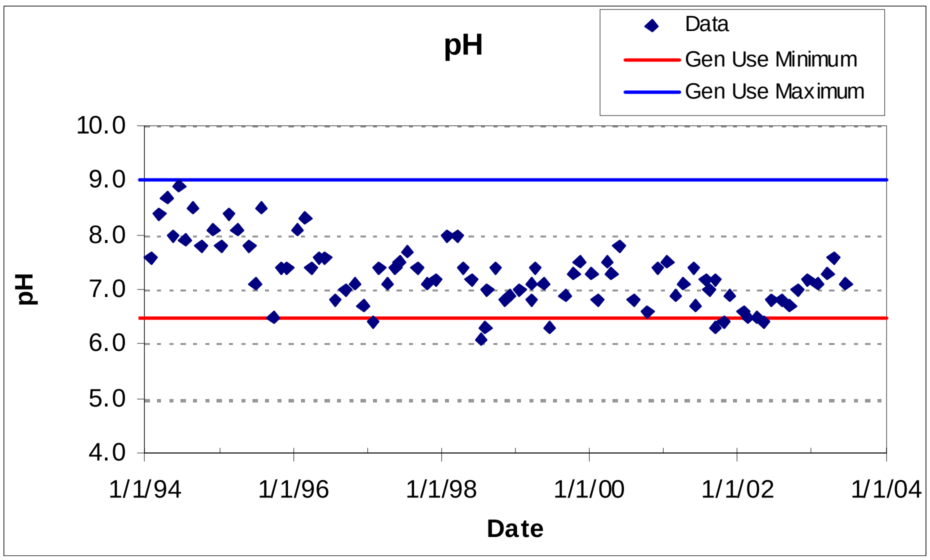

Figure 12. Skillet Fork (CA05) pH Data Compared to General Use Criterion.

Atrazine

The IEPA guidelines (IEPA, 2004a) for identifying atrazine as a cause in streams state that the aquatic life use is not supported if there is at least one exceedance of the applicable guideline (1.0 ug/L) in the average of three samples. There were three samples collected during each spring between 1996 through 1998 and in 2001 at station CA05. The average for each year was calculated and compared to the criterion. The average concentration in each year was greater than the criterion as shown in Table 23.

Table 23. Average Spring Atrazine Concentrations in Skillet Fork (CA05)

Year	Number of Measurements	IEPA 305(b) Criterion[1] (ug/L)	Average Concentration (ug/L)	Minimum Concentration (ug/L)	Maximum Concentration (ug/L)
1996	3	1.0	4.6	0.2	10.0
1997	3	1.0	5.0	0.9	10.0
1998	3	1.0	5.2	0.1	14.0
2001	3	1.0	2.9	0.3	7.5

[1] Criterion is applicable to the average concentration calculated from at least 3 measurements.

As with segment CA03, the data are limited but consistent and support the listing for this cause and sources. A discussion of the potential sources is presented in the discussion for segment CA 03.

Fecal Coliform

As discussed in the Fecal coliform section of segment CA 03 data analysis, segment CA 05 is not listed for fecal coliform, but data collected in this reach suggest that fecal coliform may be a cause of impairment in this and downstream reaches, such as CA 03, that are listed for fecal coliform. See the discussion for Segment CA 03 for more details.

Skillet Fork (Segment CA 06)

Listed for: Dissolved Oxygen, Manganese, pH, and Atrazine

Dissolved oxygen, manganese and pH were measured approximately once per month from 1994-2003 at station CA06 (Table 18), which is located near the upstream boundary of Segment CA 06. This station is routinely monitored by the IEPA as part of their Ambient Water Quality Monitoring Program. These parameters were monitored less frequently at station CA08, which is in the segment of Skillet Fork immediately upstream of segment CA 06. Atrazine was collected in CA 06 once per month in April, May and June in 1998 and in 2001. Atrazine has not been monitored at station CA08.

Dissolved Oxygen

Dissolved oxygen data collected in this segment are compared to the general use water quality criterion in Figure 13. 19 of the 82 measurements are below the general use criterion of 5 mg/l. 17 excursions were measured at station CA06 and two were measured at station CA08. Excursions ranged from 0.1 to 2.8 mg/L below the 5 mg/L criterion. The most recent excursion occurred in 2002. As stated previously, one excursion of the dissolved oxygen criterion is sufficient to list dissolved oxygen as a cause for impairment of the aquatic life use (IEPA, 2004a). Therefore, the data support the listing of this segment on the draft 2004 303(d) list for dissolved oxygen.

Typical causes of low dissolved oxygen include sediment oxygen demand (SOD), degradation of carbonaceous biochemical oxygen demand (CBOD), nitrification of ammonia and/or algal photosynthesis and respiration. CBOD and chlorophyll data are too limited to draw conclusions about their effect on dissolved oxygen. There were no SOD measurements available. There were 65 days when both ammonia and dissolved oxygen were measured but there is not a clearly defined relationship between the two parameters. The data, therefore, do not indicate whether ammonia nitrification is a significant source of dissolved oxygen depletion in this segment.

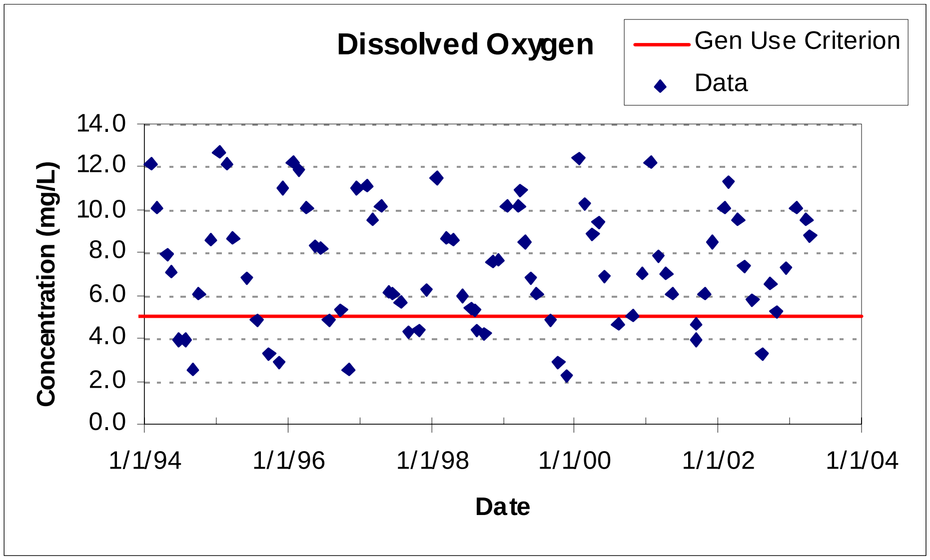

Figure 13. Skillet Fork (CA06 and CA08) Dissolved Oxygen Data Compared to General Use Criterion

As with the other Skillet Fork segments and consistent with dissolved oxygen kinetics in general, dissolved oxygen is clearly inversely related to water temperature. Although excursions occurred over a range of temperatures (6.1°C to 27°C), most of them (12 out of 19) occurred when the temperature was greater than 20°C. A comparison of DO excursions to the flow in the river (measured downstream of this segment) is shown in Figure 14, illustrating that excursions occurred over a wide range of flows (0.2 cfs to 316 cfs). However, fourteen of the nineteen excursions occurred when the flow was less than 10 cfs. As shown in Figure 4, 70% of the historical flows are greater than 10 cfs. On all of the days (9) where the water temperature was greater than 20°C and the flow was less than 10 cfs, the dissolved oxygen concentration in this segment was less than 5 mg/L. This combination of high temperature and low flow appears to reduce the assimilative capacity of the stream for oxygen-demanding loads from the potential sources in the next paragraph.

Although the data are not sufficient to determine whether low dissolved oxygen is being caused by sediment oxygen demand, CBOD degradation or algal respiration, these are typical causes contributing to low dissolved oxygen. Data were available to investigate the effect of ammonia nitrification on dissolved oxygen depletion and it does not appear to be a significant cause. Potential sources that may be generating CBOD, nutrients or ammonia include: point sources (5), runoff from agricultural areas, livestock operations, and failing septic systems. Recall that this watershed is very rural, with the primary land uses being agricultural (57%), forest (26%) and grassland (10%). Only 809 acres are developed (<1%). Additional data collection will be needed to confirm any potential sources.

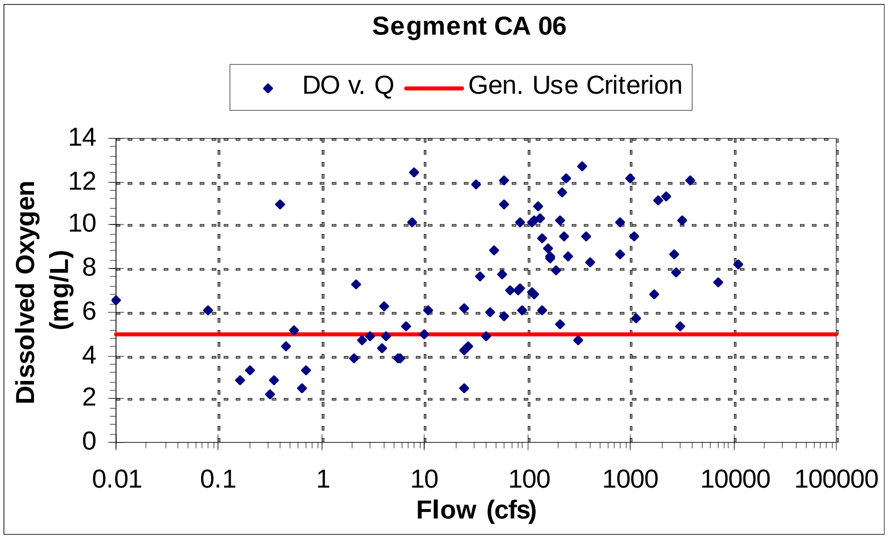

Figure 14. Skillet Fork (CA05 and CA07) Dissolved Oxygen Relationship to Flow

Manganese

80 measurements are available for manganese for Segment CA 06 of Skillet Fork for the period between 1994 and 2003. Eight of these 81 observations exceed the general use criterion of 1,000 ug/L by 200-6,000 ug/L. The most recent excursion occurred in 2002. Four manganese results are available at station CA08, in the reach just upstream of segment CA 06. None of these measurements exceeded the general use criterion. Because the IEPA guidelines state that one exceedance of the manganese criterion is sufficient to identify manganese as a cause of impairment, the data are considered sufficient to support manganese being listed on the draft 2004 303(d) list.

A discussion of background sources of manganese is provided above under Segment CA 03 of Skillet Fork. As manganese is ubiquitous in this region, the general use standard may be difficult to obtain.

pH

80 measurements are available for pH for Segment CA 06 of Skillet Fork. Nine of the 80 observations exceed the general use lower limit criterion of 6.5 S. U. by 0.1-0.5 S.U. Four pH results are available at station CA08, in the reach just upstream of segment CA 06. None of these measurements exceeded the general use criteria. The comparison of these data to the pH general use criteria is shown in Figure 15. The most recent excursion occurred in May 2002. Because the IEPA guidelines state that one excursion of either pH criterion is sufficient to identify pH as a cause of impairment, the data are considered sufficient to support the listing of this segment of Skillet Fork for pH on the draft 2004 303(d) list.

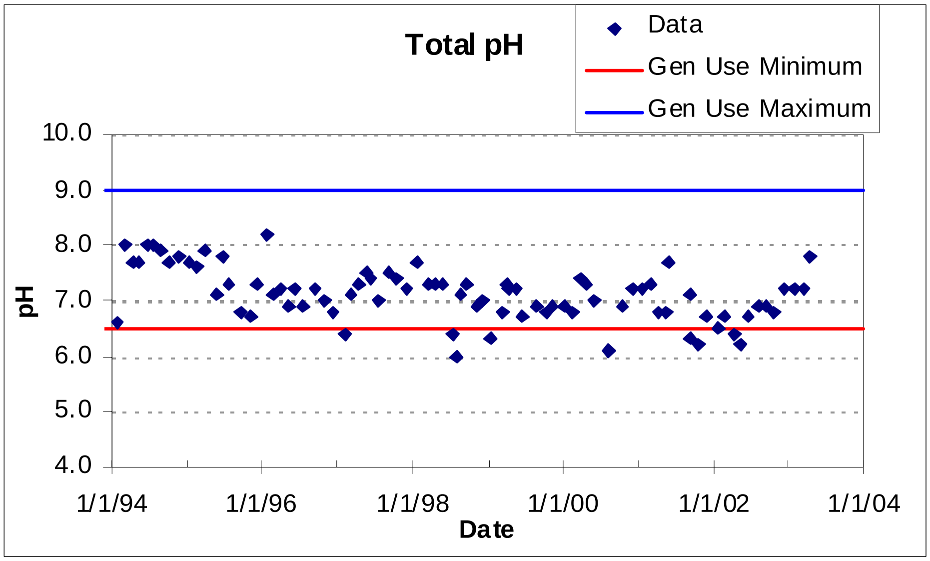

Figure 15. Skillet Fork (CA 06) pH Data Compared to General Use Criterion.

Excursions were observed during all seasons suggesting that pH does not show a seasonal correlation. As with the other Skillet Fork segments impaired by pH, relationships between pH and other parameters were examined, particularly nutrients because the respiration of algae can be a source of low pH. There does not appear to be a direct relationship between pH and dissolved oxygen, flow, total nitrogen, nitrate+nitrite, ammonia, dissolved phosphorus or total phosphorus. As with the other Skillet Fork segments, reasons for the low pH values in this segment were not clear from the data. Additional discussion of potential sources of pH is provided above under Segment CA 03 of Skillet Fork.

Atrazine

The IEPA guidelines (IEPA, 2004a) for identifying atrazine as a cause of impairment in streams state that the aquatic life use is not supported if there is at least one exceedance of the applicable guideline (1.0 ug/L) in the average of three samples. There were three samples collected during the summer of 1998 and during the summer of 2001 at station CA06. Since each year had at least three atrazine measurements, an average concentration for each year was calculated and compared to the criterion. The average concentration in each year was greater than the criterion (1998 average = 6.3 ug/L, 2001 average = 2.2 ug/L). The highest concentration in both years was observed in June, consistent with when the herbicide is applied to cornfields, as discussed in Segment CA 03. As with segment CA03, the data are limited but consistent and support the listing for this cause and sources. A discussion of the potential sources is presented in the discussion for segment CA 03.

Fecal Coliform

As discussed in the fecal coliform section of segment CA 03 data analysis, segment CA 06 is not listed for fecal coliform, but data collected in this reach suggest that fecal coliform may be a cause of impairment in this and downstream reaches, such as CA 03, that are listed for fecal coliform. See the discussion for Segment CA 03 for more details.

Skillet Fork (Segment CA 09)

Listed for: Dissolved Oxygen

Dissolved oxygen was measured three times (once per year) at station CA09 between 1998 and 2001. This segment begins at the headwaters of Skillet Fork and extends downstream to the confluence with Dums Creek. Although both Dums Creek and Stephen A. Forbes Lake, both impaired segments, drain to this segment, the data that the listing is based on was collected upstream of these waterbodies' confluence with the main stem.

Dissolved Oxygen

The three dissolved oxygen measurements collected in this segment were compared to the general use water quality criterion of 5.0 mg/L. Two of the three values were less than the criterion, with the most recent excursion occurring in 2001. Both values were approximately 2 mg/L below the criterion and occurred when the temperature was greater than 20^{o}C. Because only one exceedance of the criterion is required in the IEPA guidelines for identifying impairment, the data, though extremely limited, support the listing of this segment for dissolved oxygen.

Available data were insufficient to explore the relationship between dissolved oxygen and nutrients, CBOD and chlorophyll; however, it is likely that low dissolved oxygen at this station is caused by one or more of the following: sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Potential sources that may be contributing BOD, ammonia or nutrients include: agricultural runoff, runoff from livestock operations and failing septic systems (to a lesser extent). Recall that this watershed is predominantly rural, with 64% of the area being agricultural, 22% forested and 8% grassland. Only 192 acres are developed (<1%). There are no point sources upstream of the sampling station. Additional data are needed to better characterize the relationship between sources and the observed low dissolved oxygen.

Horse Creek (Segment CAN 01)

Listed for: Dissolved Oxygen, Manganese

Water quality measurements were recorded four and five times for dissolved oxygen and manganese, respectively, at station CAN01 between 1998 and 2001.

Dissolved Oxygen

Four dissolved oxygen measurements collected in this segment were compared to the general use water quality criterion of 5.0 mg/L. Two of the four values were less than the criterion, with the most recent excursion occurring in 2001. Excursions ranged from 0.7

to 1.9 mg/L below the criterion and occurred when the temperature was greater than 20°C. Because only one excursion of the criterion is required in the IEPA guidelines for identifying impairment, the data, though extremely limited, support the listing of this segment for dissolved oxygen.

There were insufficient data to explore the relationship between dissolved oxygen and nutrients, CBOD and chlorophyll. Low dissolved oxygen at this station is likely caused by one or more of the following: sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Although the data are not available to determine the primary processes causing low dissolved oxygen, potential sources of CBOD, ammonia and nutrients include: agricultural runoff and failing septic systems (lesser extent). Recall that this watershed is predominantly agricultural (41%), forested (30%) and grassland (22%). Only 542 acres (1%) of the watershed are developed. One turkey operation was also identified in this watershed, along with one NPDES-permitted facility (Bluford STP). Additional data are needed to better characterize the relationship between sources and the observed low dissolved oxygen.

Manganese

Five measurements are available for manganese for Horse Creek for the period between 1998 and 2001. One of the five observations exceeded the general use criterion of 1,000 ug/L and this excursion occurred in September 2001. The excursion was 500 ug/l above the criterion. Because only one exceedance of the criterion is required in the IEPA guidelines for identifying impairment, the data, though limited, support the listing of this segment for manganese.

Brush Creek (Segment CAR 01)

Listed for: Dissolved Oxygen, Manganese

Water quality samples were collected five times at station CAR01 between 1998 and 2001. Three of the samples were collected in 2001.

Dissolved Oxygen

Five dissolved oxygen measurements recorded in this segment were compared to the general use water quality criterion of 5.0 mg/L. One of the five values was less than the criterion, and this excursion occurred in 2001. The excursion was 2.7 mg/L below the criterion and occurred when the temperature was greater than 20°C. Because only one excursion of the criterion is required in the IEPA guidelines for identifying impairment, the data, though extremely limited, support the listing of this segment for dissolved oxygen.

There were insufficient data to explore the relationship between dissolved oxygen and nutrients, CBOD and chlorophyll. Low dissolved oxygen at this station is likely caused by one or more of the following: sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Although the data are not available to determine the primary processes causing low dissolved oxygen, potential sources of CBOD, ammonia and nutrients include: agricultural runoff, runoff from livestock operations, and failing septic systems (lesser extent). Recall that this watershed is very rural in nature with 57% of the area being used for agricultural purposes, 28% forested and 12% grassland. Only 91 acres are developed (<1%). Potential sources are discussed in the CA 03 dissolved oxygen sections. There are no permitted facilities in the segment's subwatershed. Additional data are needed to better characterize the relationship between sources and the observed low dissolved oxygen.

Manganese

Five measurements are available for manganese for Brush Creek for the period between 1998 and 2001. Two of these observations exceed the general use criterion of 1,000 ug/L. Both exceedances were 600 ug/L above the criterion. Because the IEPA guidelines state that one exceedance of the manganese criterion is sufficient to identify manganese as a cause of impairment, the data are considered sufficient to support manganese being listed on the draft 2004 303(d) list.

A discussion of background sources of manganese is provided above under Segment CA 03 of Skillet Fork. As manganese is ubiquitous in this region, the general use standard may be difficult to obtain.

Dums Creek (Segment CAW 01)

Listed for: Dissolved Oxygen

Water quality measurements were recorded five times at station CAW01 between 1998 and 2001. Three of the measurements were recorded in 2001.

Dissolved Oxygen

Five dissolved oxygen measurements collected in this segment were compared to the general use water quality criterion of 5.0 mg/L. Four of the five values were less than the criterion, and ranged from 1.6 mg/L to 2.8 mg/L below the criterion. Two excursions occurred when the temperature was greater than 20^{o}C. No flow data are available for this tributary. Because only one excursion of the criterion is required in the IEPA guidelines for identifying impairment, the data, though extremely limited, support the listing of this segment for dissolved oxygen.

There were insufficient data to explore the relationship between dissolved oxygen and nutrients, CBOD and chlorophyll. Low dissolved oxygen at this station likely results from one or more of the typical causes: sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Other potential sources contributing to low dissolved oxygen are agricultural runoff, runoff from livestock operations, and to a lesser extent, failing septic systems. Similar to what was observed at other monitoring stations, it is expected that low flow and high temperatures exacerbate the dissolved oxygen problem. Recall that land use in this watershed is predominantly agricultural (67%), with lesser amounts of forest (18%) and grassland (9%). Only 1% of the watershed is developed (332 acres). There are no permitted facilities in the segment's subwatershed. Potential sources are discussed in the CA 03 dissolved oxygen sections. Additional data are needed to better characterize the relationship between sources and the observed low dissolved oxygen.

Sam Dale Lake (Segment RBF)

Listed for: Total Phosphorus

Sam Dale Lake is a 194-acre lake classified for General Use. Water quality is measured in Sam Dale Lake at three locations and data are available for three years (1992, 1998, and 2002). Station locations are shown in Figure 6. The depth of the lake ranges from approximately 15 feet at station RBF-1 to approximately 8 feet at station RBF-2 to 4 feet or less at station RBF-3.

Total Phosphorus

The IEPA guidelines (IEPA, 2004a) for identifying total phosphorus as a cause of impairment in lakes greater than 20 acres in size, state that the aquatic life and secondary contact uses are not supported if there is at least one exceedance of the applicable standard (0.05 mg/L) in surface samples during the monitoring year. A total of 60 total phosphorus measurements have been made over the indicated sampling period at various depths. Forty-five (45) of these samples were collected at the surface (within 1 ft of the surface). Forty-four (44) of the 45 samples exceeded the general use criterion of 0.05 mg/L, indicating that the aquatic life and secondary contact uses are not fully supported. Exceedances ranged from 0.001 mg/L to 0.69 mg/L above the criterion. A comparison of the available data to the criterion is shown in Figure 16.

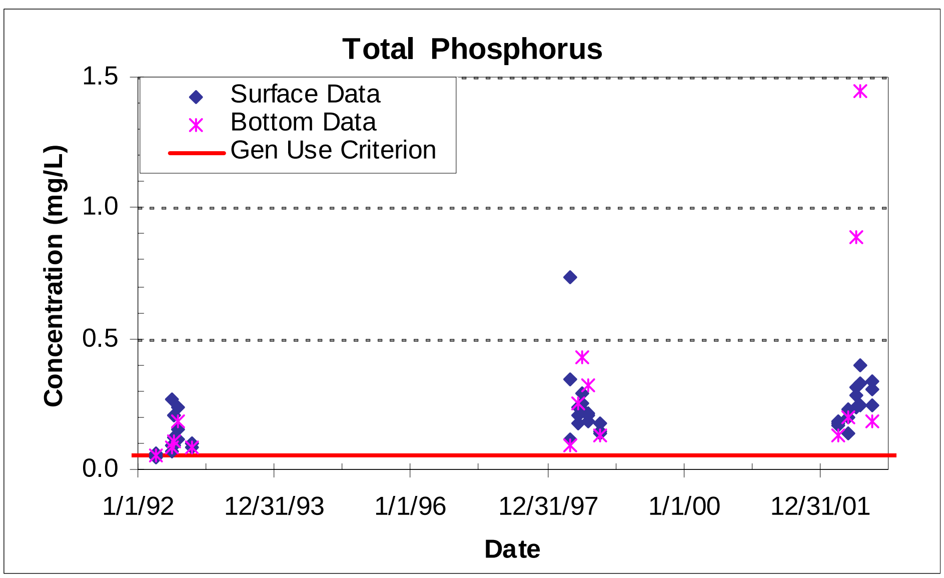

Figure 16. Sam Dale Lake (RBF) Total Phosphorus Data Compared to General Use Criterion.

The lake's water quality appears to be declining as evidenced by the increasing trend in phosphorus concentration with time. In 1992, the average concentration at the surface was 0.15 mg/L while in 2002 it was 0.26 mg/L.

An analysis of the dissolved and total phosphorus data (Figure 17) indicates that approximately 64% of the total phosphorus is in the dissolved form and 36% is in the particulate form. The presence of particulate phosphorus suggests that there may be watershed sources of phosphorus. A plot of total suspended solids (TSS) indicates that total phosphorus generally increases with TSS, supporting the potential for watershed sources, such as runoff from agricultural lands. Recall that the land use in this watershed is predominantly agricultural (59%), forest (25%) and grassland (10%). Only 6 acres are developed, indicating that failing septic systems and runoff from lawns are not likely significant sources of phosphorus.

A portion of the observed dissolved phosphorus may originate from the lake bottom sediments. An examination of the data collected at Station RBF-1 in 1992, 1998 and 2002 indicates that phosphorus concentrations increased in bottom waters in June, July and August, suggesting that phosphorus release from sediments may be occurring under anoxic conditions. The dissolved phosphorus concentrations in the bottom of the lake tended to be higher in 2002 than in previous years. Sediment concentrations of total phosphorus more than doubled between 1992 and 2002 at stations RBF-1 and RBF-3.

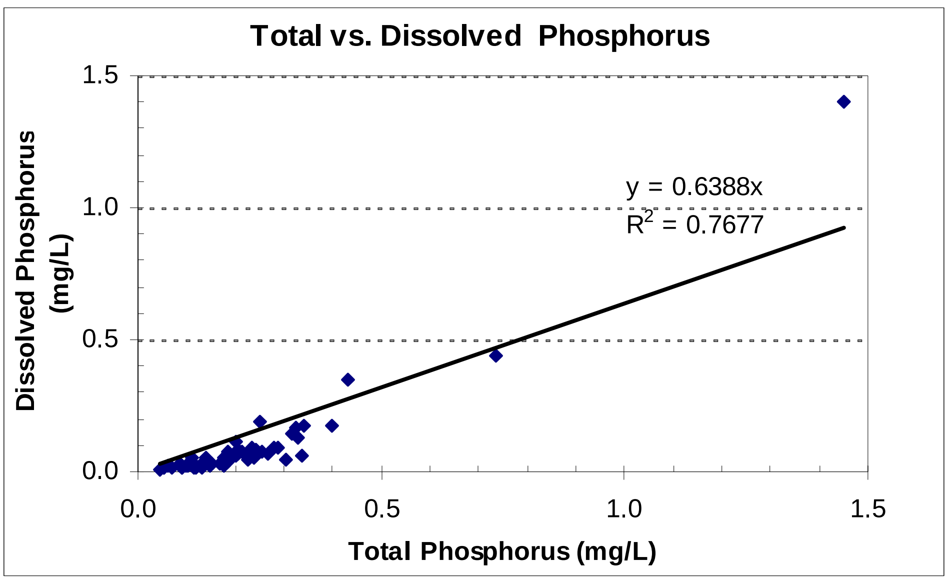

Figure 17. Total vs. Dissolved Phosphorus in Sam Dale Lake.

Depth profiles of dissolved oxygen concentrations in each year indicate that the bottom waters (hypolimnion) of the lake became anoxic from June until October. Lake stratification was confirmed by evaluating temperature profiles with depth, which show that temperatures near the bottom of the lake are 5-10°C cooler than at the surface in June, July and August. As shown in Figure 16, samples collected from deeper waters in summer months generally exhibit higher concentrations of total phosphorus, suggesting that sediment release of phosphorus is occurring during low hypolimnetic dissolved oxygen conditions. Point sources are not identified as potential phosphorus sources as there are no point sources that discharge to any of the receiving waters in the Sam Dale Lake watershed.

Stephen A. Forbes Lake (Segment RCD)

Listed for: Total Phosphorus

Stephen A. Forbes (SA Forbes) Lake is a 525-acre lake classified for General Use. Water quality is measured at five locations in SA Forbes Lake and is available for three years, 1994, 1998 and 2001. However, phosphorus data are only available at three of the five sampling locations and are available for only two years (1998, and 2002). Station locations are shown in Figure 6. The depth of the lake at station RCD-1 is approximately 25 feet, at station RCD-2, approximately 17 feet and at station RCD-3, approximately 8 feet.

Total Phosphorus

The IEPA guidelines (IEPA, 2004a) for identifying total phosphorus as a cause of impairment in lakes greater than 20 acres in size, state that the aquatic life and secondary contact uses are not supported if there is at least one exceedance of the applicable standard (0.05 mg/L) in surface samples during the monitoring year. A total of 43 total phosphorus measurements have been made over the indicated sampling period at various depths. Thirty-three (33) of these samples were collected at the surface (within 1 ft of the surface). Thirty-one (31) of the 33 samples exceeded the general use criterion of 0.05 mg/L, indicating that the aquatic life and secondary contact uses are not fully supported. Exceedances ranged from 0.003 mg/L to 0.332 mg/L above the criterion. A comparison of the available data to the criterion is shown in Figure 18.

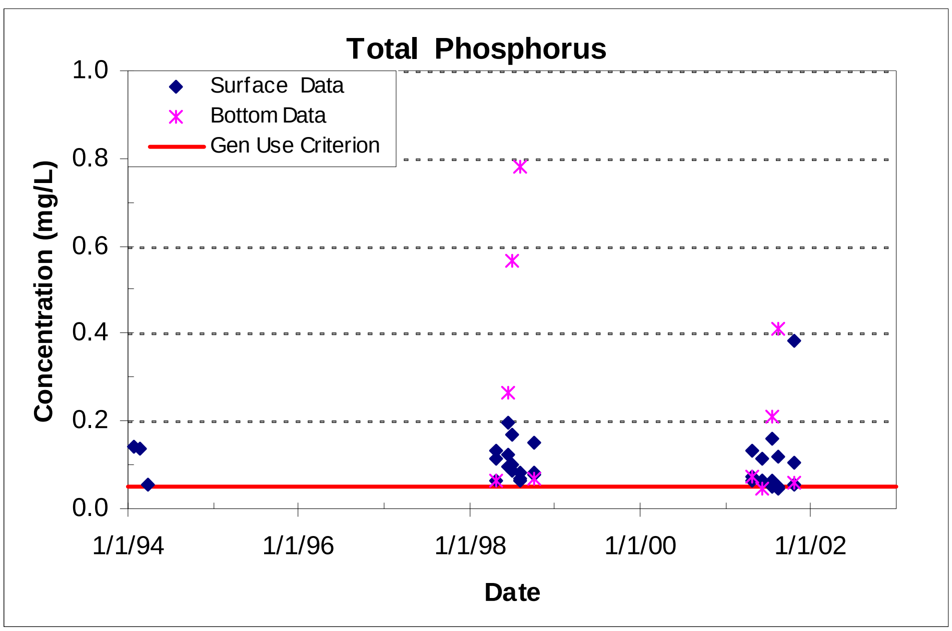

Figure 18. SA Forbes Lake (RCD) Total Phosphorus Data Compared to the General Use Criterion

An analysis of the dissolved and total phosphorus data (Figure 19) indicates that when the concentration of total phosphorus is greater than 0.2 mg/L, the fraction of phosphorus in the dissolved form much higher than when the total concentration is less than 0.2 mg/L (91% vs. 21%). Elevated concentrations (> 0.2 mg/L) were almost always measured near the bottom of the lake rather than at the surface. The presence of particulate phosphorus suggests that there may be watershed sources of phosphorus such as runoff from agricultural lands. Recall that the land use in this watershed is predominantly agricultural (60%), forest (26%) and grassland (7%). Only 46 acres are developed, indicating that failing septic systems and runoff from lawns are not likely significant sources of phosphorus.

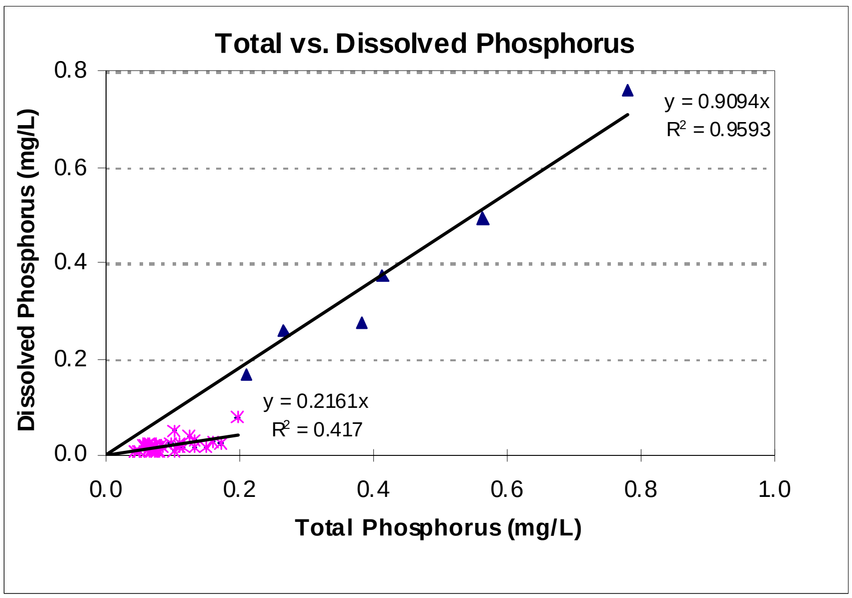

Figure 19. Total vs. Dissolved Phosphorus in SA Forbes Lake

Lake bottom sediments likely generate a significant portion of the dissolved phosphorus in SA Forbes Lake. As shown in Figure 19 and described in the previous paragraph, the dissolved fraction of phosphorus is much higher in measurements made near the sediment than measurements made in the surface. Dissolved oxygen depth profiles taken at RCD-1 and RCD-2 in 1998 and 2001 indicate that the deeper sections of the lake become anoxic in the summer and early fall. This reduction in dissolved oxygen concentrations with depth is shown in Figure 20.

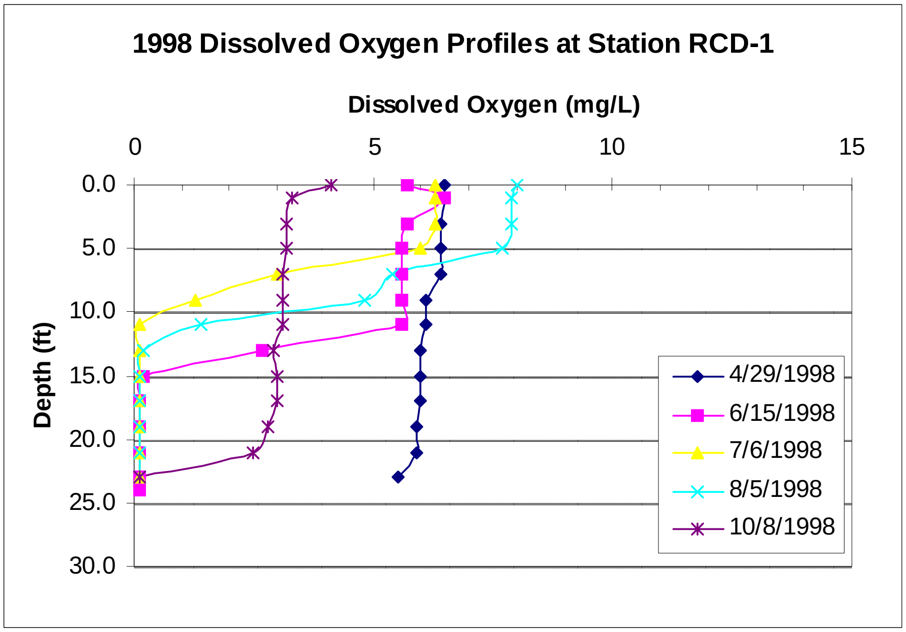

Figure 20. 1998 Dissolved Oxygen profiles at Station RCD-1

Phosphorus release during low hypolimnetic dissolved oxygen conditions is also supported by Figure 18, which shows higher phosphorus concentrations in deeper waters during the summer months. Station RCD-3 was a shallower station location and only appears to have slightly stratified in June of 1998 and 2001. As a result very low dissolved oxygen concentrations at RCD-3 were not observed with depth in 1998 and 2001.

The Phase One Diagnostic Study done on SA Forbes Lake as part of the Clean Lakes Program supports the phosphorus data shown above. The study states that SA Forbes Lake can be characterized as moderately to highly eutrophic with a significant amount of loading of phosphorus from non-point agriculture sources. Annual phosphorus loads are estimated to be between 8,822 kg and 25,402 kg in the report.

There are two point source discharges to the lake. Waste from the campground is treated with a sand filter system and discharged to the lake. The other discharge is for a similar treatment process that services the park employee offices and residential area. Both of these treatment facilities are very small (see Table 9) with a cumulative discharge of less than 0.01 MGD and are not likely to contribute a significant phosphorus load.

Wayne City Side Channel Reservoir (Segment RCT)

Listed for: Manganese

The Wayne City Side Channel Reservoir (Wayne City SCR) is an 8-acre reservoir used for supplying drinking water, along with Skillet Fork, to Wayne City. Water quality in the reservoir was monitored in 2001 at one station. The reservoir is approximately 15 feet deep at the sampling station (RCT-1). The reservoir is subject to the public water supply standards in the Illinois Administrative Code.

Manganese

Five measurements are available for manganese in the Wayne City SCR for the period between April and October 2001. The General Use guideline indicates manganese impairment if at least one observation exceeds the criterion of 1,000 ug/L. None of the available manganese data for the reservoir exceeded this criterion.

The public water supply guideline indicates impairment if more than 10% of the observations measured since 1999 exceed 150 ug/L. Two of the five observations exceed the criterion of 150 ug/L. Exceedances were 110 and 180 ug/L above the criterion. The three remaining observations were within 30 ug/L of the criterion, as shown in Figure 21.

While these data are limited, they are considered representative of water quality in the reservoir because data from nearby waterbodies supports that manganese is ubiquitous in this region. Because the IEPA guidelines state that one exceedance of the manganese criterion is sufficient to identify manganese as a cause of impairment, the data are considered sufficient to support the listing on the draft 2004 303(d) list.

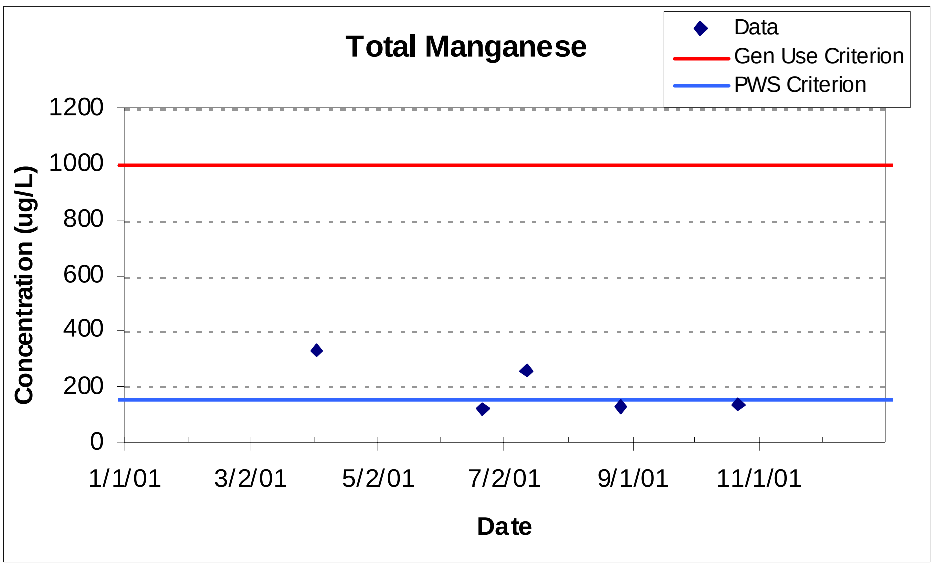

Figure 21. Wayne City SCR (RCT) Manganese Data Compared to General Use and Public Water Supply Criteria

Profiles of dissolved oxygen and temperature in the reservoir indicate that the reservoir thermally stratifies and the deeper waters go anoxic in the summer. Under anoxic conditions, manganese may be released from the sediments, contributing to elevated concentrations in the water column. The oxidation-reduction chemistry of manganese is well studied in lakes. In the oxidized state, such as in lakes, manganese is in the particulate form in the aerobic epilimnion. During summer stagnation, manganese reduces and becomes dissolved in the water column (Cole, 1994). Limnologists have found that increases in water column profiles of dissolved manganese may be associated with the reduction of manganese as particles settle into anoxic zones of lakes, or, from reduction and upward transport of dissolved manganese from lake bottom sediment (Davison, 1985). Hence, the measurements of manganese in mid-water samples from the lakes exceed the water quality criterion because of thermal stratification and the development of reducing conditions in the hypolimnion.

The Wayne City SCR is an artificially constructed waterbody whose perimeter is bermed. As such, there are no known point sources and very little watershed area draining directly to the waterbody. Because the watershed draining to this reservoir is the same as that for segment CA 05, the discussion of manganese sources for segment CA 05 also applies here. Sources include natural background sources, oil well brine and streambank erosion. A discussion of background sources of manganese is provided above under Segment CA 03 of Skillet Fork. As manganese is ubiquitous in this region, the public water supply standard may be difficult to obtain.

CONCLUSIONS

Based on Stage I work, the project team has concluded that TMDLs are warranted for the ten impaired waterbodies in this targeted watershed. Specifically:

- For **Skillet Fork (Segment CA 03)**, data are considered sufficient to support the causes listed on the draft 2004 303(d) list, and dissolved oxygen (DO), manganese, fecal coliform, pH, and atrazine TMDLs are warranted. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and algal respiration. A review of ammonia and dissolved oxygen data suggest that ammonia is not a significant source and that there are other factors besides ammonia that are contributing to the low observed dissolved oxygen. There were insufficient data to assess the relationship between sediment oxygen demand (SOD) and DO, carbonaceous biochemical oxygen demand (CBOD) and DO, and chlorophyll and DO. Based on the watershed characterization, it was determined that potential sources of nutrients, ammonia and BOD may include: municipal point sources, failing private sewage disposal systems, runoff from agricultural land (fertilized cropland and agricultural land with livestock) and intensive animal feeding operations. Low flows and high temperatures also appear to contribute to the low dissolved oxygen concentrations in this segment.

  The observed manganese concentrations in the lake likely reflect natural background conditions (soils in the watershed are naturally high in manganese), although brine from oil wells may also contribute to the elevated concentrations. Because of the naturally high levels of manganese in the soils, the general use criterion may be difficult to attain.

  Potential sources of fecal coliform include farms with livestock and intensive agricultural livestock operations, sewage treatment plants, and failing septic systems. Elevated fecal concentrations were identified in upstream segments and therefore the fecal sources are not all specific to this segment.

  Potential sources contributing to the pH excursions are unclear from the data, but the naturally acidic nature of the soils is suspected of contributing to the problem.

  The primary source of atrazine is non-irrigated cropland.

- For **Skillet Fork (Segment CA 05)**, data are considered sufficient to support the causes listed on the draft 2004 303(d) list, and dissolved oxygen, manganese, pH, and atrazine TMDLs are warranted. The discussion of sources contributing to low dissolved oxygen, manganese, pH and atrazine in Skillet Fork Segment CA 03 also applies to Segment CA 05, with two exceptions: algal respiration and ammonia nitrification are not thought to be significant factors contributing to low dissolved oxygen in this segment (CA 05). Because of the naturally high levels of manganese in the soils, the general use and public water supply criteria may be difficult to attain.

- For **Skillet Fork (Segment CA 06)**, data are considered sufficient to support the causes listed on the draft 2004 303(d) list, and dissolved oxygen, manganese, pH, and atrazine TMDLs are warranted. The discussion of sources contributing to low dissolved oxygen, manganese, pH and atrazine in Skillet Fork Segment CA 03 also applies to Segment CA 06. Because of the naturally high levels of manganese in the soils, the general use criterion may be difficult to attain.
- For **Skillet Fork (Segment CA 09)**, data are considered sufficient to support the cause listed on the draft 2004 303(d) list, and a dissolved oxygen TMDL is warranted. It should be noted that the listing, while warranted, is based on only three dissolved oxygen measurements, with two of the three measurements being approximately 2 mg/l below the criteria of 5 mg/l. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Although there were insufficient data to assess the relationship between ammonia and dissolved oxygen, SOD and DO, CBOD and DO, and chlorophyll and DO, potential sources in this watershed were identified through the watershed characterization. These sources may include runoff from agricultural land (fertilized cropland and agricultural land with livestock) and failing private sewage disposal systems (lesser extent). There are no point sources in this watershed. Similar to what was observed farther downstream of this segment, low flows and high temperatures may also exacerbate low dissolved oxygen concentrations in this segment.
- For **Horse Creek (Segment CAN 01)**, data are considered sufficient to support the listing of this segment for dissolved oxygen; however, the data were extremely limited. Only two of the four measurements were below the DO criterion. The data are also sufficient to support the listing of this segment for manganese with one of five samples exceeding the general use criteria for manganese. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Potential sources contributing to one or more of these causes include failing private sewage disposal systems (lesser extent), runoff from agricultural land (fertilized cropland and agricultural land with livestock), a permitted point source discharger, and an intensive animal feeding operation. The observed manganese concentrations likely reflect natural background conditions (soils in the watershed are naturally high in manganese), although brine from oil wells may also contribute to the elevated concentrations. Because of the naturally high levels of manganese in the soils, the general use criterion may be difficult to attain.
- For **Brush Creek (Segment CAR 01)**, the data, though extremely limited, are considered sufficient to support the listing of this segment for dissolved oxygen and

manganese. The observed manganese concentrations likely reflect natural background conditions (soils in the watershed are naturally high in manganese), although brine from oil wells may also contribute to the elevated concentrations. Because of the naturally high levels of manganese in the soils, the general use criterion may be difficult to attain. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Low dissolved can be exacerbated by low flow and/or high temperature conditions, similar to what was observed in Skillet Fork. Although the data were not available to determine the primary causes of low dissolved oxygen, potential sources of nutrients, ammonia and BOD include failing private sewage disposal systems (lesser extent), and runoff from agricultural land (fertilized cropland and agricultural land with livestock).

- For **Dums Creek (Segment CAW 01)**, data are considered sufficient to support the listing of this segment for dissolved oxygen with four of the five values less than the criterion. Because there are no point sources in this watershed, low DO is likely caused by nonpoint sources. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Low dissolved can be exacerbated by low flow and/or high temperature conditions, similar to what was observed in Skillet Fork. Although the data were not available to determine the primary causes of low dissolved oxygen, potential sources of nutrients, ammonia and BOD include failing private sewage disposal systems (lesser extent), and runoff from agricultural land (fertilized cropland and agricultural land with livestock).
- For **Sam Dale Lake (Segment RBF)**, data are considered sufficient to support the listing of this segment for total phosphorus. Phosphorus concentrations appear to be increasing over time in this lake. Potential phosphorus sources include sediment phosphorus release from the lake bottom sediments under anoxic conditions and watershed runoff from agricultural lands.
- For **Stephen A. Forbes Lake (Segment RCD)**, data are considered sufficient to support the listing of this segment for total phosphorus. Potential phosphorus sources include sediment phosphorus release from the lake bottom sediments under anoxic conditions and watershed runoff from agricultural lands. Because of the low discharge flows, the two treatment facilities in this watershed are not suspected of being significant sources of phosphorus.
- For **Wayne City Side Channel Reservoir (Segment RCT)**, data are considered sufficient to support the listing of this segment for manganese. The manganese concentrations exceed the public water supply criterion, but not the general use criterion. Potential sources of manganese include release of manganese from lake bottom sediments during summer anoxic conditions, and natural watershed sources (soils are naturally high in manganese). Because of the naturally high levels of manganese in the soils, the public water supply criterion may be difficult to attain.

NEXT STEPS

In the upcoming quarter, methods, procedures and models that will be used to develop TMDLs for the project watershed will be identified and described. This description will include documentation of any important assumptions underlying the recommended approach (methods, procedures and models) and a discussion of data needed to support the development of a credible TMDL.

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APPENDIX A. DATA SOURCES AND LOCAL CONTACTS

Table A-1. Data sources

Data description	Agency	Website
Climate summaries	Illinois State Water Survey	http://www.sws.uiuc.edu/atmos/statecli/index.htm
NPDES permit limits	United States Environmental Protection Agency	http://www.epa.gov/enviro/html/pcs/pcs_query.html
Aerial photography	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/webdocs/doqs/graphic.html
Coal mines: active and abandoned - polygons part 1	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mines: active and abandoned - polygons part 2	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mines: active and abandoned – points	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mine permit boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
County boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Cropland	United States Department of Agriculture, National Agricultural Statistics Service, via Illinois Department of Agriculture	http://www.agr.state.il.us/gis/pass/nassdata/
Dams	National Inventory of Dams (NID)	http://crunch.tec.army.mil/nid/webpages/nid.cfm
Elevation	United States Geological Survey	http://seamless.usgs.gov/viewer.htm
Federally-owned lands	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Hydrologic cataloging units	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Hydrography	United States Geological Survey	http://nhd.usgs.gov/
Impaired lakes	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Impaired streams	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Land cover	Illinois Department of Agriculture	http://www.agr.state.il.us/gis/
Landfills	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Municipal boundaries	U.S. Census Bureau	
Municipal boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
National Pollutant Discharge Elimination System (NPDES) permitted sites	United States Environmental Protection Agency	
Nature preserves	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Oil wells	United States Geological Survey	http://energy.cr.usgs.gov/oilgas/noga/
Railroads	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/

Data description	Agency	Website
Roads – state highways	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads – U.S. highways	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads- detailed road network	U.S. Census Bureau	http://www.census.gov/geo/www/tiger/tigerua/ua_tgr2k.html
Survey-level soils	United States Department of Agriculture Natural Resources Conservation Service	http://www.il.nrcs.usda.gov/technical/soils/ssurgo.html
State-level soils	United States Department of Agriculture Natural Resources Conservation Service	http://www.il.nrcs.usda.gov/technical/soils/statsgo_inf.html - statsgo8
State boundary	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State conservation areas	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State forests	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State fish and wildlife areas	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State parks	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Topographic map quadrangle index	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Topographic map quadrangles	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
USGS stream gages	Illinois State Water Survey	
Watersheds	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Water supply – Public water supply intakes	Illinois State Water Survey	
Water Quality Data	Illinois Environmental Protection Agency	
Water Quality Data	USEPA Legacy and Modern STORET databases	http://www.epa.gov/storet/
Water Quality and Hydraulic	United States Geological Survey (USGS)	http://water.usgs.gov/

Table A-2. Local and State Contacts

Contact	Agency/ Organization	Contact Means	Contact #	Subject
Tony Antonacci	Marion Co. NRCS	Telephone	618-548-2230 x3	BMPs, farming practices and pesticides
Art J. Friederich	Jefferson Co. NRCS	Telephone	618-244-0773 x3	Watershed characterization questions
Bill Webber	White Co. NRCS	Telephone	618-382-2213 x 3	Watershed characterization questions
Bruce Currie	Wayne Co. NRCS	Telephone	618-847-7516	Watershed characterization questions
Laurie King	Clay Co. NRCS	Telephone	618-665-3327 x3	Impairments to Brush Creek and areas downstream of Pickle Creek. General information on the portions of the Skillet Fork watershed contained within Clay county
Rhonda Cox	Hamilton Co. NRCS	Telephone	618.643.4326 ext. 3	Transferred to Chris Mitchell, Hamilton Co. SWCD
Bill Bruce	Clay Co. Health Dept.	Telephone	618-662-4406	Septic systems, sewers, water quality issues
Gary Ashby	Jefferson Co. Health Dept.	Telephone	618-244-7134	Watershed characterization questions
Clark Griffith	Wayne/Hamilton Dept. of Environmental Health	Telephone	618-842-5166	Watershed characterization questions
Karen Raney	Egyptian Health Dept.	Telephone	618-382-7311 x 2014	Septic systems, sewers, water quality issues
Melissa Mallow	Marion Co. Health Dept.	Telephone	618-548-3878	Discussed septic systems and pathogens
Bruce Morrison	Hamilton Co. FSA	Telephone	618-643-4326 x2	Watershed characterization questions
Scott Prahlmann	White Co. FSA	Telephone	618-382-2213 x2	Watershed characterization questions
Burke Davies	Marion County SWCD	Telephone	618-548-2230 x3	Farming and fertilization practices, BMPs. Potential sources of iron and manganese
Chris Mitchell	Hamilton Co. SWCD	Fax	618-643-2459	Fax with map for him to locate CAFOs, area in CRP, tile drains
Debbie Gray	White County SWCD	Telephone	618-382-4822	Watershed characterization questions
Denny Massie	Sam Dale Lake Conservation Area	Telephone	618-835-2292	Discussed phosphorus and potential algae problems in Sam Dale Lake.
Glen Weggner	Stephen A. Forbes State Park	Telephone	618-547-3381	Diagnostic Plan, NPDES dischargers, lake WQ
Lisa Simpson	IL extension office	Telephone	618-842-3702	Info on classes/training sessions that they offer in Hamilton, Wayne, White Counties

Contact	Agency/ Organization	Contact Means	Contact #	Subject
Robin Pyle	Univ. of IL Extension Office	Telephone	618-382-2662	Recommended calling Dennis Epplin- Mt Vernon Ag Extension Educator
Dennis Epplin	Univ. of IL Extension Office- Mt. Vernon	Telephone	618-242-9310	Watershed characterization questions
Jenni	Marion County Ag. Extension Office	Telephone	618-548-1446	Told to talk with Tony Antonacci
Peter Berrini	Cochran & Wilken, Inc.	Telephone	217-585-8300	Discussed Clean Lakes Study for Stephen A. Forbes Lake.
Matt Diana	Illinois Natural History Survey	Telephone	217-728-4851	1998-2003 data for Stephen A. Forbes
Sue Ebetsch	Illinois State Data Center	Telephone	217-782-1381	Requested Population projection report
Laura Biewick	U.S. Geological Survey	Telephone	303-236-7773	GIS data for oil & gas wells
Kathy Brown	Illinois State Water Survey	Telephone	217-333-6778	USGS gage locations; water supply intakes
Sharie Heller	SW Illinois GIS resource Center	Telephone	618-566-9493	Discussed CRP maps
Steve Sobaski	Illinois Department of National Resources		ssobaski@dnrmail.state.il.us	Formal request for conservation related GIS files
Don Pitts	United States Department of Agriculture Natural Resources Conservation Service	Telephone	217-353-6642	Potential sources of iron and manganese in south-central Illinois surface waters.
Tony Meneghetti	IEPA	Telephone and e-mail	217-782-3362 Anthony.Meneghetti@epa.state.il.us	Lake data and SWAPs
Teri Holland	IEPA	Telephone and e-mail	217-782-3362 Teri.Holland@epa.state.il.us	Lake Data from 2001-2003, Clean Lakes Program Report
Dave Muir	IEPA Marion Regional office	Personal visit	618-993-7200	Assessment data used in 303(d) and 305(b) reports
Tim Kelly	IEPA Springfield Regional office	Telephone and e-mail	217/-786-6892 Tim.Kelly@epa.state.il.us	NPDES DMR data
Jeff Mitzelfelt	IEPA	e-mail	jeff.mitzelfelt@epa.state.il.us	Websites for GIS information

APPENDIX B. PHOTOGRAPHS

Wayne City Side Channel Reservoir (Segment RCT)

Wayne City Side Channel Reservoir (Segment RCT)

Wayne City Water Works photographed near Wayne City Side Channel Reservoir

Skillet Fork at Illinois Rte. 15 (Segment CA 05)

Skillet Fork (Segment CA05) at Rte. 242, looking downstream. Photo taken from bank, under the highway bridge. Can see some stream bank erosion.

Skillet Fork (Segment CA05) looking upstream from Rte. 242 bridge. Note channelization and bank erosion on left side of stream

Cropland in Skillet Fork watershed (near Segment CA05)

Small oil rig near Segment CA05. These were very common.

Cropland near Skillet Fork Segment CA03.

Skillet Fork, near upstream boundary of Segment CA 03, looking upstream.

Horse Creek (Segment CAN01) at Orchardville Road, north of Illinois Rte. 15. Note sediment islands and incised bank.

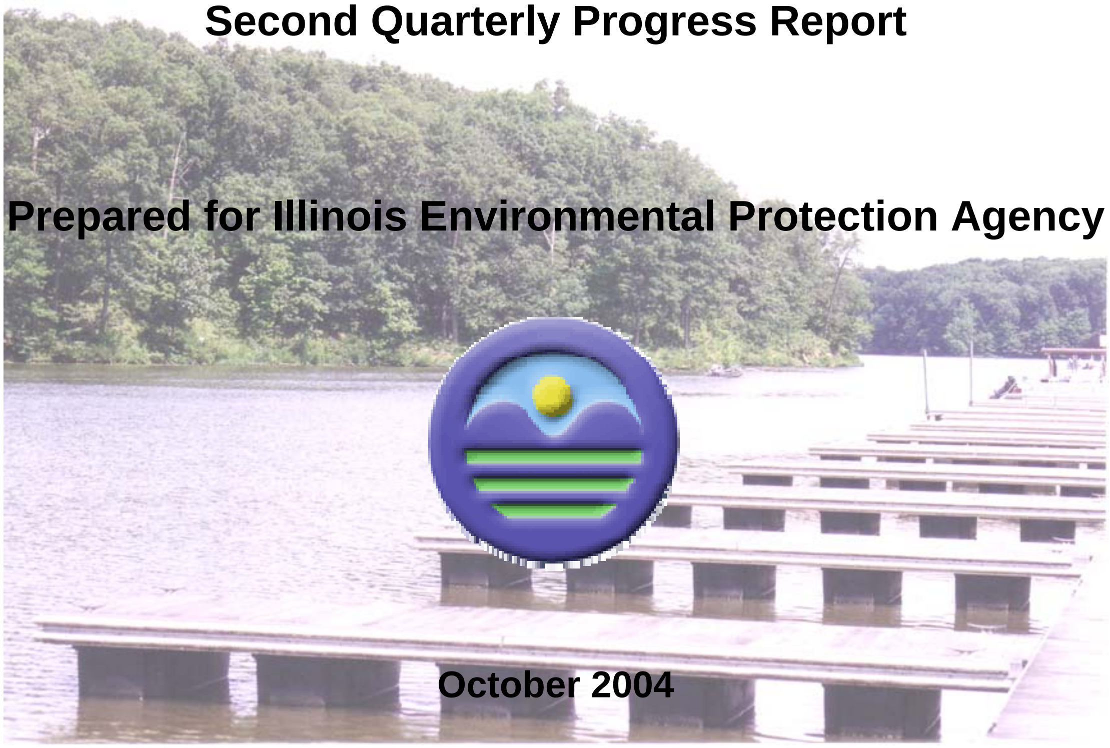
Sam Dale Lake (Segment RBF)

Stephen A. Forbes Lake (Segment RCD) at marina

Stephen A. Forbes Lake (Segment RCD)

Typical landscape near Stephen A. Forbes Lake (Segment RCD)

Second Quarterly Progress Report



Prepared for Illinois Environmental Protection Agency

October 2004

Skillet Fork Watershed

Skillet Fork (CA03, CA05, CA06, CA09),

Horse Creek (CAN 01), Brush Creek (CAR 01),

Dums Creek (CAW 01), Sam Dale Lake (RBF),

Stephen A. Forbes Lake (RCD), and

Wayne City Side Channel Reservoir (RCT)

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EXECUTIVE SUMMARY

This is the second in a series of quarterly status reports documenting work completed on the Skillet Fork project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA, 2004), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be completed for each pollutant listed for an impaired water body. TMDLs are prepared by the States and submitted to the U.S. EPA. In developing the TMDL, a determination is made of the greatest amount of a given pollutant that a water body can receive without exceeding water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review were presented in the first quarterly status report.

The intent of this second quarterly status report is to:

- Identify and briefly describe the methodologies/procedures/models to be used in the development of TMDLs
- Document important assumptions underlying the recommended methodologies
- Identify the data needs for the methodologies to be used in TMDL development, including an assessment of whether additional data are needed to develop credible TMDLs

In future phases of this project, Illinois EPA and consultants will develop the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired water bodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) would be strictly voluntary.

Methods

The effort completed in the second quarter included: 1) summarizing potentially applicable model frameworks for TMDL development, 2) Recommending specific model frameworks for application to the ten listed waterbodies in the Skillet Fork watershed, and 3) Making a determination whether sufficient data exist to allow development of a credible TMDL. Selection of specific model frameworks was based upon consideration of three separate factors, consistent with the guidance of DePinto et al (2004):

- **Site-specific characteristics:** The characteristics define the nature of the watershed and water bodies. For Skillet Fork (CA03) watershed, the relevant site-specific characteristics include a watershed with predominantly agricultural land use containing several intensive animal feeding operations, eleven sewage treatment plants, and a channelized creek impaired by manganese, pH, low dissolved oxygen, fecal coliform and atrazine. For the Skillet Fork (CA05) watershed, the relevant site-specific characteristics include a watershed with predominantly agricultural land use containing several intensive animal feeding operations, and eleven sewage treatment plants, and a channelized creek impaired by manganese, pH, low dissolved oxygen, and atrazine. For the Skillet Fork (CA06) watershed, the relevant site-specific characteristics include a watershed with predominantly agricultural land use, manganese-enriched soils and groundwater (IUKA groundwater data) and a creek impaired by manganese, pH, low dissolved oxygen and atrazine. For the Skillet Fork (CA09) watershed, the relevant site-specific characteristics include a predominantly agricultural watershed and a creek impaired by low dissolved oxygen. For the Horse Creek (CAN01) watershed, the relevant site-specific characteristics include a watershed with agricultural, forest and grassland an animal feeding operation, and a creek impaired by manganese and low dissolved oxygen. For the Brush Creek (CAR01) watershed, the relevant site-specific characteristics include a predominantly agricultural watershed with no point source discharges, soils enriched in manganese, and a creek impaired by manganese and low dissolved oxygen. For the Dums Creek (CAW01) watershed, the relevant site-specific characteristics include a predominantly agricultural watershed with no point source dischargers, and a creek impaired by low dissolved oxygen. For both the Sam Dale Lake (RBF) and Stephen A. Forbes Lake (RCD) watersheds, the relevant site-specific characteristics include predominantly agricultural watersheds, and lakes impaired by phosphorus. For the Wayne City Side Channel Reservoir (RCT) watershed, the relevant site-specific characteristics include a watershed with predominantly agricultural land use and soils enriched in manganese, and a lake impaired by manganese.

- **Management objectives:** These objectives consist of the specific questions to be addressed by the model. For this application, the management objective is to develop a credible TMDL.
- **Available resources:** This corresponds to the amount and time and data available to support TMDL development. Water quality data currently exist for all ten listed water bodies in the Skillet Fork watershed. One aspect of this work is to define whether or not the existing data are sufficient to allow development of a credible TMDL.

Results

Several modeling frameworks potentially applicable for developing TMDLs were identified, spanning a range of detail from simple to complex. Selection of a specific modeling framework is complicated by the fact that the definition of a “credible” TMDL depends upon the level of detail to be contained in the implementation plan. If the goal of the TMDL implementation plan is to define the primary sources of impairment and quickly identify the general level of reduction required, relatively simple models can be used to develop a credible TMDL. If the goal of the TMDL implementation plan is to explicitly define the specific levels of controls required, more detailed models (and additional data) are required to develop a credible TMDL. Specific recommendations are provided which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date.

Because of the wide range of impairment types and water bodies in the Skillet Fork watershed, a range of modeling approaches is required. They are summarized here by individual water body segment and grouped together as appropriate.

The recommended modeling approach for Skillet Fork segments CA03, CA05, and CA06 consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese and pH impairments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach. QUAL2E was selected for dissolved oxygen modeling because it is the most commonly used water quality model for addressing low flow conditions. Because problems appear to be restricted to low flow conditions, watershed loads are not expected to be significant contributors to the impairment. For this reason, an empirical approach was selected for determining watershed loads. For these same segments, development of a load-duration curve is recommended to address atrazine impairments. This will allow for determination of the degree of impairment under different flow conditions. Results from the load-duration curve can also be used to identify the approximate level of source control needed under each set of flow conditions. The recommended approach to address fecal coliform impairments in segment CA03 consists of developing a load-duration curve. This will allow for determination of the degree of impairment under different flow conditions and the respective importance of dry weather and wet weather fecal coliform sources. Results from the load-duration curve can also be used to identify the approximate level of source control needed under each set of flow conditions.

The recommended modeling approach for Skillet Fork segment CA09 and Dums Creek (CAW01) consists of using the water quality model QUAL2E to address dissolved oxygen problems. Watershed loads for this segment will be defined using an empirical approach. QUAL2E was selected for dissolved oxygen modeling because it is the most commonly used water quality model for addressing low flow conditions. Because problems appear to be restricted to low flow conditions, watershed loads are not expected to be significant contributors to the impairment. For this reason, an empirical approach was selected for determining watershed loads.

The recommended modeling approach for Horse Creek (CAN01) and Brush Creek (CAR01) consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese impairments in these two segments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach. QUAL2E was selected for dissolved oxygen modeling because it is the most commonly used water quality model for addressing low flow conditions. Because problems appear to be restricted to low flow conditions, watershed loads are not expected to be significant contributors to the impairment. For this reason, an empirical approach was selected for determining watershed loads.

The recommended modeling approach for Wayne City Side Channel Reservoir, Sam Dale Lake, and Stephen A. Forbes Lake consists of using the GWLF and BATHTUB models. Specifically, GWLF will be applied to calculate phosphorus loads to these reservoirs over a time scale consistent with their respective nutrient residence times. BATHTUB will then be used to predict the relationship between phosphorus load and resulting in-lake phosphorus (for Sam Dale Lake and Stephen A. Forbes Lake) and dissolved oxygen concentrations (for Wayne City Side Channel Reservoir, where it assumed that the only controllable source of manganese is that which is released form lake sediments during periods of low dissolved oxygen.) This relationship will be used to define the dominant sources of phosphorus to the lakes, and the extent to which they must be controlled to attain water quality standards for phosphorus and manganese.

Alternative model frameworks are also provided in the event a different level of detail is desired for the implementation plans. Some alternative approaches require no additional data collection; however, others have significantly greater data requirements, and their use would require additional data collection.

INTRODUCTION/PURPOSE

This Stage 1 report describes intermediate activities related to the development of TMDLs for the ten 303(d)-listed water bodies in the Skillet Fork watershed. Earlier Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed.

The remaining sections of this report include:

- **Identification of potentially applicable methodologies to be used in TMDL development:** This section describes the range of potentially applicable watershed loading and water quality methodologies that could be used to conduct the TMDL, and identifies their strengths and weaknesses.
- **Model selection process:** This section describes how management objectives, available resources and site-specific conditions in the Skillet Fork watershed affect the recommendation of specific methodologies.
- **Selection of specific methodologies and future data requirements:** This section provides specific recommendation of methodologies for the ten listed waterbodies in the Skillet Fork watershed, along with the data needed to support application of the methodologies.

IDENTIFICATION OF POTENTIALLY APPLICABLE MODELS AND PROCEDURES TO BE USED IN TMDL DEVELOPMENT

Development of TMDLs requires: 1) a method to estimate the amount of pollutant load being delivered to the water body of interest from all contributing sources, and 2) a method to convert these pollutant loads into an in-stream (or in-lake) concentration for comparison to water quality targets. Both of these steps can be accomplished using a wide range of methodologies, ranging from simple calculations to complex computer models. This section describes the methodologies that are potentially applicable for the ten waterbodies in the Skillet Fork watershed, and is divided into separate discussions of watershed methodologies and receiving water quality model frameworks.

Watershed Methodologies and Modeling Frameworks

Numerous methodologies exist to characterize watershed loads for TMDL development. These include:

- Empirical Approaches
- Unit Area Loads/Export Coefficients
- Universal Soil Loss Equation
- Watershed Characterization System (WCS) Sediment Tool
- Generalized Watershed Loading Functions (GWLF) Model
- Agricultural Nonpoint Source Pollution Model (AGNPS)
- Hydrologic Simulation Program - Fortran (HSPF)
- Better Assessment Science Integrating point and Nonpoint Sources (BASINS)/ Nonpoint Source Model (NPSM)
- Storm Water Management Model (SWMM)
- Soil & Water Assessment Tool (SWAT)

This section describes each of the model frameworks and their suitability for characterizing watershed loads for TMDL development. Table 1 summarizes some important characteristics of each of the models relative to TMDL application.

Table 1 Summary of Potentially Applicable Models for Estimating Watershed Loads

Model	Data Needs	Output Timescale	Potential Accuracy	Calibration	Applicability for TMDL
Empirical Approach	High	Any	High	N/A	Good for defining existing total load; less applicable for defining individual contributions or future loads
Unit Area Loads	Low	Annual average	Low	None	Acceptable when limited resources prevent development of more detailed model
USLE	Low	Annual average	Low	Requires data describing annual average load	Acceptable when limited resources prevent development of more detailed model
WCS Sediment Tool	Low	Annual average	Low	Requires data describing annual average load	Acceptable when limited resources prevent development of more detailed model
GWLF	Moderate	Monthly average	Moderate	Requires data describing flow and concentration	Good for mixed use watersheds; compromise between simple and more complex models
SWMM	Moderate	Continuous	Moderate	Requires data describing flow and concentration	Primarily suited for urban watersheds
AGNPS	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available
HSPF	High	Continuous	High	Requires data describing flow and concentration	Good for mixed use watersheds; highly applicable if sufficient resources are available
SWAT	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available

Empirical Approaches

Empirical approaches estimate pollutant loading rates based upon site-specific measurements, without the use of a model describing specific cause-effect relationships. Time series information is required on both stream flow and pollutant concentration.

The advantage to empirical approaches is that direct measurement of pollutant loading will generally be far more accurate than any model-based estimate. The approach, however, has several disadvantages. The empirical approach provides information specific to the storms that are monitored, but does not provide direct information on conditions for events that were not monitored. Statistical methods (e.g., Preston et al., 1989) can be used to integrate discrete measurements of suspended solids concentrations with continuous flow records to provide estimates of solids loads over a range of conditions.

The primary limitation of empirical techniques is their inability to separate individual contributions from multiple sources. This problem can be addressed by collecting samples from tributaries serving single land uses, but most tributary monitoring stations reflect multiple land uses. The EUTROMOD and BATHTUB water quality models described below contain routines that apply the empirical approach to estimating watershed loads.

Unit Area Loads/Export Coefficients

Unit area loads (also called export coefficients) are routinely used to develop estimates of pollutant loads in a watershed. An export coefficient is a value expressing pollutant generation per unit area and unit time for a specific land use (Novotny and Olem, 1994).

The use of unit areal loading or export coefficients has been used extensively in estimating loading contributions from different land uses (Beaulac 1980, Reckhow et al. 1980, Reckhow and Simpson 1980, Uttormark et al. 1974). The concept is straightforward; different land use areas contribute different loads to receiving waters. By summing the amount of pollutant exported per unit area of land use in the watershed, the total pollutant load to the receiving system can be calculated.

These export coefficients are usually based on average annual loads. The approach permits estimates of current or existing loading, as well as reductions in pollutant export for each land use required to achieve a target TMDL pollutant load. The accuracy of the estimates is dependent on good land use data, and appropriate pollutant export coefficients for the region. EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables, which can estimates phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al. (1980) and Reckhow and Simpson (1980). The FLUX module of the BATHTUB software program estimates nutrient loads or fluxes to a lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified.

Universal Soil Loss Equation

The Universal Soil Loss Equation (USLE), and variations of the USLE, are the most widely used methods for predicting soil loss. When applied properly, the USLE can be used as a means to estimate loads of sediment and sediment-associated pollutants for TMDLs. The USLE is empirical, meaning that it was developed from statistical regression analyses of a large database of runoff and soil loss data from numerous watersheds. It does not describe specific erosion processes. The USLE was designed to predict long-term average annual soil erosion for combinations of crop systems and management practices with specified soil types, rainfall patterns, and topography.

Required model inputs to the USLE consist of:

- Rainfall erosivity index factor
- Soil-erodibility factor
- Slope length factor reflecting local topography
- Cropping-management factor
- Conservation practice factor

Most of the required inputs for application of the USLE are tabulated by county Natural Resources Conservation Service (NRCS) offices.

There are also variants to the USLE: the Revised USLE (RUSLE) and the Modified USLE (MUSLE). The RUSLE is a computerized update of the USLE incorporating new data and making some improvements. The basic USLE equation is retained, but the technology for evaluating the factor values has been altered and new data introduced to evaluate the terms for specific conditions. The MUSLE is a modification of USLE, with the rainfall energy factor of the USLE replaced with a runoff energy factor. MUSLE allows for estimation of soil erosion on an event-specific basis.

While the USLE was originally designed to consider soil/sediment loading only, it is also commonly used to define loads from pollutants that are tightly bound to soils. In these situations, the USLE is used to define the sediment load, with the result multiplied by a pollutant concentration factor (mass of pollutant per mass of soil) to define pollutant load.

The USLE is among the simplest of the available models for estimating sediment and sediment-associated loads. It requires the least amount of input data for its application and consequently does not ensure a high level of accuracy. It is well suited for screening-level calculations, but is less suited for detailed applications. This is because it is an empirical model that does not explicitly represent site-specific physical processes. Furthermore, the annual average time scale of the USLE is poorly suited for model calibration purposes, as field data are rarely available to define erosion on an annual average basis. In addition, the USLE considers erosion only, and does not explicitly consider the amount of sediment that is delivered to stream locations of interest. It is best used in situations where data are available to define annual loading rates, which allows for site-specific determination of the fraction of eroded sediment that is delivered to the surface water.

Watershed Characterization System (WCS) Sediment Tool

The Watershed Characterization System (WCS) Sediment Tool was developed by EPA Region 4. The Watershed Characterization System is an ArcView-based application used to display and analyze GIS data including land use, soil type, ground slope, road networks, point source discharges, and watershed characteristics. WCS has an extension called the Sediment Tool that is specifically designed for sediment TMDLs. For each grid cell within the watershed, the WCS Sediment Tool calculates potential erosion using the USLE based on the specific cell characteristics. The model then calculates the potential sediment delivery to the stream grid network. Sediment delivery can be calculated using one of the four available sediment delivery equations: a distance-based equation, a distance slope-based equation, an area-based equation, or a WEPP-based regression equation.

The applicability of WCS for estimating sediment loads for TMDLs is similar to that of the USLE in terms of data requirements and model results; i.e., it is relatively simple to apply but has the potential to be inaccurate. It provides three primary enhancements over the USLE: 1) Model inputs are automatically incorporated into the model through GIS coverages; 2) Topographic factors are calculated in the model based on digital elevation data; and 3) The model calculates the fraction of eroded sediment that is delivered to the surface water. It is only applicable to sediment TMDLs whose target represents long-term loading conditions. Because its predictions represent average annual conditions, it is not suitable for predicting loads associated with specific storm events. Like the USLE, it is does not lend itself to model calibration unless data are available to define annual loading rates.

Generalized Watershed Loading Functions Model (GWLF)

The Generalized Watershed Loading Functions Model (GWLF) simulates runoff and sediment loadings from mixed-use watersheds. It is a continuous simulation model (i.e., predicts how concentrations change over time) that uses daily time steps for weather data and water balance calculations. Sediment results are provided on a monthly basis. GWLF requires the user to divide the watershed into any number of distinct groups, each of which is labeled as rural or urban. The model does not spatially distribute the source areas, but simply aggregates the loads from each area into a watershed total; in other words, there is no spatial routing. Erosion and sediment yield for rural areas are estimated using monthly erosion calculations based on the USLE (with monthly rainfall-runoff coefficients). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are then applied to the calculated erosion to determine how much of the sediment eroded from each source area is delivered to the watershed outlet. Erosion from urban areas is considered negligible.

GWLF provides more detailed temporal results than the USLE, but also requires more input data. Specifically, daily climate data are required as well as data on processes related to the hydrologic cycle (e.g., evapotranspiration rates, groundwater recession constants). By performing a water balance, it has the ability to predict concentrations at a watershed outlet as opposed to just loads. It lacks the ability to calculate the sediment delivery ratio that is present in the WCS sediment tool. Because the model performs on a continuous simulation basis, it is more amenable to site-specific calibration than USLE or the WCS sediment tool.

Agricultural Nonpoint Source Pollution Model (AGNPS)

The Agricultural Nonpoint Source Pollution Model (AGNPS) is a joint USDA-Agricultural Research Service and -Natural Resources Conservation Service system of computer models developed to predict nonpoint source pollutant loadings within agricultural watersheds. The sheet and rill erosion model internal to AGNPS is based upon RUSLE, with additional routines added to allow for continuous simulation and more detailed consideration of sediment delivery.

AGNPS was originally developed for use in agricultural watersheds, but has been adapted to allow consideration of construction sources.

AGNPS provides more spatial detail than GWLF and is therefore more rigorous in calculating the delivery of eroded sediment to the receiving water. This additional computational ability carries with it the cost of requiring more detailed information describing the topography of the watershed, as well as requiring more time to set up and apply the model.

Hydrologic Simulation Program – Fortran (HSPF)

The Hydrologic Simulation Program – Fortran (HSPF) uses continuous rainfall and other meteorologic records to compute stream flow hydrographs and pollutographs. HSPF is well suited for mixed-use (i.e., containing both urban and rural land uses) watersheds, as it contains separate sediment routines for pervious and impervious surfaces. HSPF is an integrated watershed/stream/reservoir model, and simulates sediment routing and deposition for different classes of particle size. HSPF was integrated with a geographical information system (GIS) environment with the development of Better Assessment Science Integrating point and Nonpoint Sources (BASINS). Although BASINS was designed as a multipurpose analysis tool to promote the integration of point and nonpoint sources in watershed and water quality-based applications, it also includes a suite of water quality models. One such model is Nonpoint Source Model (NPSM). NPSM is a simplified version of HSPF that is linked with a graphical user interface within the GIS environment of BASINS. HSPC is another variant of the HSPF model, consisting of the equations used by HSPF recoded into the C++ programming language.

HSPF provides a more detailed description of urban areas than AGNPS and contains direct linkage to a receiving water model. This additional computational ability carries with it the cost of requiring more detailed model inputs, as well as requiring more time to set up and apply the model. BASINS software can automatically incorporate existing environmental databases (e.g., land use, water quality data) into HSPF, although it is important to verify the accuracy of these sources before using them in the model.

Storm Water Management Model (SWMM)

The Storm Water Management Model (SWMM) is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. SWMM is designed to be able to describe both single events and continuous simulation over longer periods of time. SWMM is commonly used to simulate urban hydraulics, although its sediment transport capabilities are not as robust as some of the other models described here.

Soil & Water Assessment Tool (SWAT)

The Soil & Water Assessment Tool (SWAT) is a basin-scale, continuous-time model designed for agricultural watersheds. It operates on a daily time step. Sediment yield is calculated with the Modified Universal Soil Loss Equation. It contains a sediment routing model that considers deposition and channel erosion for various sediment particle sizes. SWAT is also contained as part of EPA's BASINS software.

SWAT is a continuous time model, i.e., a long-term yield model. The model is not designed to simulate detailed, single-event flood routing. SWAT was originally developed strictly for application to agricultural watersheds, but it has been modified to include consideration of urban areas.

Water Quality Methodologies and Modeling Frameworks

Numerous methodologies exist to characterize the relationship between watershed loads and water quality for TMDL development. These include:

- Spreadsheet Approaches
- EUTROMOD
- BATHTUB
- WASP5
- CE-QUAL-RIV1
- CE-QUAL-W2
- EFDC

This section describes each of the methodologies and their suitability for defining water quality for TMDL development. Table 2 summarizes some important characteristics of each of the models relative to TMDL application.

Table 2. Summary of Potentially Applicable Models for Estimating Water Quality

Model	Time scale	Water body type	Spatial scale	Data Needs	Pollutants Simulated	Applicability for TMDL
Spreadsheet approaches	Steady State	River or lake	0- or 1-D	Low	DO, nutrients, algae, metals	Good for screening-level assessments
EUTROMOD	Steady State	Lake	0-D	Low	DO, nutrients, Algae	Good for screening-level assessments
BATHTUB	Steady State	Lake	1-D	Moderate	DO, nutrients, algae	Good for screening-level assessments; can provide more refined assessments if supporting data exist
QUAL2E	Steady State	River	1-D	Moderate	DO, nutrients, algae, bacteria	Good for low-flow assessments of conventional pollutants in rivers
WASP5	Dynamic	River or lake	1-D to 3-D	High	DO, nutrients, metals, organics	Excellent water quality capability; simple hydraulics
CE-QUAL-RIV1	Dynamic	River	1-D	High	DO, nutrients, algae	Good for conventional pollutants in hydraulically complex rivers
HSPF	Dynamic	River or lake	1-D	High	DO, nutrients, metals, organics, bacteria	Wide range of water quality capabilities, directly linked to watershed model
CE-QUAL-W2	Dynamic	Lake	2-D vertical	High	DO, nutrients, algae, some metals	Good for conventional pollutants in stratified lakes or impoundments
EFDC	Dynamic	River or lake	3-D	High	DO, nutrients, metals, organics, bacteria	Potentially applicable to all sites, if sufficient data exist

Spreadsheet Approaches

A wide range of simple methods are available to describe the relationship between pollutant loads and receiving water quality, for a variety of situations including rivers and lakes. These methods are documented in Mills et al. (1985). These approaches do not require specific computer software, and are designed to be implemented on a hand calculator or computer spreadsheet. These approaches have the benefit of relatively low data requirements, as well as being easy to apply. Because of their simplistic nature, these approaches are best considered as screening procedures incapable of producing highly accurate results. They do provide good initial estimates of the primary cause-effect relationships.

EUTROMOD

EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables, distributed by the North American Lake Management Society (Reckhow 1990). The modeling system first estimates phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al. (1980) and Reckhow and Simpson (1980). The model accounts for both point and nonpoint source loads. Statistical algorithms are based on regression analyses performed on cross-sectional lake data. These algorithms predict in-lake phosphorus, nitrogen, hypolimnetic dissolved oxygen, chlorophyll, and trihalomethane precursor concentrations, and transparency (Secchi depth). The model also estimates the likelihood of blue-green bacteria dominance in the lake. Lake morphometry and hydrologic characteristics are incorporated in these algorithms. EUTROMOD also has algorithms for estimating uncertainty associated with the trophic state variables and hydrologic variability and estimating the confidence interval about the most likely values for the various trophic state indicators.

BATHTUB

BATHTUB is a software program for estimating nutrient loading to lakes and reservoirs, summarizing information on in-lake water quality data, and predicting the lake/reservoir response to nutrient loading (Walker 1986). It was developed, and is distributed, by the U.S. Army Corps of Engineers. BATHTUB consists of three modules: FLUX, PROFILE, and BATHTUB (Walker 1986). The FLUX module estimates nutrient loads or fluxes to the lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified. PROFILE is an analysis module that permits the user to display lake water quality data. PROFILE algorithms can be used to estimate hypolimnetic oxygen depletion rates, area-weighted or mixed layer average constitutent concentrations, and similar trophic state indicators. BATHTUB is the module that predicts lake/reservoir responses to nutrient fluxes. Because reservoir ecosystems typically have different characteristics than many natural lakes, BATHTUB was developed to specifically account for some of these differences, including the effects of non-algal turbidity on transparency and algae responses to phosphorus.

BATHTUB contains a number of regression equations that have been calibrated using a wide range of lake and reservoir data sets. It can treat the lake or reservoir as a continuously stirred, mixed reactor, or it can predict longitudinal gradients in trophic state variables in a reservoir or narrow lake. These trophic state variables include in-lake total and ortho-phosphorus, organic nitrogen, hypolimnetic dissolved oxygen, metalimnetic dissolved oxygen, and chlorophyll concentrations, and Secchi depth (transparency).

Uncertainty estimates are provided with predicted trophic state variables. There are several options for estimating uncertainty based on the distribution of the input and in-lake data. Both tabular and graphical displays are available from the program.

QUAL2E

QUAL2E is a one-dimensional water quality model that assumes steady-state flow, but allows simulation of diurnal variations in dissolved oxygen and temperature. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model simulates the following state variables: temperature, dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, inorganic phosphorus, organic phosphorus, algae, and conservative and non-conservative substances. QUAL2E also includes components that allow implementation of uncertainty analyses using sensitivity analysis, first-order error analysis, or Monte Carlo simulation. QUAL2E has been used for wasteload allocation purposes throughout the United States. QUAL2E is also linked into EPA's BASINS modeling system.

The primary advantages of using QUAL2E include its widespread use and acceptance, and ability to simulate all of the conventional pollutants of concern. Its disadvantage is that it is restricted to one-dimensional, steady-state analyses.

WASP5

WASP5 is EPA's general-purpose surface water quality modeling system. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model can be applied in one, two, or three dimensions and is designed for linkage with the hydrodynamic model DYNHYD5. WASP5 has also been successfully linked with other one, two, and three dimensional hydrodynamic models such as RIVMOD, RMA-2V and EFDC. WASP5 can also accept user-specified advective and dispersive flows. WASP5 provides separate submodels for conventional and toxic pollutants. The EUTRO5 submodel describes up to eight state variables in the water column and bed sediments: dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, organic phosphorus, and phytoplankton. The TOXI5 submodel simulates the transformation of up to three different chemicals and three different solids classes.

The primary advantage of using WASP5 is that it provides the flexibility to describe almost any water quality constituent of concern, along with its widespread use and acceptance. Its primary disadvantage is that it is designed to read hydrodynamic results only from the one-dimensional RIVMOD-H and DYNHYD5 models. Coupling of WASP5 with multi-dimensional hydrodynamic model results will require extensive site-specific linkage efforts.

CE-QUAL-RIV1

CE-QUAL-RIV1 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. Water quality state variables consist of temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, dissolved iron, and dissolved manganese. The effects of algae and macrophytes can also be included as external forcing functions specified by the user.

The primary advantage of CE-QUAL-RIV1 is its direct link to an efficient hydrodynamic model. This makes it especially suitable to describe river systems affected by dams or experiencing extremely rapid changes in flow. Its primary disadvantage is that it simulates conventional pollutants only, and contains limited eutrophication kinetics. In addition, the effort and data required to support the CE-QUAL-RIV1 hydrodynamic routines may not be necessary in naturally flowing rivers.

HSPF

HSPF (Hydrological Simulation Program - FORTRAN) is a one-dimensional modeling system for simulation of watershed hydrology, point and non-point source loadings, and receiving water quality for both conventional pollutants and toxicants (Bicknell et al, 1993). It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The water quality component of HSPF allows dynamic simulation of both conventional pollutants (i.e. dissolved oxygen, nutrients, and phytoplankton) and toxics. The toxics routines combine organic chemical process kinetics with sediment balance algorithms to predict dissolved and sorbed chemical concentrations in the upper sediment bed and overlying water column. HSPF is also linked into EPA's BASINS modeling system.

The primary advantage of HSPF is that it exists as part of a linked watershed/receiving water modeling package. Nonpoint source loading and hydrodynamic results are automatically linked to the HSPF water quality submodel, such that no external linkages need be developed.

CE-QUAL-W2

CE-QUAL-W2 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. CE-QUAL-W2 simulates variations in water quality in the longitudinal and lateral directions, and was developed to address water quality issues in long, narrow reservoirs. Water quality state variables consist of temperature, algae, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, and dissolved iron.

The primary advantage of CE-QUAL-W2 is the ability to simulate the onset and breakdown of vertical temperature stratification and resulting water quality impacts. It will be the most appropriate model for those cases where these vertical variations are an important water quality consideration. In un-stratified systems, the effort and data required to support the CE-QUAL-W2 hydrodynamic routines may not be necessary.

EFDC

EFDC (Environmental Fluid Dynamics Code) is a three-dimensional hydrodynamic and water quality model supported by the U. S. EPA Ecosystems Research Division. EFDC simulates variations in water quality in the longitudinal, lateral and vertical directions, and was developed to address water quality issues in rivers, lakes, reservoirs, wetland systems, estuaries, and the coastal ocean. EFDC transports salinity, heat, cohesive or noncohesive sediments, and toxic contaminants that can be described by equilibrium partitioning between the aqueous and solid phases. Unique features of EFDC are its ability to simulate wetting and drying cycles, it includes a near field mixing zone model that is fully coupled with a far field transport of salinity, temperature, sediment, contaminant, and eutrophication variables. It also contains hydraulic structure representation, vegetative resistance, and Lagrangian particle tracking. EFDC accepts radiation stress fields from wave refraction-diffraction models, thus allowing the simulation of longshore currents and sediment transport.

The primary advantage of EFDC is the ability to combine three-dimensional hydrodynamic simulation with a wide range of water quality modeling capabilities in a single model. The primary disadvantages are that data needs and computational requirements can be extremely high.

MODEL SELECTION

A wide range of watershed and water quality modeling tools is available and potentially applicable to develop TMDLs for the ten waterbodies in the Skillet Fork watershed. This chapter presents the general guidelines used in model selection process, and then applies these guidelines to make specific recommendations.

General Guidelines

A wide range of watershed and water quality modeling tools is available and potentially applicable to develop TMDLs. This section provides the guidelines to be followed for the model selection process, based upon work summarized in (DePinto et al, 2004). Three factors will be considered when selecting an appropriate model for TMDL development:

- **Management objectives:** Management objectives define the specific purpose of the model, including the pollutant of concern, the water quality objective, the space and time scales of interest, and required level or precision/accuracy.
- **Available resources:** The resources available to support the modeling effort include data, time, and level of effort of modeling effort
- **Site-specific characteristics:** Site-specific characteristics include the land use activity in the watershed, type of water body (e.g. lake vs. river), important transport and transformation processes, and environmental conditions.

Model selection must be balanced between competing demands. Management objectives typically call for a high degree of model reliability, although available resources are generally insufficient to provide the degree of reliability desired. Decisions are often required regarding whether to proceed with a higher-than-desired level of uncertainty, or to postpone modeling until additional resources can be obtained. There are no simple answers to these questions, and the decisions are often made using best professional judgment.

The required level of reliability for this modeling effort is one able to “support development of a credible TMDL”. The amount of reliability required to develop a credible TMDL depends, however, on the degree of implementation to be included in the TMDL. TMDL implementation plans that require complete and immediate implementation of strict controls will require much more model reliability than an implementation plan based upon adaptive management which allows incremental controls to be implemented and includes follow-up monitoring of system response to dictate the need for additional control efforts.

The approach to be taken here regarding model selection is to provide recommendations which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date. Alternative methodologies are also provided that will support the development of differing levels of TMDL implementation plans. For each approach, the degree of implementation that can be supported to produce a credible TMDL will be provided. Specific recommendations are provided which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date.

Model Selection for Waterbodies in the Skillet Fork Watershed

Tables 1 and 2 summarized the characteristics of the various watershed and water quality methodologies with potential applicability to TMDL development. This section reviews the relevant site-specific characteristics of the systems, summarizes the data available, and provides recommended approaches. Data needs, assumptions, and level of TMDL implementation support are provided for each of the recommended approaches.

Site Characteristics

Watershed characterization for the Skillet Fork watershed was provided in the first quarterly status report (LTI, 2004). In summary, this watershed is located in Southeastern Illinois, approximately 10 miles east of the city of Mount Vernon and the intersection of Interstates 57 and 64. Skillet Fork is a tributary to the Little Wabash River, with its confluence located three miles northeast of Carmi, Illinois, near river mile 39. Brief descriptions of each of the listed segments in the Skillet Fork watershed are provided below.

Skillet Fork (CA03) – Skillet Fork Segment CA03 is 7.13 miles in length and its watershed is 672,425 acres in size. The watershed draining to this segment is the entire Skillet Fork project watershed. Portions of the Skillet Fork watershed lie in Clay, Marion, Wayne, Jefferson, White and Hamilton counties. Major tributaries in the watershed include Horse Creek, Auxier Ditch, Dry Fork, Big Creek, Brush Creek, Dums Creek and Sevenmile Creek. Land use is predominantly agricultural, forest and grassland. Primary crops are soybeans (51%), corn (32%) and winter wheat, other small grains and hay (17%). Atrazine application is fairly common throughout the watershed and the soils in this region are enriched in manganese. There are a number of large CAFOs in the watershed draining to this segment with others located farther upstream. Seventeen entities were identified that are permitted to discharge treated wastewater to Skillet Fork or its tributaries. Ten of these are municipal discharges, one is a water treatment plant, two are gas or oil company operations, two serve the Stephen A. Forbes State Park facilities, one is a rest area, and one serves a school.

The listing of Skillet Fork (CA03) on the Illinois 303(d) list for impairment due to dissolved oxygen, manganese, fecal coliform, pH and atrazine has been confirmed based on a review of the data. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and algal respiration. A review of ammonia and dissolved oxygen data suggest that ammonia is not a significant source and that there are other factors besides ammonia that are contributing to the low observed dissolved oxygen. There were insufficient data to assess the relationship between sediment oxygen demand (SOD) and DO, carbonaceous biochemical oxygen demand (CBOD) and DO, and chlorophyll and DO. Based on the watershed characterization, it was determined that potential sources of nutrients, ammonia and BOD may include: municipal point sources, failing private sewage disposal systems, runoff from agricultural land (fertilized cropland and agricultural land with livestock) and intensive animal feeding operations. Low flows and high temperatures also appear to contribute to the low dissolved oxygen concentrations in this segment.

The observed manganese concentrations in the lake likely reflect natural background conditions (soils in the watershed are naturally high in manganese), although brine from oil wells may also contribute to the elevated concentrations. Because of the naturally high levels of manganese in the soils, the general use criterion may be difficult to attain.

Potential sources of fecal coliform include farms with livestock and intensive agricultural livestock operations, sewage treatment plants, and failing septic systems. Elevated fecal concentrations were identified in upstream segments and therefore the fecal sources are not all specific to this segment.

Potential sources contributing to the pH excursions are unclear from the data, but the naturally acidic nature of the soils is suspected of contributing to the problem.

The primary source of atrazine is non-irrigated cropland.

Skillet Fork (CA05) - Skillet Fork Segment CA05 is 10.96 miles in length and its subwatershed is 372,134 acres in size. This segment is entirely within Wayne County and flows through Wayne City, open agricultural areas and some forested lands. A portion of the subwatershed lies within Jefferson County. The communities of Bluford, Johnsonville, Sims and Keene are also in this subwatershed. Approximately 58% of the land is used for agriculture, and approximately 23% is forested. Point sources in this segments subwatershed include: Wayne City South STP, Wayne City WTP, Bluford STP, Trunkline Gas Co.-Johnsonville, IL DNR S. A. Forbes State Park, IL DNR Stephen Forbes State Park, Xenia STP, Iuka STP and Prosise Oil Co.

The listing of Skillet Fork (CA05) on the Illinois 303(d) list for impairment due to dissolved oxygen, manganese, pH and atrazine has been confirmed based on a review of the data. The discussion of sources contributing to low dissolved oxygen, manganese, pH and atrazine in Skillet Fork Segment CA03 also applies to Segment CA05, with two exceptions: algal respiration and ammonia nitrification are not thought to be significant factors contributing to low dissolved oxygen in this segment (CA05).

Skillet Fork (CA06) - Skillet Fork Segment CA06 is 16.63 miles in length and its subwatershed is 166,494 acres in size. It is in the upper portion of the watershed, originating at the confluence of Nickolson Creek with the main stem Skillet Fork and ending at the confluence of Brush Creek with the main stem. Other tributaries draining to this segment include Turner Creek, Poplar Creek and Paintrock Creek. This segment begins in Marion County and ends in Wayne County with approximately half of the segment in each county. Portions of the subwatershed lie within Clay and Jefferson counties. The stream flows through open agricultural areas and some forested lands. Point sources in this segment's subwatershed include: IL DNR S. A. Forbes State Park, IL DNR Stephen Forbes State Park, Iuka STP, Xenia STP and Prosise Oil Co. Approximately 57% of the land is used for agriculture, and approximately 26% is forested.

The listing of Skillet Fork (CA06) on the Illinois 303(d) list for impairment due to dissolved oxygen, manganese, pH and atrazine has been confirmed based on a review of the data. The discussion of sources contributing to low dissolved oxygen, manganese, pH and atrazine in Skillet Fork Segment CA03 also applies to Segment CA06.

Skillet Fork (CA09) - Skillet Fork Segment CA09 is 19.77 miles in length and its subwatershed is 60,263 acres in size. It is the most upstream segment of the main stem, originating at the headwaters and extending downstream to the confluence with Dums Creek. Other tributaries draining to this segment include Lost Fork (which includes Stephen A. Forbes Lake), Sutton Creek and Pickle Creek. This segment itself is entirely within Marion County but a portion of the subwatershed is in Clay County. Approximately 64% of the land is used for agriculture, and approximately 18% is forested. Point source dischargers located within this subwatershed include: the Prosise Oil Company, IL DNR S. A. Forbes State Park, IL DNR Stephen Forbes State Park, and the Iuka STP (discharge enters the most downstream end of this segment).

The listing of Skillet Fork (CA09) on the Illinois 303(d) list for impairment due to dissolved oxygen has been confirmed based on a review of the data. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Although there were insufficient data to assess the relationship between ammonia and dissolved oxygen, SOD and DO, CBOD and DO, and chlorophyll and DO, potential sources in this watershed were identified through the watershed characterization. These sources may include runoff from agricultural land (fertilized cropland and agricultural land with livestock) and failing private sewage disposal systems (lesser extent).

Horse Creek (CAN01) - Horse Creek Segment CAN 01 is 28.21 miles in length and its subwatershed is 64,040 acres in size. The stream flows through open agricultural areas and some forested and grass lands. Very small areas of the communities of Kell and Bluford are in the subwatershed. Approximately 41% of the land is used for agriculture, approximately 30% is forested and approximately 22% is grassland. The water in the creek was observed to be coffee-colored and very slow moving during a site visit on June 24, 2004. Deeply incised, steep stream banks and sediment islands were also observed. Also noted (by smell) during the site visit was a hog operation just north of Horse Creek. The riparian zone was heavily wooded with many trees and shrubs that shade the creek very well. The point source discharger in this watershed is the Bluford STP.

The listing of Horse Creek (CAN01) on the Illinois 303(d) list for impairment due to manganese and low dissolved oxygen has been confirmed based on a review of the data. Potential sources of manganese include: natural background sources, oil well brine, and streambank erosion. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Potential sources contributing to one or more of these causes include failing private sewage disposal systems (lesser extent), runoff from agricultural land (fertilized cropland and agricultural land with livestock), a permitted point source discharger, and an intensive animal feeding operation.

Brush Creek (CAR01) - Brush Creek Segment CAR 01 is 21.27 miles in length and its subwatershed is 35,834 acres in size. The entire creek length is included in the segment, which drains to Skillet Fork at the terminus of Skillet Fork segment CA06. Brush Creek has several smaller tributaries and ditches that drain to it. The largest of the tributaries include Johnson Fork and Gum Branch. The outlet for Sam Dale Lake also drains to Brush Creek. The headwaters of the creek are in Clay County but the majority of the stream and subwatershed are in Wayne County. There are no incorporated municipalities within the subwatershed boundaries. Approximately 57% of the land is used for agriculture and approximately 28% is forested. There are no point source discharges located within the Brush Creek subwatershed.

The listing of Brush Creek (CAR01) on the Illinois 303(d) list for impairment due to dissolved oxygen and manganese has been confirmed based on a review of the data. Potential sources contributing to the listing of this segment for manganese include: natural background sources, oil well brine, and streambank erosion. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Low dissolved can be exacerbated by low flow and/or high temperature conditions, similar to what was observed in Skillet Fork. Although the data were not available to determine the primary causes of low dissolved oxygen, potential sources of nutrients, ammonia and BOD include failing private sewage disposal systems (lesser extent), and runoff from agricultural land (fertilized cropland and agricultural land with livestock).

Dums Creek (CAW01) - Dums Creek Segment CAW 01 is 25.38 miles in length and its subwatershed is 33,727 acres in size. The entire creek length is included in the segment, which drains to Skillet Fork at the terminus of Skillet Fork segment CA09 near the Highway 50 bridge. Bee Branch is the only significant tributary to Dums Creek but there are several smaller tributaries and ditches that drain to it. Dums Creek is located entirely within Marion County. The Marion County Prairie Chicken Sanctuary is located near the headwaters of the creek. The community of Iuka is the only incorporated municipality within the subwatershed boundaries. Approximately 67% of the land is used for agriculture and approximately 18% is forested. During a site visit on June 24, 2004, much bank incision was observed at Omega Road, with many trees undercut and falling (or fallen) into the creek. This suggests that stream bank erosion is a concern. There are no point source dischargers located within this subwatershed.

The listing of Dums Creek (CAW01) on the Illinois 303(d) list for impairment due to dissolved oxygen has been confirmed based on a review of the data. Causes of low dissolved oxygen typically include sediment oxygen demand, degradation of CBOD, nitrification of ammonia and/or algal respiration. Low dissolved can be exacerbated by low flow and/or high temperature conditions, similar to what was observed in Skillet Fork. Although the data were not available to determine the primary causes of low dissolved oxygen, potential sources of nutrients, ammonia and BOD include failing private sewage disposal systems (lesser extent), and runoff from agricultural land (fertilized cropland and agricultural land with livestock).

Sam Dale Lake (RBF) - Sam Dale Lake is located in Wayne County and is 194 acres in size. Its subwatershed is 4,342 acres in size. Water enters the lake through direct drainage from the subwatershed. The outlet, at the western end of the lake, drains to a small tributary of Brush Creek. The Sam Dale Lake Conservation Area surrounds the lake and is largely forested. The lake is generally clear compared to the surrounding creeks. Excessive algae problems tend to occur in the Trout Pond, rather than in the lake itself. The Trout Pond is a small pond that drains through a ditch into Sam Dale Lake. Land use upstream of the conservation area is primarily cropland, corn and soybeans. There are no point source dischargers located within this subwatershed.

The listing of Sam Dale Lake (RBF) on the Illinois 303(d) list for impairment due to total phosphorus has been confirmed based on a review of the data. Potential phosphorus sources include sediment phosphorus release from the lake bottom sediments under anoxic conditions and watershed runoff from agricultural lands.

Stephen A. Forbes Lake (RCD) - Stephen A. Forbes Lake is located in Marion County and is 525 acres in size. This lake was completed in 1963 and has 18 miles of shoreline. Its subwatershed is 13,628 acres in size. The lake is an impoundment of Lost Fork, a tributary to the Skillet Fork segment CA09 in the upper portion of the watershed. Lost Fork and an unnamed tributary provide flow to the upper end of the lake. Several smaller tributaries, including Philips Branch, Mountain Branch and Rocky Branch, also flow to the lake. The lake is the centerpiece of the Stephen A. Forbes State Recreation Area.). Based on a conversation with the site superintendent, the lake has algae blooms and the general condition is murky and unclear, especially in the upstream, shallower areas. After a period of low rainfall, the lake becomes somewhat clearer, perhaps to a Secchi depth of 3 ft. There is little to no discharge of groundwater to the lakes or their tributaries due to the presence of impermeable loess deposits that are typically located in the upper five feet of the stratigraphic column (Illinois Department of Conservation, ca. 1993). There are no municipalities in the lake's subwatershed. Outside of the park, land use is primarily for cropland.

The listing of Stephen A. Forbes Lake (RCD) on the Illinois 303(d) list for impairment due to total phosphorus has been confirmed based on a review of the data. Potential phosphorus sources include sediment phosphorus release from the lake bottom sediments under anoxic conditions and watershed runoff from agricultural lands.

Wayne City Side Channel Reservoir (RCT) - The Wayne City Side Channel Reservoir (Wayne City SCR) is located just north of Wayne City near Skillet Fork segment CA05 and Shoe Creek. It is an 8-acre reservoir created by diverting a portion of the flow from Skillet Fork and is used as a drinking water source for the residents of Wayne City. It is contained entirely within the subwatershed for Skillet Fork segment CA05. The reservoir does not have a subwatershed per se, since it is an artificially constructed water body surrounded by a constructed berm and thus, receives little to no runoff from direct drainage. The communities of Bluford, Johnsonville, Sims and Keene are in this subwatershed. Approximately 58% of the land is used for agriculture, and approximately 23% is forested. Point sources in this segments subwatershed include: Wayne City South STP, Wayne City WTP, Bluford STP, Trunkline Gas Co.-Johnsonville, IL DNR S. A. Forbes State Park, IL DNR Stephen Forbes State Park, Xenia STP, Iuka STP and Prosise Oil Co.

The listing of Wayne City Side Channel Reservoir (RCT) on the Illinois 303(d) list for impairment due to manganese has been confirmed based on a review of the data. Potential sources of manganese include release of manganese from lake bottom sediments during summer anoxic conditions, and natural watershed sources (soils are naturally high in manganese).

Data Available

Table 3 provides a summary of available water quality data from the first quarterly status report (LTI, 2004). This amount of data is sufficient to confirm the presence of water quality impairment, but not sufficient to support development of a rigorous watershed or water quality model. Specific items lacking in this data set include tributary loading data for all pollutants of concern, especially for the lakes and chlorophyll a data to better define the processes controlling dissolved oxygen throughout the lake.

Table 3. Water Quality Data Summary for the Skillet Fork Watershed

Waterbody Segment	Parameter	Sampling Station	Period of Record (#)	Minimum	Maximum	Average
Skillet Fork CA03	Dissolved Oxygen (mg/L)	CA 02[a]	5/2001-9/2001 (3 samples)	7.60	11.20	9.03
		CA 03	1/1994-4/2003 (80 samples)	0.80	15.90	8.13
		CAGC01[a]	7/1998-9/2001 (5 samples)	5.80	12.30	8.32
		CAJ 01[a]	7/1998-9/2001 (5 samples)	4.40	11.90	7.20
	Manganese (ug/L)	CA 02[a]	5/2001-9/2001 (3 samples)	180	390	270
		CA 03	1/1994-4/2003 (82 samples)	78	1,700	577
		CAGC01[a]	7/1998-9/2001 (5 samples)	120	620	268
		CAJ 01[a]	7/1998-9/2001 (5 samples)	120	290	192
	pH (S.U.)	CA 02[a]	5/2001-9/2001 (3 samples)	8.10	8.40	8.20
		CA 03	1/1994-4/2003 (82 samples)	6.10	8.57	7.26
		CAGC01[a]	7/1998-9/2001 (5 samples)	7.60	7.90	7.72
		CAJ 01[a]	7/1998-9/2001 (5 samples)	6.80	7.70	7.32
	Atrazine (ug/L)	CA 03	4/1998-7/2001 (5 samples)	<0.10	15.00	4.22
	Fecal coliform (cfu/100 ml)	CA 03	1/1994-12/1998 (39 samples)	<2	5,700	577
Skillet Fork CA05	Dissolved Oxygen (mg/L)	CA 05	1/1994-6/2003 (81 samples)	3.20	12.90	7.42
		CA 07[a]	8/1998-9/2001 (6 samples)	3.80	10.40	5.37
	Manganese (ug/L)	CA 05	1/1994-6/2003 (81 samples)	97	1,600	511
		CA 07[a]	8/1998-9/2001 (6 samples)	270	980	507
	pH (S.U.)	CA 05	1/1994-6/2003 (81 samples)	6.10	8.90	7.28
		CA 07[a]	8/1998-9/2001 (6 samples)	7.00	7.40	7.15
	Atrazine (ug/L)	CA 05	4/1996-6/2001 (11 samples)	<0.10	14.00	4.82

Waterbody Segment	Parameter	Sampling Station	Period of Record (#)	Minimum	Maximum	Average
Skillet Fork CA06	Dissolved Oxygen (mg/L)	CA 06	1/1994-4/2003 (79 samples)	2.20	12.70	7.48
		CA 08[a]	8/1998-9/2001 (3 samples)	4.40	10.90	6.67
	Manganese (ug/L)	CA 06	1/1994-4/2003 (80 samples)	96	7,000	612
		CA 08[a]	8/1998-9/2001 (4 samples)	230	610	415
	pH (S.U.)	CA 06	1/1994-4/2003 (80 samples)	6.00	8.20	7.10
		CA 08[a]	8/1998-9/2001 (4 samples)	7.10	7.70	7.30
	Atrazine (ug/L)	CA 06	4/1998-6/2001 (5 samples)	0.16	16.00	5.06
Skillet Fork CA09	Dissolved Oxygen (mg/L)	CA 09	7/1998-7/2001 (3 samples)	2.80	12.30	6.00
Horse Creek CAN 01	Dissolved Oxygen (mg/L)	CAN 01	7/1998-7/2001 (4 samples)	3.10	12.90	6.43
	Manganese (ug/L)	CAN 01	7/1998-9/2001 (5 samples)	230	1500	552
Brush Creek CAR 01	Dissolved Oxygen (mg/L)	CAR 01	7/1998-9/2001 (5 samples)	2.30	11.90	6.62
	Manganese (ug/L)	CAR 01	7/1998-9/2001 (5 samples)	260	1,600	950
Dums Creek CAW 01	Dissolved Oxygen (mg/L)	CAW 01	8/1998-9/2001 (5 samples)	2.2	14.5	5.38
Sam Dale Lake RBF	Total Phosphorus (mg/L)	RBF-1	4/1992-10/2002 (30 samples)	0.05	1.45	0.23
		RBF-2	4/1992-10/2002 (15 samples)	0.05	0.34	0.20
		RBF-3	4/1992-10/2002 (15 samples)	0.06	0.74	0.26
Stephen A. Forbes Lake RCD	Total Phosphorus (mg/L)	RCD-1	1/1994-10/2001 (23 samples)	0.04	0.78	0.15
		RCD-2	4/1998-10/2001 (10 samples)	0.05	0.12	0.08
		RCD-3	4/1998-10/2001 (10 samples)	0.08	0.38	0.16
Wayne City Side Channel Reservoir RCT	Manganese (ug/L)	RCT-1	4/2001-10/2001 (5 samples)	120	330	196

[a] Indicates monitoring station is located upstream of assessed segment. These stations were not located within the listed segment. Data collected at these stations were used to help identify sources, but were not used in determining whether the data support the segment listing.

Recommended Approaches

This section provides recommendations for specific modeling approaches to be applied for the stream and lake segments in the Skillet Fork Watershed. Recommended and alternate approaches are provided (where appropriate) in Tables 4, 5 and 6 for the stream segments, and in Table 7 for the three reservoirs, with each approach having unique data needs and resulting degree of detail.

Table 4. Recommended Modeling Approaches for Skillet Fork Segments CA03, CA05, and CA06

Modeling Approach	Pollutants considered	Watershed Model	Water Quality Model	Additional data needs	Level of TMDL implementation supported
Recommended					
	Dissolved oxygen	Empirical approach	QUAL2E	Low flow stream surveys	Identify primary sources to be controlled and approx. level of control needed
	Manganese, pH	Empirical approach	Spreadsheet approach	Low flow stream surveys	Identify manmade versus natural sources
	Atrazine	Load duration curve		Low and high flow stream surveys	Identify whether sources occur during dry or wet weather; and identify approximate level of control needed
	Fecal coliform (CA03 only)	Load duration curve		None	Identify whether sources occur during dry or wet weather; and identify approximate level of control needed
Alternative					
	Fecal coliform (CA03)	HSPF	HSPF	Tributary flow and coliform concentrations at multiple locations	Define specific sources of bacteria and detailed control strategies

The recommended modeling approach for Skillet Fork segments CA03, CA05, and CA06 consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese and pH impairments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach. QUAL2E was selected for dissolved oxygen modeling because it is the most commonly used water quality model for addressing low flow conditions. Because problems appear to be restricted to low flow conditions, watershed loads are not expected to be significant contributors to the impairment. For this reason, an empirical approach was selected for determining watershed loads. For these same segments, development of a load-duration curve is recommended to address atrazine impairments. A load-duration curve is also recommended for addressing fecal coliform impairments in segment CA03.

A load-duration curve is a graphical representation of observed pollutant load compared to maximum allowable load over the entire range of flow conditions. Such a graph can be developed by 1) developing a flow duration curve by ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results as shown in Figure 1; 2) translating the flow duration curve into a load duration curve by multiplying the flows by the water quality standard as shown in Figure 2; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph as shown in Figure 3.

% Exceed	Flow
99	694.2
95	803.3
90	920.2
85	1213.3
80	1629.7
75	2081.3
70	2692.9
65	3130.3
60	3583.3
55	4177.9
50	5092.2
45	6074.7
40	7068.8
35	8398.1
30	9801.8
25	11617.5
20	13838.5
15	17136.8
10	22281.1

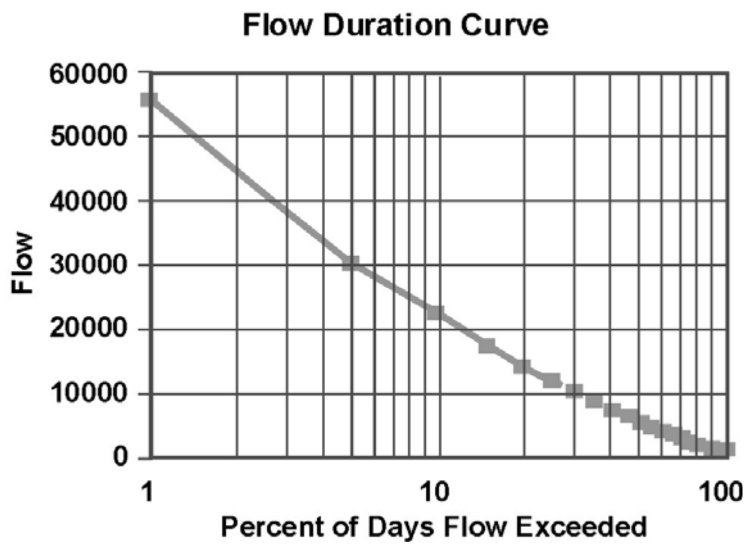

Figure 1. Calculation of a Flow Duration Curve (from Freedman et al., 2003)

% Exceed	Flow	Atrazine (lbs/day)
99	694.2	11.50
95	803.3	13.31
90	920.2	15.25
85	1213.3	20.10
80	1629.7	27.00
75	2081.3	34.49
70	2692.9	44.62
65	3130.3	51.87
60	3583.3	59.38
55	4177.9	69.23
50	5092.2	84.38
45	6074.7	100.66
40	7068.8	117.13
35	8398.1	139.16
30	9801.8	162.42
25	11617.5	192.50
20	13838.5	229.30
15	17136.8	283.96
10	22281.1	369.20
5	30245.9	501.17
1	55562.3	920.67

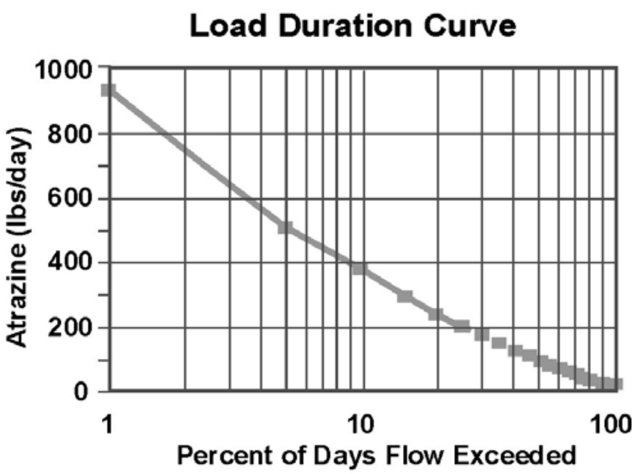

Figure 2. Calculation of a Load Duration Curve (from Freedman et al., 2003)

% Exceed	Flow	Atrazine (lbs/day)	Atrazine Load
99	694.2	11.50	4.33
95	803.3	13.31	
90	920.2	15.25	
85	1213.3	20.10	12.92
80	1629.7	27.00	
75	2081.3	34.49	
70	2692.9	44.62	122.91
65	3130.3	51.87	
60	3583.3	59.38	95.87
55	4177.9	69.23	
50	5092.2	84.38	
45	6074.7	100.66	
40	7068.8	117.13	
35	8398.1	139.16	
30	9801.8	162.42	
25	11617.5	192.50	
20	13838.5	229.30	
15	17136.8	283.96	154.43
10	22281.1	369.20	804.32
5	30245.9	501.17	
1	55562.3	920.67	

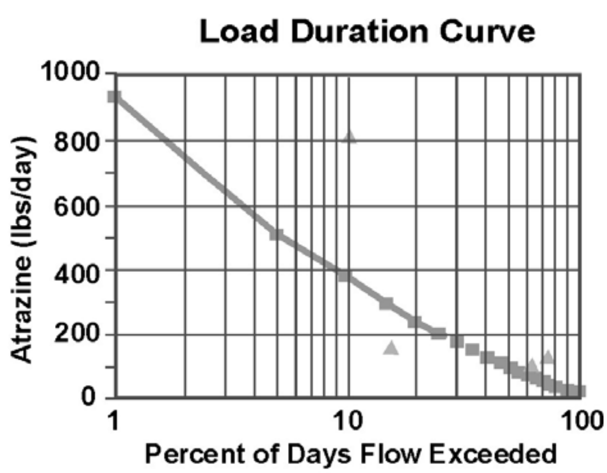

Figure 3. Load Duration Curve with Observed Loads (from Freedman et al., 2003)

The load duration curve provides information to:

- Help identify the issues surrounding the problem and differentiate between point and nonpoint source problems, as discussed immediately below;
- Address frequency of deviations (how many samples lie above the curve vs. those that plot below), and duration (potentially how long the deviation is present) questions; and
- Aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards for different flow conditions.

The location of loads that plot above the load duration curve is meaningful. Loads which plot above the curve in the area of the plot defined as being exceeded 85-99 percent of the time are considered indicative of point source influences on the water quality. Those loads plotting above the curve over the range of 10-70 percent exceedence likely reflect nonpoint source load contributions. NPS loads are pollution associated with runoff or snowmelt from numerous, dispersed sources over an extended area. Some combination of the two source categories lies in the transition zone of 70-85 percent exceedence. Those loads plotting above the curve at exceedences less than 10 percent or more than 99 percent reflect extreme hydrologic conditions of flood or drought (Freedman et al, 2003).

The load duration curve approach will identify broad categories of coliform sources and the extent of control required from these sources to attain water quality standards.

The alternative approach for fecal coliform in Skillet Fork (CA03) consists of applying the HSPF model to define watershed loads for all fecal coliform sources and using the water quality component of this model to simulate in-stream concentrations and water quality response. This approach, coupled with intensive monitoring, would define specific sources of bacteria and identify detailed control strategies necessary to attain water quality standards.

Table 5. Recommended Modeling Approaches for Skillet Fork Segment CA09 and Dums Creek (CAW01)

Modeling Approach	Pollutants considered	Watershed Model	Water Quality Model	Additional data needs	Level of TMDL implementation supported
Recommended					
	Dissolved oxygen	Empirical approach	QUAL2E	Low flow stream surveys	Identify primary sources to be controlled and approx. level of control needed

The recommended modeling approach for Skillet Fork segment CA09 and Dums Creek (CAW01) consists of using the water quality model QUAL2E to address dissolved oxygen problems. Watershed loads for this segment will be defined using an empirical approach. QUAL2E was selected for dissolved oxygen modeling because it is the most commonly used water quality model for addressing low flow conditions. Because problems appear to be restricted to low flow conditions, watershed loads are not expected to be significant contributors to the impairment. For this reason, an empirical approach was selected for determining watershed loads.

Table 6. Recommended Modeling Approaches for Horse Creek (CAN01) and Brush Creek (CAR01)

Modeling Approach	Pollutants considered	Watershed Model	Water Quality Model	Additional data needs	Level of TMDL implementation supported
Recommended					
	Dissolved oxygen	Empirical approach	QUAL2E	Low flow stream surveys	Identify primary sources to be controlled and approx. level of control needed
	Manganese	Empirical approach	Spreadsheet approach	Low flow stream surveys	Identify manmade versus natural sources

The recommended modeling approach for Horse Creek (CAN01) and Brush Creek (CAR01) consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese impairments in these two segments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach. QUAL2E was selected for dissolved oxygen modeling because it is the most commonly used water quality model for addressing low flow conditions. Because problems appear to be restricted to low flow conditions, watershed loads are not expected to be significant contributors to the impairment. For this reason, an empirical approach was selected for determining watershed loads.

The recommended modeling approach for Wayne City Side Channel Reservoir, Sam Dale Lake, and Stephen A. Forbes Lake consists of using the GWLF and BATHTUB models. Specifically, GWLF will be applied to calculate phosphorus loads to these reservoirs over a time scale consistent with their respective nutrient residence times. BATHTUB will then be used to predict the relationship between phosphorus load and resulting in-lake phosphorus (for Sam Dale Lake and Stephen A. Forbes Lake) and dissolved oxygen concentrations (for Wayne City Side Channel Reservoir, where it assumed that the only controllable source of manganese is that which is released form lake sediments during periods of low dissolved oxygen.) This relationship will be used to define the dominant sources of phosphorus to the lakes, and the extent to which they must be controlled to attain water quality standards for phosphorus and manganese. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed lake data. GWLF was selected as the watershed model because it can provide loading information on the time-scale required by BATHTUB, with moderate data requirements that can be satisfied by existing data.

Table 7. Recommended Modeling Approaches for Wayne City Side Channel Reservoir (RCT), Sam Dale Lake (RBF) and Stephen A. Forbes Lake (RCD)

Modeling Approach	Waterbody	Pollutants considered	Watershed Model	Water Quality Model	Additional data needs	Level of TMDL implementation supported
Recommended						
	Sam Dale Lake, S.A. Forbes Lake	Total phosphorus	GWLF	BATHTUB	None	Identify primary sources to be controlled; and approximate level of control needed
	Wayne City Side Channel Reservoir	Manganese				
Alternative 1						
	Sam Dale Lake, S.A. Forbes Lake	Total phosphorus, Manganese	None	BATHTUB	None	Identify approximate level of control needed
	Wayne City Side Channel Reservoir	Total phosphorus				
Alternative 2						
	Sam Dale Lake, S.A. Forbes Lake	Total phosphorus, Manganese	SWAT	CE-QUAL-W2	Tributary flow and concentrations; lake concentrations	Define detailed control strategies
	Wayne City Side Channel Reservoir	Total phosphorus				

The first alternative approach would not include any watershed modeling for phosphorus, but would focus only on determining the pollutant loading capacity of the lake. Determination of existing loading sources and prioritization of restoration alternatives would be conducted by local experts as part of the implementation process. Based upon their recommendations, a voluntary implementation plan would be developed that includes both accountability and the potential for adaptive management.

The second alternative is provided in the event that more detailed implementation plans are desired. These frameworks recommended for the second alternative have significantly greater data requirements, and their use would require additional data collection.

<u>Assumptions Underlying the Recommended Methodologies</u>

The recommended approach is based upon the following assumptions:

- The only controllable source of manganese to Wayne City Side Channel Reservoir is that which enters from lake sediments during periods of low dissolved oxygen; this source can be (partially) controlled by reducing phosphorus loads and increasing hypolimnetic dissolved oxygen concentrations.
- A credible TMDL implementation plan can be developed based upon relatively simple models

LTI believes that these assumptions are appropriate.

DATA NEEDS FOR THE METHODOLOGIES TO BE USED

The recommended modeling approaches for Sam Dale Lake, Stephen A. Forbes Lake and Wayne City Side Channel Reservoir can be applied without collection of any additional data. The first alternative approach for these reservoirs can also be applied without any additional data collection. However, follow-up monitoring is strongly recommended after controls are implemented, to verify their effectiveness in reducing loads and documenting lake response.

Application of the recommended approaches for the stream segments in the Skillet Fork watershed will require conduct of additional field sampling to support TMDL development. The existing data, while sufficient to document impairment, are not sufficient to define the cause-effect relationships. Two low- to medium-flow surveys are recommended to synoptically measure sources and receiving water concentrations of oxygen demanding substances (all stream segments), manganese (segments CA03, CA05, CA06, CAN 01, CAR 01) and pH (segments CA03, CA05 and CA06) to support dissolved oxygen, manganese and pH modeling.

Application of the recommended approach for atrazine will also require conduct of additional field sampling to support TMDL development. The existing data, while sufficient to document impairment, are not sufficient to develop a load-duration curve. At least 5 atrazine samples are recommended for collection at a range of flows to support development of a load-duration curve for Skillet Fork segments CA03, CA05 and CA06.

Should the alternative approach be selected for Skillet Fork (segment CA03) for fecal coliform or the second alternative approach be selected for the three reservoirs, extensive data collection efforts would be required in order to calibrate the watershed and water quality models. The purpose of the detailed data collection is as follows:

1) define the distribution of specific loading sources throughout the watershed,
2) define the extent to which these loads are being delivered to the river or lake, and
3) define important reaction processes in Sam Dale Lake, Stephen A. Forbes Lake Lake, and Wayne City Side Channel Reservoir.

To satisfy objective one for the three lakes, wet weather event sampling of phosphorus (Sam Dale Lake and Stephen A. Forbes Lake) and manganese (Wayne City Side Channel Reservoir) at multiple tributary and mainstem locations in the watershed will be needed.

To satisfy objective one for Skillet Fork Segment CA03, wet weather event sampling of fecal coliform at multiple tributary and mainstem locations in the watershed will be needed. To satisfy objective two, routine monitoring of loads to the lake and to the creek will be needed. Flows could be estimated using the USGS gage on Skillet Fork at Wayne City, Illinois (03380500), however, because of the size of the watershed, the flows at this gage may not be reflective of precipitation patterns in other portions of the watershed, especially small streams and near the Skillet Fork headwaters. Therefore, it is recommended that flows be measured in the watershed near the headwaters of Skillet Fork, and on several tributaries to reflect watershed-specific flow conditions. It is also recommended that flows be measured on the primary tributaries to Sam Dale Lake and S.A. Forbes Lake. Water quality sampling and analyses would be required for several wet and dry weather events for the lakes for: total suspended solids, manganese (Wayne City Side Channel Reservoir only), total phosphorus, and ortho-phosphorus. Water quality sampling and analyses would be required for several wet and dry weather events for Skillet Fork (CA03) for total suspended solids and fecal coliform. To satisfy the third objective, routine in-lake monitoring will be needed. In the three lakes, bi-monthly sampling would need to be conducted for water temperature, in addition to total suspended solids, manganese (Wayne City Side Channel Reservoir only), total phosphorus, ortho-phosphorus, dissolved oxygen, and chlorophyll a.

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Third Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

October 2004

Skillet Fork Watershed

Skillet Fork (CA03, CA05, CA06, CA09),
Horse Creek (CAN 01), Brush Creek (CAR 01),
Dums Creek (CAW 01), Sam Dale Lake (RBF),
Stephen A. Forbes Lake (RCD), and
Wayne City Side Channel Reservoir (RCT)

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EXECUTIVE SUMMARY

This is the third in a series of quarterly status reports documenting work completed on the Skillet Fork project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA, 2004), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be completed for each pollutant listed for an impaired water body. TMDLs are prepared by the States and submitted to the U.S. EPA. In developing the TMDL, a determination is made of the greatest amount of a given pollutant that a water body can receive without exceeding water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review were presented in the first quarterly status report.

In a second quarterly status report, the methodologies/procedures/models to be used in the development of TMDLs were identified and described and models were recommended for application to the project watershed.
The intent of this third quarterly status report is to:

- Identify the amount of data needed to support the modeling (if additional data collection is recommended);
- Provide a general data collection plan; and
- Identify, to the extent possible, the responsible parties for additional data collection.

In future phases of this project, Illinois EPA and consultants will develop the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired water bodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) would be strictly voluntary.

Methods

The effort completed in the third quarter included summarizing additional data needs to support the recommended methodologies/procedures/models to be used in the development of TMDLs, and where needed, providing general information related to the data collection.

Results

The recommended modeling approach for Skillet Fork segments CA03, CA05, and CA06 consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese and pH impairments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach. For these same segments, development of a load-duration curve is recommended to address atrazine impairments. The recommended approach to address fecal coliform impairments in segment CA03 consists of developing a load-duration curve.

The recommended modeling approach for Skillet Fork segment CA09 and Dums Creek (CAW01) consists of using the water quality model QUAL2E to address dissolved oxygen problems. Watershed loads for this segment will be defined using an empirical approach.

The recommended modeling approach for Horse Creek (CAN01) and Brush Creek (CAR01) consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese impairments in these two segments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach.

The recommended modeling approach for Wayne City Side Channel Reservoir, Sam Dale Lake, and Stephen A. Forbes Lake consists of using the GWLF and BATHTUB models.

The recommended modeling approaches for Sam Dale Lake, Stephen A. Forbes Lake and Wayne City Side Channel Reservoir can be applied without collection of any additional data. Application of the recommended approaches for the stream segments in the Skillet Fork watershed will require conduct of additional field sampling to support TMDL development. The existing data, while sufficient to document impairment, are not sufficient to define the cause-effect relationships. Two low- to medium-flow surveys are recommended to synoptically measure sources and receiving water concentrations of oxygen demanding substances (all stream segments), manganese (segments CA03, CA05, CA06, CAN 01, CAR 01) and pH (segments CA03, CA05 and CA06) to support dissolved oxygen, manganese and pH modeling.

Application of the recommended approach for atrazine will also require conduct of additional field sampling to support TMDL development. The existing data, while sufficient to document impairment, are not sufficient to develop a load-duration curve. At least 5 atrazine samples are recommended for collection at a range of flows to support development of a load-duration curve for Skillet Fork segments CA03, CA05 and CA06.

INTRODUCTION/PURPOSE

This Stage 1 report describes intermediate activities related to the development of TMDLs for impaired water bodies in the Skillet Fork watershed. Earlier Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed, and the recommendation of models to support TMDL development.

The remaining sections of this report include:

- **Description of additional data collection, if any, to support modeling:** This section describes the amount (temporal and spatial) of data, if any, to be collected, and also includes a general description of a data collection plan. Potential parties that may be responsible for additional data collection are also identified.
- **Next steps**

DESCRIPTION OF ADDITIONAL DATA COLLECTION TO SUPPORT MODELING

In the second quarterly progress report for the Skillet Fork watershed (LTI, 2004), modeling approaches were recommended. The recommended modeling approach for Skillet Fork segments CA03, CA05, and CA06 consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese and pH impairments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach. For these same segments, development of a load-duration curve is recommended to address atrazine impairments. The recommended approach to address fecal coliform impairments in segment CA03 consists of developing a load-duration curve.

The recommended modeling approach for Skillet Fork segment CA09 and Dums Creek (CAW01) consists of using the water quality model QUAL2E to address dissolved oxygen problems. Watershed loads for this segment will be defined using an empirical approach.

The recommended modeling approach for Horse Creek (CAN01) and Brush Creek (CAR01) consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese impairments in these two segments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach.

The recommended modeling approach for Wayne City Side Channel Reservoir, Sam Dale Lake, and Stephen A. Forbes Lake consists of using the GWLF and BATHTUB models.

The recommended modeling approaches for Sam Dale Lake, Stephen A. Forbes Lake and Wayne City Side Channel Reservoir can be applied without collection of any additional data.

Application of the recommended approaches for the stream segments in the Skillet Fork watershed will require conduct of additional field sampling to support TMDL development. The existing data, while sufficient to document impairment, are not sufficient to define the cause-effect relationships. Two low- to medium-flow surveys are recommended to synoptically measure sources and receiving water concentrations of oxygen demanding substances (all stream segments), manganese (segments CA03, CA05, CA06, CAN 01, CAR 01) and pH (segments CA03, CA05 and CA06) to support dissolved oxygen, manganese and pH modeling.

Application of the recommended approach for atrazine will also require conduct of additional field sampling to support TMDL development. The existing data, while sufficient to document impairment, are not sufficient to develop a load-duration curve. At least 5 atrazine samples are recommended for collection at a range of flows to support development of a load-duration curve for Skillet Fork segments CA03, CA05 and CA06.

No additional data collection is recommended for the three reservoirs.

Data Collection Plan

The data collection plan outlined in general terms below, will support development of the recommended approaches for TMDL development. Two low- to medium-flow surveys are recommended to synoptically measure sources and receiving water concentrations of oxygen-demanding substances at twenty-eight stations located within and upstream of the seven stream segments listed for dissolved oxygen impairments. These stations are shown in Figure 1. One low-flow survey is recommended to synoptically measure sources and receiving water concentrations of manganese, iron, and pH at a subset of these stations (10 stations for manganese, 4 stations for iron and 6 stations for pH). Finally, at a range of flow conditions, it is recommended that five atrazine samples be collected from three different locations, with one station in each of the following segments: CA 03, CA 05 and CA 06. No additional data collection is recommended for the three reservoirs.

Sample collection

Twenty-eight essential monitoring stations are shown in Figure 1. It is recommended that these twenty-eight stations be sampled during low- to medium-flow conditions to support model development and application. Twelve of these stations are located along the mainstem of Skillet Fork (including previously sampled stations CA03, CA02, CA05, CA06, CA08, CA09) and sixteen are located on tributaries that are either listed for low dissolved oxygen or which are potentially significant contributors to the listed stream segments. While it is recommended that all twenty-eight stations be sampled for oxygen-demanding substances during two low-flow surveys, only a subset of these stations are recommended for sampling of manganese, iron, pH and atrazine.

Essential monitoring

Two low flow surveys are recommended to provide data to support model development and calibration. At each of the essential stations shown in Figure 1, it is recommended that the measurements shown in Table 1 be collected on the same day, under low river flow conditions.

Table 1. Sampling recommendations

Measurement	Number of low flow surveys recommended	Number of stations
Dissolved oxygen	2	28
Water temperature	2	28
Biochemical oxygen demand (BOD),	2	28
Ammonia	2	28
Channel morphometry	2	28
pH	1	6 (2 per segment: CA03, CA05, CA06)
Total manganese	1	10 (2 per segment: CA03, CA05, CA06, CAN01, CAR01)
Total iron	1	4 (2 per segment: CA03, CA06)

In addition, it is recommended that depth and velocity be measured at six of the stations (one per segment, excluding segment CA05 which has a USGS flow gage), at the same time as the water quality sampling, to support flow calculation.

Also, at stations determined to be representative of each segment (7 total), based on a field survey, it is recommended that sediment oxygen demand (SOD) be measured, in addition to either continuous dissolved oxygen measurements or dissolved oxygen measurements collected in the morning and afternoon. The purpose of these dissolved oxygen measurements is to assess the effect of algae on instream dissolved oxygen concentrations. The SOD only needs to be measured during one survey.

Finally, at stations CA03, CA05 and CA06 five atrazine samples should be collected over a range of flow conditions to support development of the load-duration curve.

Potential parties that may be responsible for additional data collection

Both Baetis Environmental Services, Inc. and Limno-Tech, Inc. are qualified to conduct the recommended data collection in the Skillet Fork watershed. It should be noted that two of the atrazine samples may be collected during the low-flow surveys, but the remaining three sampling events for atrazine will need to be conducted at a later time. The Illinois Natural History Survey routinely collects data from Stephen A. Forbes Lake. Although they have not been contacted about their availability to collect data in the watershed, they may be a potential partner for collection of atrazine data during the higher flow conditions.

NEXT STEPS

In the upcoming month, the IEPA will confer with the Scientific Advisory Committee to discuss the work presented in the three quarterly status reports. A public meeting will also be scheduled and held in the watershed to present the conclusions and recommendations of Stage 1 to local stakeholders and to obtain feedback on the work completed to date.

REFERENCES

Illinois Environmental Protection Agency, 2004. Final Draft Illinois Water Quality Report 2004 Illinois Environmental Protection Agency Bureau of Water. IEPA/BOW/04-006. May 2004

Limno-Tech, Inc., 2004. Second Quarterly Status Report Skillet Fork Watershed. October 2004.

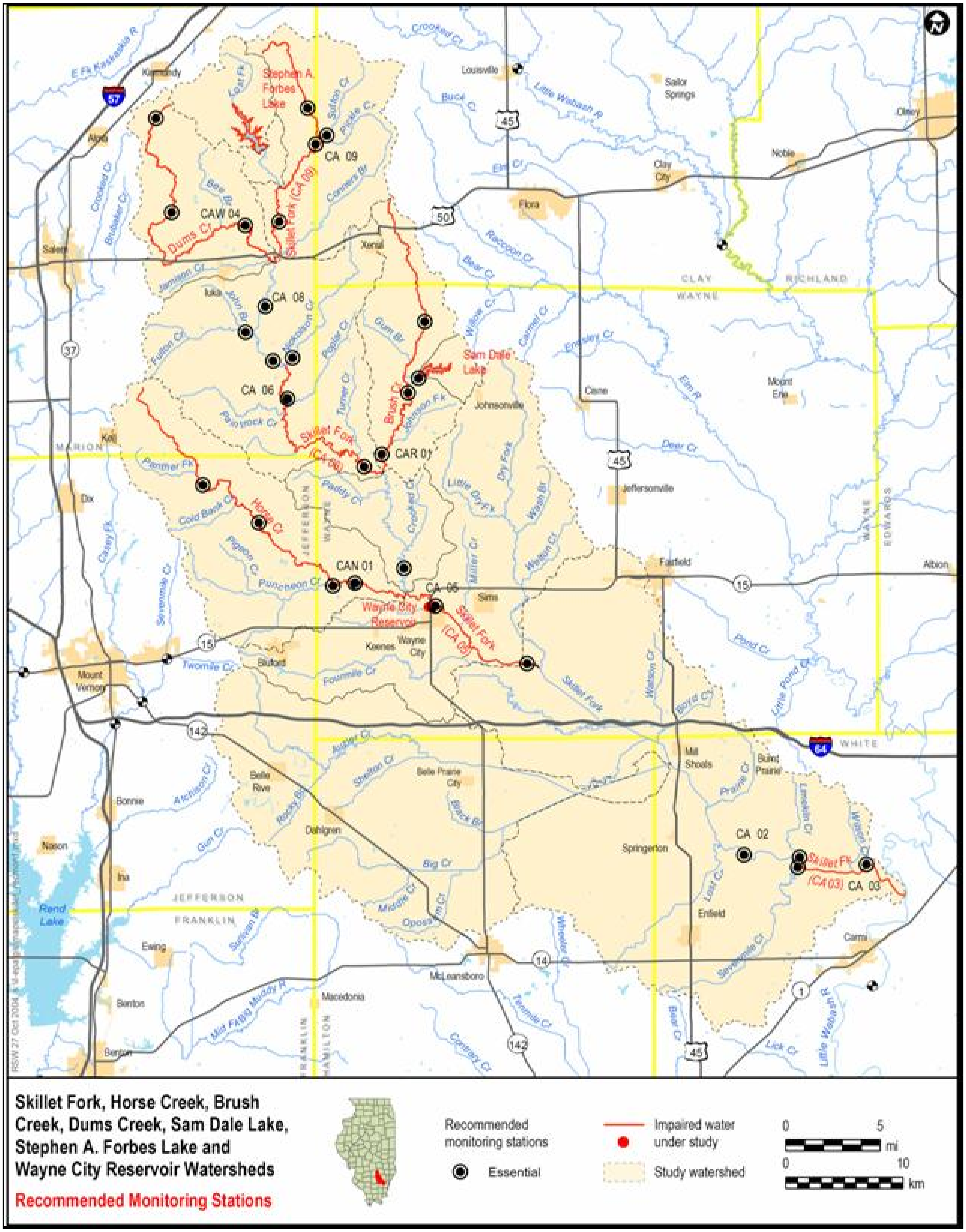

Figure 1. Recommended Stage 2 Sampling Locations

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Fourth Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

March 2005

Skillet Fork Watershed

Skillet Fork (CA03, CA05, CA06, CA09),
Horse Creek (CAN 01), Brush Creek (CAR 01),
Dums Creek (CAW 01), Sam Dale Lake (RBF),
Stephen A. Forbes Lake (RCD), and
Wayne City Side Channel Reservoir (RCT)

Limno-Tech, Inc.
www.limno.com

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PUBLIC PARTICIPATION

Stage One included opportunities for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in June 2004 to initiate Stage One. As quarterly progress reports were produced, the Agency posted them to their website. The draft Stage One Report for this watershed was available to the public for review beginning in December 2004.

In February 2005, a public meeting was announced for presentation of the Stage One findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Monday, March 14, 2005 in Wayne City, Illinois at the Community Center. In addition to the meeting's sponsors, 18 individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage One findings by Limno-Tech, Inc. This was followed by a general question and answer session.

The Agency entertained questions and concerns from the public through April 16, 2005. While there were several general questions, comments were focused on potential sources of fecal coliform, including litter from a nearby prairie chicken sanctuary that is spread near SA Forbes State Park. Since Sam Dale Lake is a conservation area, it is likely that a potential source of phosphorus was the practice in the 1960s-1970s of these clubs to apply phosphorus to the lake as a fertilization practice to increase fish population. There was some skepticism expressed regarding the value of conducting a TMDL for manganese, given its natural occurrence and prevalence in the soils in the watershed. It was also noted that the Wayne City water treatment plant uses water from the Side Channel Reservoir exclusively during atrazine season (April-June).

This is the fourth in a series of quarterly status reports documenting work completed on the Skillet Fork project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

REFERENCES

Illinois Environmental Protection Agency, 2004. Final Draft Illinois Water Quality Report 2004 Illinois Environmental Protection Agency Bureau of Water. IEPA/BOW/04-006. May 2004

Limno-Tech, Inc., 2004. Second Quarterly Status Report Skillet Fork Watershed. October 2004.

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DATA REPORT

Prepared for Illinois Environmental Protection Agency

FINAL

March 2006

Macoupin Creek Watershed

Hodges Creek Watershed

North Fork Kaskaskia River Watershed

Skillet Fork Watershed

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INTRODUCTION

Limno-Tech, Inc. (LTI) completed surface water sampling in the summer and fall of 2005 to support Total Maximum Daily Load (TMDL) development for impaired water bodies in four State of Illinois watersheds. This report describes the field investigations and results of the sampling program completed in 2005. This report is divided into sections describing:

- Field investigation overview
- Water sample collection and field measurements
- Discharge measurements
- Sediment oxygen demand and continuous dissolved oxygen monitoring
- Quality assurance review
- Conclusions

FIELD INVESTIGATION OVERVIEW

TMDL streams and their tributaries were sampled during the summer and fall of 2005 to collect data needed to support water quality modeling and TMDL development. The sampled waterbodies are all located within the following watersheds:

- Macoupin Creek (Figure 1),
- Hodges Creek (Figure 2),
- North Fork Kaskaskia River (Figure 3), and
- Skillet Fork (Figure 4).

Sampling was initially planned for six watersheds, as described in the IEPA-approved Quality Assurance Project Plan (LTI, 2005); however, weather conditions did not permit completion of sampling in two of the project watersheds (Mauvaise Terre and East Fork Kaskaskia River). Sampling in these two watersheds will be completed in 2006 and documented separately.

Data were collected during two low-flow periods in accordance with an Illinois EPA-approved QAPP (LTI, 2005). In each of the sampled watersheds, the 303(d)-listed stream segment(s) had water present, although tributaries to these segments were not always flowing. Samples were collected from the tributaries if water was present.

Table 1 presents a summary of the sampling completed by watershed, field observations, and any changes in station location.

The sampling and analysis activities included:

- collection of water samples for laboratory analysis;
- measurement of in-stream water quality and channel morphology parameters;
- stream discharge measurements;
- continuous dissolved oxygen (DO) monitoring; and
- sediment oxygen demand (SOD) measurements.

Water samples and stream measurements were collected from the selected locations in each watershed during both events. Discharge measurements, SOD and 24-hour continuous DO measurements were conducted at a subset of locations in each watershed. In accordance with the QAPP, sample collection and field measurement activities (quality, morphometry and discharge) were conducted during two separate dry weather periods and continuous DO and SOD monitoring were conducted only during one dry weather period.

Following the completion of field investigation and laboratory analysis activities, the generated data were compiled and a quality assurance review was conducted to assess data quality and usability.

Table 1. Sampling summary

Site ID	IEPA Station ID	Station Description	Location Change From QAPP Listing	DO, NH_3, BOD_5, Water Temp, channel morphometry		Flow (depth & velocity)		SOD & diurnal DO	Fe		Mn		Round 1 Notes	Round 2 Notes
				Round 1	Round 2	Round 1	Round 2	Round 1	Round 1	Round 2	Round 1	Round 2		
Macoupin Creek Watershed													**8/22-25/2005**	**10/11/2005**
MAC-1	DA 03	Macoupin Ck at US 67		✔	✔	✔	✔				✔	✔	Water flowing; Sampled u.s. side of bridge	Same as Round 1
MAC-2		Coop Branch at Victory Rd											Upstream - dry; Downstream - pooled water covered with duckweed; Not sampled	Same as Round 1
MAC-3	DA 04	Macoupin Ck at Shipman Rd		✔	✔	✔	✔				✔	✔	Water present; Sampled u.s. side of bridge	Same as Round 1
MAC-4		Dry Fork at Lake Catatoga Rd											Dry; Not sampled	Same as Round 1
MAC-5		Honey Ck at Brushy Mount Rd		✔	✔						✔	✔	Water present, no apparent flow; Sampled u.s. side of bridge	Same as Round 1
MAC-6	DAZN	Briar Ck at Crumystone Rd		✔	✔						✔	✔	Water flowing; 3 8' circular c.s. culverts; discharge from W. culvert; Sampled ~20' d.s. of W. culvert; flow measurements ~80 d.s. of culverts and beyond sand bar	Water present; flow from all 3 culverts; Sampled ~80 d.s. of culverts and beyond sand bar
MAC-7	DA 05	Macoupin Ck at Illinois Rte 4		✔	✔	✔	✔	✔			✔	✔	Water present; Sampled u.s. side of bridge	Water present; Sampled d.s. side of bridge
MAC-8		Shaw Point Branch at Sumpter Rd			✔							✔	Dry with pools of water 100'-200' upstream and downstream; Not sampled	Upstream - water under bridge and ~50 u.s., then dry channel for ~75', then water present beyond; Downstream - water present for ~15' d.s., then ~10' of dry bed, then water present beyond; Sampled u.s. side of bridge
MAC-9	DA 11	Macoupin Ck at Coops Mound Rd		✔	✔	✔	✔				✔	✔	Water present; Sampled d.s. side of bridge	No flow, low water levels, duckweed covered
MAC-10		Horse Ck (East) at Sulphur Springs Road		✔	✔						✔	✔	Dry under bridge with water upstream and downstream; Sampled 50' d.s. of bridge & ~10' below u.s. edge of water	Same as Round 1
---			Additional observation: Macoupin Ck at Sulphur Springs Rd										Upstream - dry; Downstream - water present	
---			Additional observation: Macoupin Ck at Boston Chapel Rd										Water present upstream and downstream, duckweed covered	
MAC-11		Horse Ck (West) at Boston Chapel Road		✔							✔		Upstream - dry; Downstream and under bridge - pooled with duckweed cover; sampled d.s. side of bridge	Dry with small pool under bridge; Not sampled
---			Additional observation: Macoupin Ck at Macoupin Rd./Co. Rd. 2725N Rd										Dry under bridge with pooled water upstream and downstream	
---			Additional observation: Macoupin Ck at East 1st Rd./Co. Rd. 100E										Dry under bridge with puddled water upstream and downstream	
---			Pasture Rd./Co. Rd. 2850N										Water present	
MAC-12		Macoupin Ck at East 2nd Rd/County Rd. 200E		✔	✔		✔				✔	✔	Dry under bridge with moist sediments and small puddle, water present `10' upstream and ~25' downstream; Sampled d.s. side of bridge	Pools u.s. and d.s. with slow trickle of water between under bridge; Sampled
---			Additional observation: Macoupin Ck at I-55										Upstream and under bridge - very little water with trickle flow under bridge; Downstream - duckweed covered pool	
---			Additional observation: Mine Ave./Co. Rd. 3050N (E. of I-55)										Upstream - very little water; Downstream - dry	

Table 1. Sampling Summary Continued

Site ID	IEPA Station ID	Station Description	Location Change From QAPP Listing	DO, NH_3, BOD_5, Water Temp, channel morphometry		Flow (depth & velocity)		SOD & diurnal DO	Fe		Mn		Round 1 Notes	Round 2 Notes
				Round 1	Round 2	Round 1	Round 2	Round 1	Round 1	Round 2	Round 1	Round 2		
Hodges Creek Watershed													**8/22-25/2005**	**10/11/2005**
HOD-1	DAG 03	Hodges Ck at Co. Hwy. 24/Co. Rd. 1050N/Chesterfield Rd.		✔	✔	✔	✔	✔					Water present, ~40' wide, narrows to ~10' under bridge with flow observed; Sampled channel (10' width) and measured flows (20' width) under d.s. side of bridge	Pooled water, very low flow
HOD-2		Joes Ck. At Joes Ck Rd.											Dry with small puddle at upstream side of bridge	Same as Round 1
---			Additional observation: Joes Cr at Illinois Rte 108										Upstream - water present; Downstream - dry	
HOD-3		Hodges Ck at Illinois Route 108	Otter Cr. incorrectly referenced in QAPP	✔	✔	✔	✔						Shallow, narrow 1-4' wide stream widening to a ~50' pool ~50' downstream of bridge; Sampled 2' wide channel under d.s. side of bridge	Water pooled u.s. and d.s. and connected by small trickle of water
HOD-4		Solomon Ck at Boyscout Rd (d/s of Hettick STP)											Dry with small puddle downstream	Same as Round 1
HOD-5		Solomon Ck East off of Goshen Rd., no bridge (d.s. of Palmyra STP)											Dry, 2.5-3' c.s. culvert, no bridge	Same as Round 1
HOD-6		Nassa Ck near end of Wildcat Ln, no bridge											Dry with pool ~60' upstream (pool size: 12'x12'x2-6" deep), no bridge	Dry, small puddles, no flow
HOD-7		East Fork Otter Ck at Henry Rd (W of Girard)		✔	✔	✔	✔						Water present, narrows to <1' under bridge, no apparent flow; Sampled d.s. side of bridge	Similar to Round 1
North Fork Kaskaskia River Watershed													**8/26/05-9/2/05**	**10/13/2005**
NFK-1		N.F. Kaskaskia R. at Boulder Rd/Co. Rd 300E/2700E		✔	✔	✔	✔		✔	✔	✔	✔	Water present; Sampled u.s. side of bridge	Water present; Sampled d.s. side of bridge
NFK-2		Louse Run at Co. Rd. 2150/Co. Rd. 475E/Co. Rd. 450E		✔	✔				✔	✔	✔	✔	Water present, flow observed; Sampled u.s. side of bridge	Same as Round 1
NFK-3		N.F. Kaskaskia R. at Co. Rd 100N		✔	✔			✔	✔	✔	✔	✔	Water present, duckweed covered u.s.; Sampled d.s. side of bridge	Same as Round 1; deer carcass observed in water
NFK-4		Unnamed tributary 600' S of Bond Ave., no bridge. D/S of Patoka STP											Dry, ~5' wide shallow channel, no bridge; Not sampled	Same as Round 1
NFK-5	OKA 01	N.F. Kaskaskia R at US 51		✔	✔	✔	✔		✔	✔	✔	✔	Water present; Sampled u.s. side of bridge	Water present; Sampled u.s. side of bridge; flow measurements d.s. side of bridge
NFK-6		N.F. Kaskaskia R at Griffin Rd.		✔	✔	✔	✔		✔	✔	✔	✔	Water present; Sampled u.s. side of bridge	Same as Round 1
NFK-7		N.F. Kaskaskia R at Hadley Rd.		✔	✔				✔	✔	✔	✔	Upstream - water present; Downstream - only small puddles present for ~50' d.s. of bridge, then water; Sampled u.s. side of bridge	Sampled from u.s. side of bridge; water present u.s., under bridge & ~6' d.s., then dry for ~15' d.s., then a 20' long puddle, then dry for ~5', then water present

Table 1. Sampling Summary Continued

Site ID	IEPA Station ID	Station Description	Location Change From QAPP Listing	DO, NH_3, BOD_5, Water Temp, channel morphometry		Flow (depth & velocity)		SOD & diurnal DO	Fe		Mn		Round 1 Notes	Round 2 Notes
				Round 1	Round 2	Round 1	Round 2	Round 1	Round 1	Round 2	Round 1	Round 2		
Skillet Fork Watershed													**8/26/05-9/1/05**	**10/12/2005**
SKIL-1		Skillet Fork at Neal Road/Faye Road		✓	✓								Upstream - water pooled from under bridge to ~50' u.s.; Downstream - dry for ~75', then a pool; Sampled	Similar to Round 1
SKIL-2		Dums Cr. at Williams Road		✓	✓								Water present, not continuous u.s., no flow; Sampled	Similar to Round 1
SKIL-3		Sutton Cr. At Co. Rd. 050E/Scotch Pine Rd.		✓	✓								Water present; Sampled	Same as Round 1
SKIL-4	CA 09	Skillet Fork at Wilcoxen Rd.		✓	✓	✓	✓	✓					Water present; Sampled	Same as Round 1
SKIL-5		Dums Cr. At Bee Branch Rd.		✓	✓								Upstream and under bridge - dry for ~50' u.s., then pooled; Downstream - dry for ~20', then pooled; Sampled	Similar to Round 1
SKIL-6		Skillet Fork at Allen Rd/Kirby Rd		✓	✓								Water present; skinned animal carcass observed in water on 8/26/05; Sampled	Same as Round 1
SKIL-7	CAW 04	Dums Cr at end of Landmark Rd (no bridge)		✓	✓	✓	✓	✓					Water present, duckweed covered; Sampled	Same as Round 1
SKIL-8	CA 08	Skillet Fork at River Rd.	Difficult access at end of Blank Rd., no bridge, moved d.s. to nearest bridge	✓	✓								Water present; Sampled	Same as Round 1
SKIL-9		Brush Cr. at Co. Rd 2200N		✓	✓						✓		Water present; Sampled	no visible flow, pooled water u.s. and d.s.; 50 gal. drum and trash in water; Sampled u.s. side of culvert
SKIL-10		Fulton Cr at Landmark Rd.		✓	✓								Water on u.s. side of bridge; pool of water on d.s. side, then dry d.s.; concreted wash over culvert; Sampled u.s. side of culvert	no visible flow, pooled water u.s. and d.s.; Sampled u.s. side of culvert
SKIL-11		Nickolson Cr at Dago Hill Rd.		✓	✓								Water present, flow observed; Sampled	Small pond under bridge, no flow
SKIL-12		Skillet Fork beyond end of Seed House Rd.		✓	✓								Water present, flowing, no bridge; Sampled	Same as Round 1
SKIL-13		Bob Branch Co. Rd 1900N											Water present on 8/26/05 after heavy thunderstorms, Dry on 9/1/05; 2 4' culverts; Not sampled u.s. side	Dry with very small pools u.s.; water level ~1' below culverts; Not sampled
SKIL-14		Brush Cr at Co. Hwy 16/Co. Rd. 1825 N		✓	✓								Water present; Sampled	
SKIL-15	CA 06	Skillet Fork at State Route 161		✓	✓	✓	✓	✓			✓		Water present; Sampled u.s. side of bridge	Same as Round 1
SKIL-16	CAR 01	Brush Creek at Co. Hwy. 27/Co. Rd. 1500N		✓	✓	✓	✓	✓			✓		Water present; Sampled d.s. side of bridge	Same as Round 1
SKIL-17		Skillet Fork at Co. Hwy. 13/Co. Rd 250E		✓	✓						✓		Water present; Sampled d.s. side of bridge	Same as Round 1
SKIL-18		Horse Creek beyond end of Moonbeam Ln		✓	✓						✓		Water present, small 6" wide trickle of water flowing between pools u.s. and d.s., no bridge; Sampled	Pools u.s. and d.s., no flow between; Sampled pool, no morphometry measurements recorded
---			Additional observation: Horse Cr at Harmony Rd./Co. Rd. 1900E										Water present	
SKIL-19		Horse Cr at Malecki R./Co. Rd. 2050N		✓	✓						✓		Water present; no observable flow; Sampled u.s. side of bridge	Same as Round 1
SKIL-20		Skillet Fork at Co. Rd. 900N		✓	✓			✓ SOD only					Water present; flow observed; Sampled u.s. side of bridge	Same as Round 1
SKIL-21	CAN 01	Horse Cr at Co. Rd. 200E		✓	✓	✓	✓	✓			✓		Water present; Sampled d.s. side of bridge	Same as Round 1
SKIL-22		Puncheon Cr at Co. Rd. 000E/2400E		✓	✓								Water present; slight flow observed; Sampled u.s. side of bridge	Same as Round 1
SKIL-23	CA 05	Skillet Fork at Illinois Route 15		✓	✓			✓ DO only			✓		Water present; Sampled u.s. side of bridge	Same as Round 1
SKIL-24		Skillet Fork at Co. Rd. 100N at corner with 1500 E	No access at Co. Rd. 1225E, no bridge, moved d.s. to nearest bridge	✓	✓						✓		Water present; Sampled d.s. side of bridge	Same as Round 1
SKIL-25	CA 02	Skillet Fork at Co. Rd. 800E		✓	✓						✓		Water present; Sampled d.s. side of bridge	Same as Round 1; deer carcass observed in water
SKIL-26		Limekiln Cr at Co. Rd. 2000N		✓	✓								Water present; Sampled u.s. side of bridge	Same as Round 1
SKIL-27	CA 03	Skillet Fork at Co. Hwy 1/Co. Rd. 1125E/1150E		✓	✓	✓	✓	✓			✓		Water present; Sampled d.s. side of bridge	Same as Round 1
SKIL-28		Sevenmile Cr. At Co. Rd. 750E (N. of Co. Rd. 1800N)	No access, private land, no bridge at original location, moved u.s. to nearest bridge	✓	✓								Water present; Sampled u.s. side of bridge	Same as Round 1

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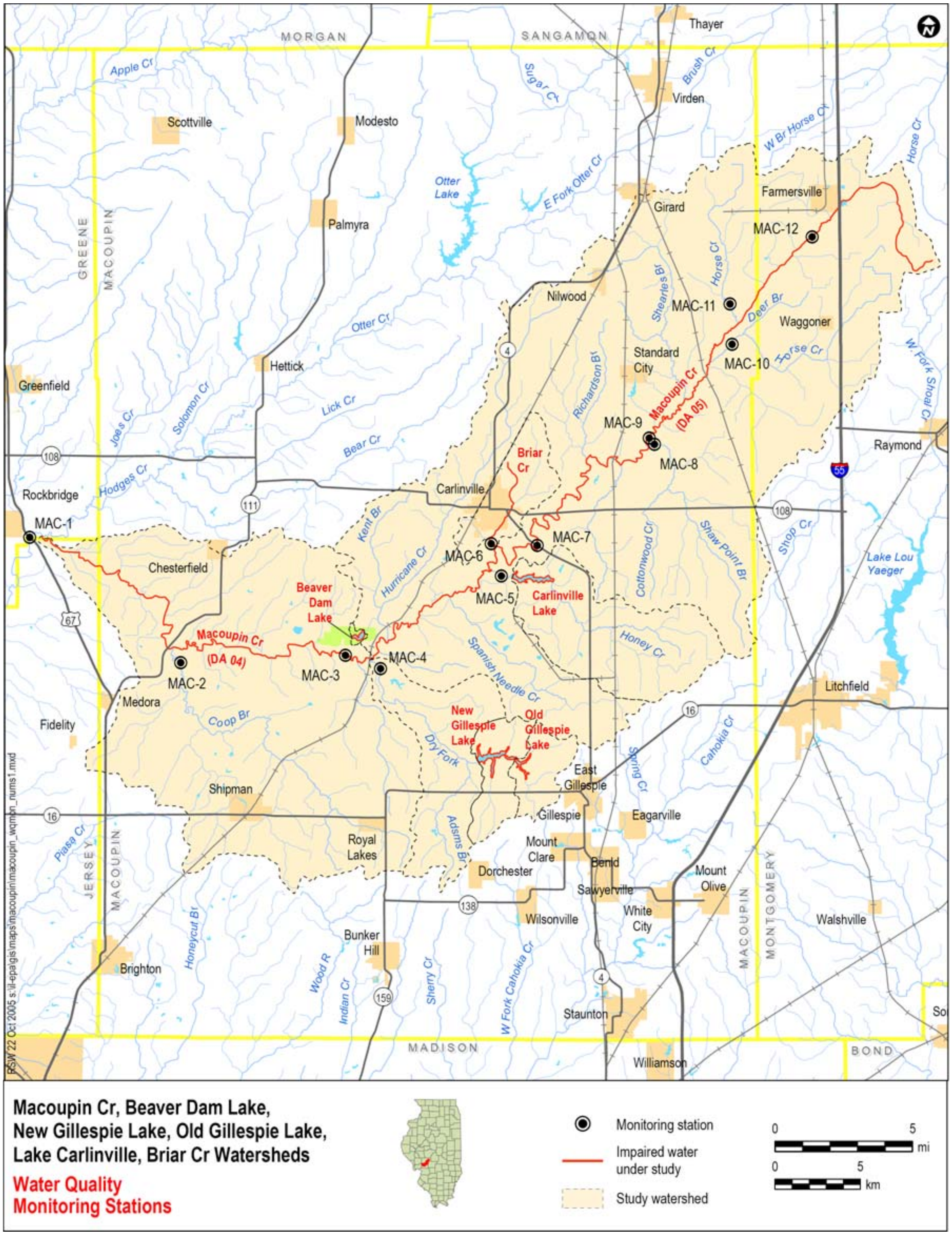

Figure 1. Macoupin Creek Watershed Sampling Locations

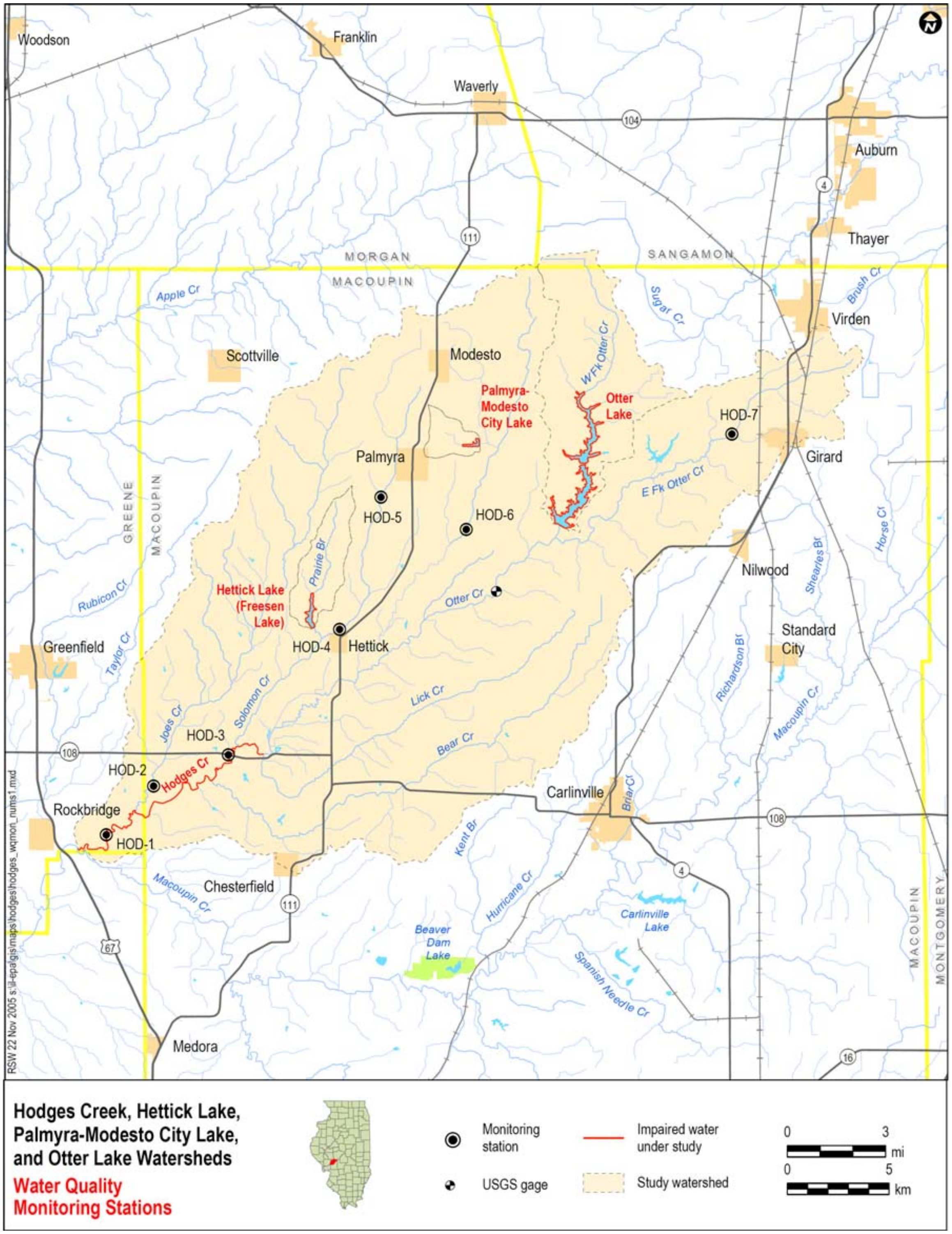

Figure 2. Hodges Creek Watershed Sampling Locations

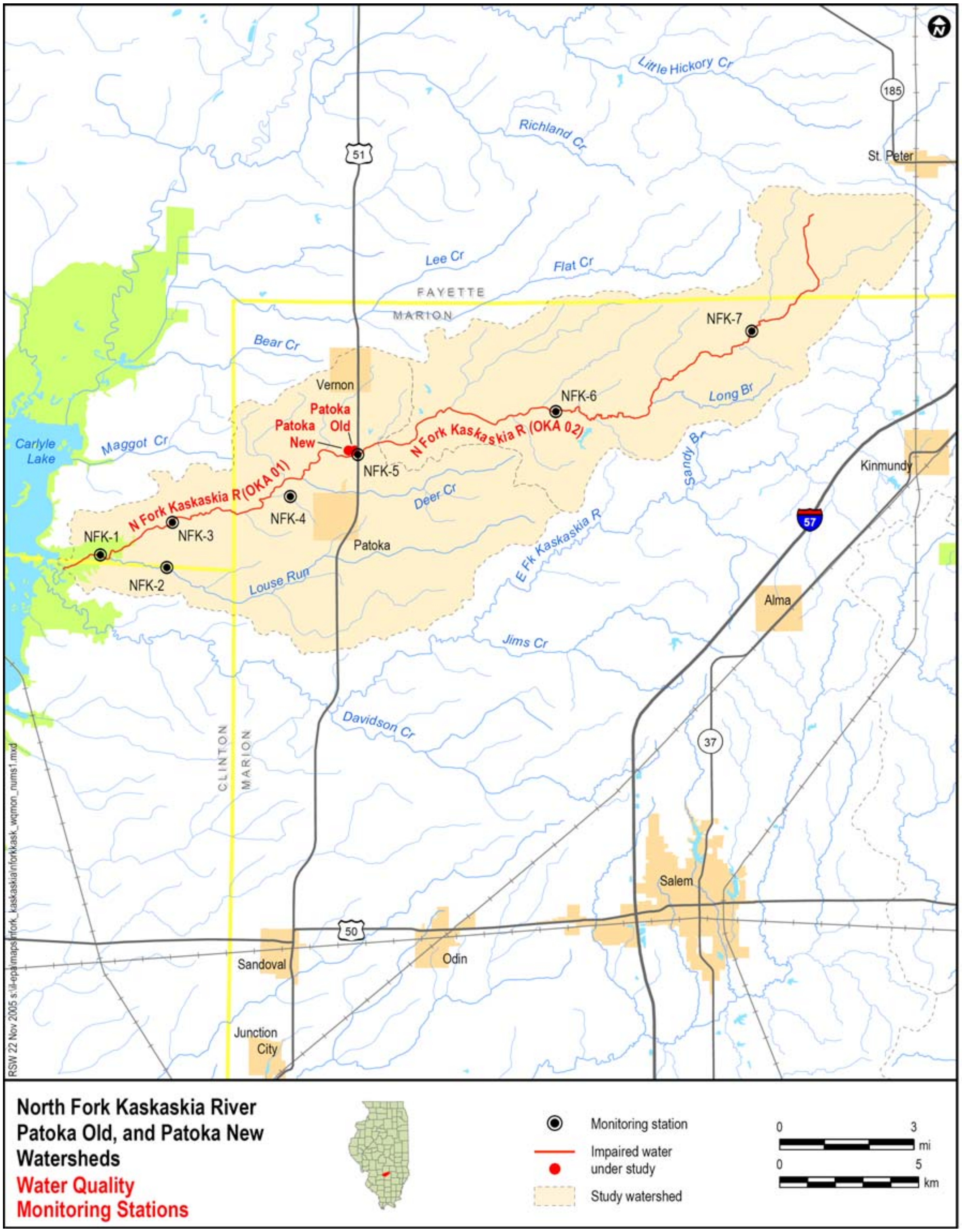

Figure 3. North Fork Kaskaskia River Watershed Sampling Locations

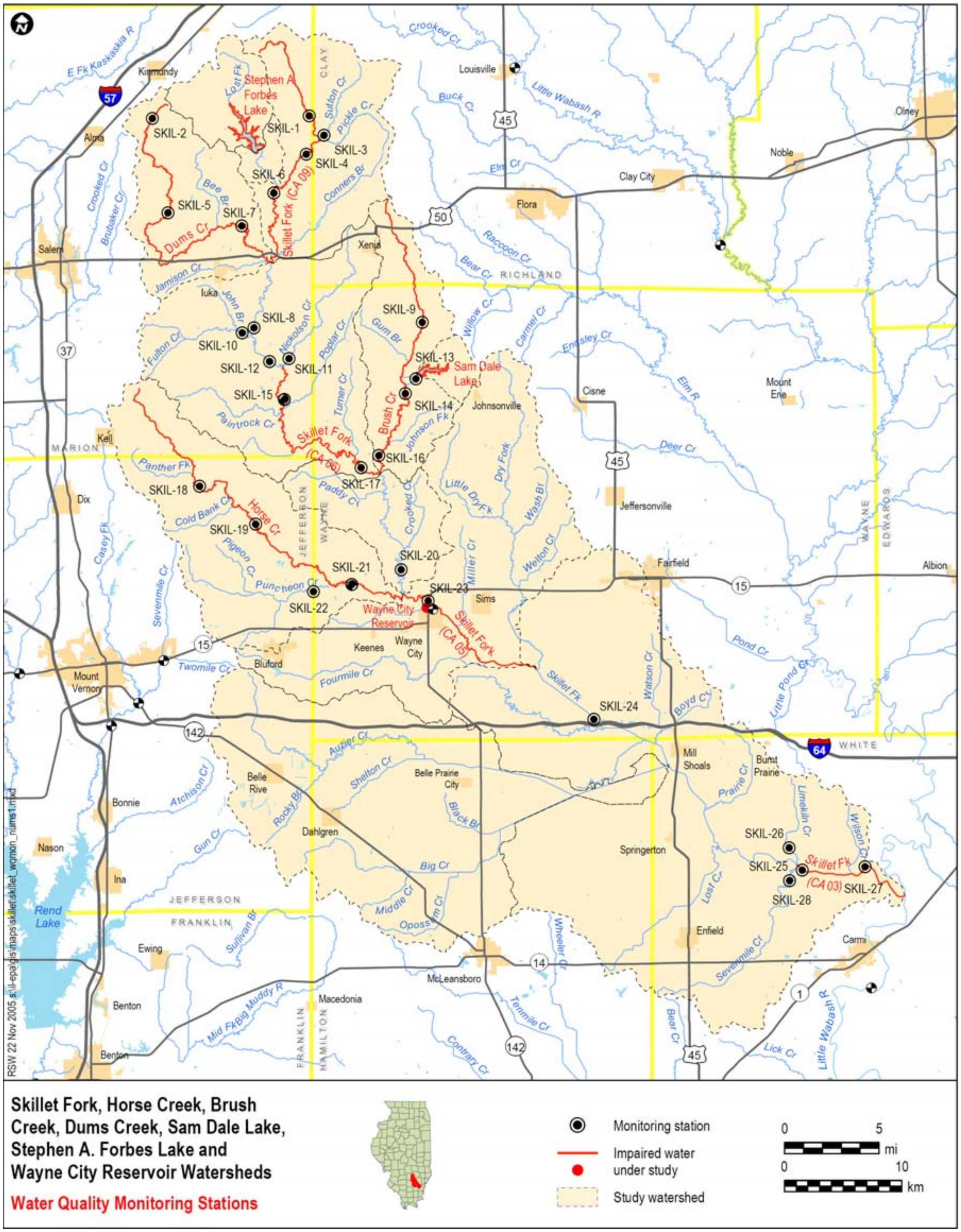

Figure 4. Skillet Fork Watershed Sampling Locations

WATER SAMPLE COLLECTION AND FIELD MEASUREMENTS

Sampling activities were conducted in accordance with the QAPP during low flow conditions on two separate occasions (Round 1 and Round 2) for each watershed, as noted in Table 1. Surface water samples and field measurements were collected by LTI at 45 stream locations (out of a possible 54 planned locations) in four watersheds; nine locations were not sampled because there was insufficient water present. For some streams, alternating reaches of water-filled and “dry” channels were observed. In these locations, it appears that the stream went underground for a short stretch, resurfacing further downstream. A small number of locations were sampled from standing pools of water such as these, which had no observable surface hydraulic connection to upstream or downstream sampling locations. Water level conditions observed in the field are noted in Table 1.

Table 1 presents a summary of the parameters analyzed at each location. Analytes were based on the causes of impairment identified in the 303(d) list. Field instruments were used to measure in-situ water quality parameters, and Brighton Analytical, Inc. conducted all laboratory analyses. At all locations, water samples were collected for laboratory analysis of ammonia and 5-day biochemical oxygen demand (BOD_5), while field measurements included dissolved oxygen (DO), water temperature (T), and channel morphometry (water depth and width). In addition, iron samples and pH measurements were collected at all locations in the North Fork Kaskaskia watershed, and manganese samples and pH measurements were collected at a subset of locations in the Skillet Fork watershed.

The analytical and field measurement results for Round 1 and Round 2 sampling are presented in Tables 2 through 4.

Table 2. Round 1 Laboratory and Field Measurement Results

Sample ID	Colletion Date/Time	Ammonia (mg/L)	BOD_5 (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)	Temp (degC)	DO (mg/L)	pH (s.u.)
Hodges Creek Watershed								
HOD-1	8/24/05 8:25	<0.01	<2			23.00	5.00	
HOD-3	8/24/05 9:55	0.14	<2			22.40	8.60	
HOD-7	8/24/05 10:45	0.07	<2			19.40	4.35	
Macoupin Creek Watershed								
MAC-1	8/23/05 8:15	<0.01	2.7		0.57 J	25.80	4.28	
MAC-1 Dup	8/23/05 8:15	<0.01	3.2					
MAC-3	8/23/05 10:05	<0.01	2.9		0.52 J	25.30	4.65	
MAC-5	8/23/05 11:40	0.02	<2		0.06 J	27.00	13.10	
MAC-6	8/23/05 12:10	<0.01	<2		0.03 J	19.00	8.65	
MAC-7	8/23/05 12:50	0.01	4.8		0.5 J	24.50	4.15	
MAC-9	8/23/05 14:25	0.31	<2		0.65 J	25.00	3.90	
MAC-10	8/23/05 15:30	0.16	5.5		0.95 J	22.00	6.60	
MAC-11	8/23/05 15:50	0.22	4.9		1.9 J	21.80	1.50	
MAC-12	8/23/05 16:25	0.06	2.8		0.19 J	22.00	9.40	
North Fork Kaskaskia River Watershed								
NFK-1	8/31/05 12:05	0.08	3.2	0.88	0.47	26.00	3.50	7.90
NFK-1 Dup	8/31/05 12:05	0.09	3.2	0.89				
NFK-2	8/31/0511:40	0.24	<2	1.5	0.47	23.10	2.30	7.50
NFK-3	8/31/05 11:10	0.07	3.2	1.7	1.7	23.10	0.50	7.50
NFK-5	8/31/05 9:40	0.51	<2	0.93	1.2	22.10	1.85	7.60
NFK-6	8/31/05 8:40	0.3	<2	1.6	1.1	21.50	1.65	7.60
NFK-7	8/31/05 7:55	0.2	<2	0.85	1.4	21.50	1.40	7.60
Skillet Fork Watershed								
SKIL-1	9/1/05 14:55	0.66	<2			24.00	4.10	
SKIL-2	9/1/05 15:40	0.04	<2			28.00	10.20	
SKIL-3	9/1/05 14:10	0.72	<2			25.00	2.20	
SKIL-4	9/1/05 13:30	0.03	6.7			21.00	0.40	
SKIL-5	9/1/05 12:00	0.41	<2			22.80	5.00	
SKIL-6	9/1/05 11:25	0.02	<2			23.90	2.50	
SKIL-6 Dup	9/1/05 11:25	<0.01	<2					
SKIL-7	9/1/05 10:40	0.13	<2			22.00	3.00	
SKIL-8	9/1/05 9:50	0.27	<2			22.90	3.10	7.28
SKIL-9	9/1/05 9:35	0.25	<2		2.3	21.20	1.56	
SKIL-10	9/1/05 7:45	1.2	<2			19.90	2.36	
SKIL-11	9/1/05 9:00	0.06	<2			20.70	4.74	
SKIL-12	9/1/05 8:20	0.51	<2			22.20	1.78	
SKIL-14	9/1/05 10:00	0.15	<2			21.80	3.25	
SKIL-15	9/1/05 7:50	0.16	<2		0.69	22.50	3.50	7.22
SKIL-16	9/1/05 7:55	0.16	<2		1.2	21.55	2.10	6.67
SKIL-17	9/1/05 8:50	0.12	<2		0.6	22.96	3.51	6.78

Sample ID	Colletion Date/Time	Ammonia (mg/L)	BOD_5 (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)	Temp (degC)	DO (mg/L)	pH (s.u.)
SKIL-18	9/1/05 11:55	0.14	<2		0.98	23.50	6.74	
SKIL-19	9/1/05 12:20	0.08	<2		0.58	22.40	3.75	
SKIL-19 Dup	9/1/05 12:20	0.09	<2		0.61			
SKIL-20	9/1/05 13:30	0.09	<2			24.60	5.03	
SKIL-21	9/1/05 9:20	0.16	<2		1.2	21.96	3.20	6.92
SKIL-22	9/1/05 12:55	0.03	<2			22.60	3.60	
SKIL-23	9/1/05 10:35	0.15	<2		0.6	24.36	3.15	7.12
SKIL-24	9/1/05 11:20	0.2	<2		0.75	25.26	6.06	7.32
SKIL-25	9/1/05 12:40	<0.01	<2		0.3	24.89	5.54	7.23
SKIL-26	9/1/05 12:15	0.12	<2			22.35	4.20	6.89
SKIL-27	9/1/05 13:30	<0.01	<2		0.26	25.94	8.12	7.61
SKIL-27 Dup	9/1/05 13:30	<0.01	<2		0.26			
SKIL-28	9/1/05 13:00	0.07	<2			22.47	4.19	6.85
Rinse Blank	9/1/05 16:00	<0.01	<2		<0.02			
Rinse Blank 2	9/1/05 16:30	0.04	<2		<0.02			

Notes: J = Value is considered estimated based on quality control/quality assurance deficiencies. The nature of the deficiency and its significance are discussed in the QA section of this report.

Table 3. Round 2 Laboratory and Field Measurement Results

Sample ID	Collection Date/TIme	Ammonia (mg/L)	BOD_5 (mg/L)	Dissolved Fe (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)	Temp (degC)	DO (mg/L)	pH (s.u.)
Hodges Creek Watershed									
HOD-1	10/11/05 8:55	<0.01	2.7				14.85	5.77	
HOD-3 DUP1	10/11/05 9:50	0.23	<2				14.60	5.67	
HOD-3 DUP2	10/11/05 9:50	0.23	<2						
HOD-7	10/11/05 11:45	0.02	<2				14.17	6.96	
Rinse Blank H	10/11/05 7:00	0.06	<2						
Macoupin Creek Watershed									
MAC-1	10/11/05 9:20	<0.01	<2			0.35 J	14.69	8.39	
MAC-3	10/11/05 10:15	<0.01	<2			0.34 J	13.56	7.92	
MAC-5	10/11/05 12:20	0.01	3.5			1.1 J	15.67	8.73	
MAC-6	10/11/05 12:50	0.05	<2			<0.02 J	18.42	8.57	
MAC-7 DUP1	10/11/05 14:00	0.02	2.6			0.21 J	14.42	5.59	
MAC-7 DUP2	10/11/05 14:00	0.03	<2						
MAC-8	10/11/05 14:45	0.02	<2			0.2 J	14.02	4.27	
MAC-9	10/11/05 13:45	0.2	6			1.6 J	13.85	0.67	
MAC-10	10/11/05 13:10	0.36	<2			0.39 J	14.25	4.05	
MAC-12	10/11/05 12:30	1.8	16			0.47 J	13.18	2.57	
Rinse Blank MAC	10/11/05 7:00	0.05	<2						
North Fork Kaskaskia River Watershed									
NFK-1	10/13/05 8:35	0.13	<2	0.06	1.9	0.31	16.41	3.88	6.57
NFK-2	10/13/05 12:00	0.41	5.1	0.34	2.3	1.3	14.40	1.74	7.24
NFK-3	10/13/05 10:10	0.44	3.8	0.34	3.6	1.8	14.41	0.57	6.90
NFK-5 DUP1	10/13/05 10:55	0.25	3.7	0.6	2.6	0.89	13.92	2.26	6.89
NFK-5 DUP2	10/13/05 10:55	0.22	4.5	0.55	2.8				
NFK-6	10/13/05 12:45	0.43	4.3	1.4	3.8	1.9	13.67	0.49	6.64
NFK-7	10/13/05 13:25	0.33	4.5	0.48	2.8	1.6	15.85	1.25	7.19
Rinse Blank	10/13/05 8:00	0.09	<2	0.06	0.11				
Skillet Fork Watershed									
SKIL-1	10/12/05 13:20	0.03	<2				14.67	3.40	
SKIL-2	10/12/05 12:45	0.15	3				16.34	9.01	
SKIL-3	10/12/05 13:40	0.47	<2				14.03	2.22	
SKIL-4	10/12/05 14:00	0.02	17				13.54	1.02	
SKIL-5	10/12/05 11:40	1.5	<2				14.37	2.65	
SKIL-6 DUP1	10/12/05 14:35	0.16	3.7				14.94	2.74	
SKIL-6 DUP2	10/12/05 14:35	0.02	3						
SKIL-7	10/12/05 11:10	0.18	<2				13.73	1.73	
SKIL-8	10/12/05 10:30	0.24	4.8				13.72	2.65	
SKIL-9	10/12/05 9:30	0.16	<2				14.18	3.64	7.78
SKIL-10	10/12/05 8:20	1.2	<2				13.64	4.07	7.95
SKIL-11	10/12/05 9:05	0.06	<2				13.87	5.29	7.89
SKIL-12	10/12/05 8:45	0.19	<2				14.55	2.93	7.78
SKIL-14	10/12/05 9:50	0.08	<2				14.19	6.17	7.82
SKIL-15	10/12/05 8:15	0.14	<2				14.42	3.69	7.41

Sample ID	Collection Date/TIme	Ammonia (mg/L)	BOD_5 (mg/L)	Dissolved Fe (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)	Temp (degC)	DO (mg/L)	pH (s.u.)
SKIL-16	10/12/05 8:20	0.18	<2				13.85	3.43	7.09
SKIL-17	10/12/05 9:10	0.08	<2				14.62	5.94	7.32
SKIL-18	10/12/05 10:50	0.09	<2				15.26	4.82	7.80
SKIL-19 DUP1	10/12/05 11:05	0.32	<2				14.19	2.42	7.57
SKIL-19 DUP2	10/12/05 11:05	0.36	<2						
SKIL-20	10/12/05 11:40	0.12	<2				16.54	7.36	7.66
SKIL-21	10/12/05 9:40	0.08	<2				14.47	3.48	7.24
SKIL-22	10/12/05 12:05	0.12	<2				15.15	7.37	7.59
SKIL-23	10/12/05 10:35	0.03	8.1				16.71	4.22	7.00
SKIL-24	10/12/05 11:30	0.05	4.8				17.07	8.76	7.23
SKIL-25	10/12/05 12:55	0.05	<2				18.80	6.85	7.60
SKIL-26	10/12/05 12:35	0.07	2.5				16.00	6.60	7.60
SKIL-27 DUP1	10/12/05 15:00	<0.01	4.1				19.71	7.21	7.91
SKIL-27 DUP2	10/12/05 15:00	0.03	4						
SKIL-28	10/12/05 13:35	0.09	5.8				15.39	3.35	7.25
RB-1	10/12/05 7:00	0.07	<2						
RB-2	10/12/05 7:00	0.04	<2						
RB-3	10/12/05 7:00	0.07	<2						

Notes: J = Value is considered estimated based on quality control/quality assurance deficiencies. The nature of the deficiency and its significance are discussed in the QA section of this report.

Table 4. Stream Morphometry Results

	Round 1			Round 2		
Site ID	Time	River Width (ft)	Avg. Water Depth (ft)	Time	River Width (ft)	Avg. Water Depth (ft)
Macoupin Watershed						
	8/23/2005			**10/11/2005**		
MAC-1	8:15	48	1.09	9:00	48	1.11
MAC-2	9:40	dry	dry	9:45	dry	dry
MAC-3	10:05	60	3.34	10:15	60	3.30
MAC-4	11:15	dry	dry	11:55	dry	dry
MAC-5	11:40	14	0.28	12:15	14	0.33
MAC-6	12:10	14	0.55	12:50	10	0.72
MAC-7	10:05	58	1.83	14:00	55	1.03
MAC-8	14:10	dry	dry	14:45	15	0.27
MAC-9	14:25	41	1.42	13:45	31	0.84
MAC-10	15:30	10.5	0.39	13:05	6	0.40
MAC-11	15:50	22	1.42	12:50	dry	dry
MAC-12	16:25	18	0.28	12:45	5	0.20
Hodges Watershed						
	8/24/2005			**10/11/2005**		
HOD-1	10:45	20	0.78	8:55	20	0.76
HOD-2	na	dry	dry	9:30	dry	dry
HOD-3	9:55	2	0.20	9:55	2	0.15
HOD-4	na	dry	dry	10:10	dry	dry
HOD-5	na	dry	dry	10:30	dry	dry
HOD-6	na	dry	dry	11:15	dry	dry
HOD-7	8:25	15	0.48	11:45	13	0.86
N. Fork Kaskaskia Watershed						
	8/31/2005			**10/13/2005**		
NFK-1	12:05	104	4.87	8:35	105	4.89
NFK-2	11:40	20.5	1.43	12:00	19	1.21
NFK-3	11:10	31	1.06	10:10	28	1.22
NFK-4	10:40	dry	dry	10:45	dry	dry
NFK-5	12:05	42	1.77	10:55	38	1.39
NFK-6	8:40	17.5	0.75	12:45	18.5	0.73
NFK-7	7:55	14	0.57	13:25	16	0.61
Skillet Fork Watershed						
	9/1/2005			**10/12/2005**		
SKIL-1	14:55	16	0.68	13:20	16	0.79
SKIL-2	15:40	6	0.33	12:45	4	0.15
SKIL-3	14:10	22	1.14	13:40	23	1.07
SKIL-4	13:30	24	1.30	14:00	25	1.19
SKIL-5	12:00	13.5	0.41	11:40	13	0.37
SKIL-6	11:25	67	2.30	14:35	65	2.29
SKIL-7	10:30	30	0.71	11:10	29	0.68
SKIL-8	9:50	18	1.05	10:30	14	0.71
SKIL-9	9:35	20	1.10	9:30	14.5	1.32

	Round 1			Round 2		
Site ID	Time	River Width (ft)	Avg. Water Depth (ft)	Time	River Width (ft)	Avg. Water Depth (ft)
SKIL-10	7:45	6	0.81	8:20	7.5	0.40
SKIL-11	9:00	31	1.51	9:05	28	1.65
SKIL-12	8:20	13.5	0.24	8:45	10.5	0.13
SKIL-13	9:55	dry	dry	9:40	dry	dry
SKIL-14	10:00	33	1.73	9:50	24	1.76
SKIL-15	10:30	70	4.75	8:15	60	5.03
SKIL-16	7:55	40	1.36	8:20	38	1.45
SKIL-17	8:50	59	2.56	9:10	59	2.32
SKIL-18	11:55	0.5	0.04	10:50	dry	dry
SKIL-19	12:20	46	1.97	11:05	39	1.54
SKIL-20	13:30	52	0.81	11:40	10	0.25
SKIL-21	9:20	57	1.71	9:40	55	1.91
SKIL-22	12:55	23	1.44	12:05	23	1.36
SKIL-23	10:35	82	5.92	10:35	81	5.81
SKIL-24	11:20	60	2.32	11:30	60	1.70
SKIL-25	12:40	90	3.49	12:55	88	3.29
SKIL-26	12:15	23	0.71	12:30	19	0.46
SKIL-27	13:30	92	5.01	15:00	90	5.20

DISCHARGE MEASUREMENTS

Discharge measurements were conducted at a subset of locations representative of the water bodies in each watershed. Discharge measurements were recorded using standard USGS techniques employing an electromagnetic point velocity meter (Marsh–McBirney Flo-Mate 2000) and a bridgeboard or a wading rod. Information supporting flow calculation was recorded in field notebooks and included:

- Site location,
- Date and time,
- Measurement monitoring point,
- Distance between measurement points,
- Depth at each measurement point,
- Velocities at each measurement point,
- Angle of flow at each measurement point,
- Angle of bridge with respect to river channel (where measurements were conducted from bridges), and
- Any significant observations of monitoring procedures or river conditions

The discharge measurement results are presented in Table 5.

Table 5. Discharge Results

Macoupin Creek Watershed												
Site ID:	MAC-1		MAC-3		MAC-7		MAC-9		MAC-12			
Date	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**		
8/23/05	8:15	1.67	10:05	0*	12:50	0.28	14:25	0.09				
10/11/05	9:00	0.76	10:15	0*	12:50	1.27	13:45	0*	12:45	0*		
Hodges Creek Watershed							**North Fork Kaskaskia Watershed**					
Site ID:	HOD-1		HOD-3		HOD-7		NFK-1		NFK-5		NFK-6	
Date	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**
8/24/05	10:35	0.067	9:55	0.008	8:25	0*	12:05	1.62	12:05	1.33	8:40	0.2
10/11/05	8:55	0*	9:55	0.0006	11:45	0.13	8:35	0*	10:55	0*	12:45	0*
Skillet Fork Watershed												
Site ID:	SKIL-4		SKIL-7		SKIL-15		SKIL-16		SKIL-21		SKIL-27	
Date	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**
9/1/05	13:30	0*	10:30	0*	10:30	0.74	7:55	0*	9:20	0.08	13:30	35.07
10/12/05	14:00	0*	11:10	0*	8:15	0*	8:20	1.05	9:40	0.82	15:00	3.81

Notes: Q = discharge
*No observable and/or measured downstream current

SEDIMENT OXYGEN DEMAND AND CONTINUOUS DO MONITORING

Sediment oxygen demand and continuous dissolved oxygen were measured at select locations representative of river conditions in each watershed. SOD respirometer chambers were installed in accordance with the QAPP, and DO measurements during SOD testing were manually recorded in the field notes for a period of 2 hours or until DO dropped by 2 mg/L or to zero mg/L. The data were used to calculate SOD rates for use in the DO modeling activities. The SOD rate results are presented in Table 6.

In-Situ Mini-Troll multi-parameter data-logging sondes were used for continuous DO measurements. The sondes were deployed for at least 24 hours at each of the selected locations. Calibration of the sondes for DO using the Winkler titration method was conducted before deployment and again after deployment to check the system for drift in DO values over time. Calibration and drift-check results were recorded in the field notes and are presented in Table 7. DO and temperature data were recorded at 15 minute intervals during sonde deployment, after which the sonde was removed and data were downloaded to a laptop computer. The continuous DO and temperature data are presented in Figures 5 through 14.

Table 6. Sediment Oxygen Demand Results

Date	Site ID	<=SOD, g/m2/day @ 20^{c}
8/25/2005	HOD1	1.24
8/25/2005	MAC7	0.78
8/31/2005	NFK3	0.38
8/28/2005	SKIL4	0.95
8/28/2005	SKIL7	0.63
8/28/2005	SKIL15	0.31
8/29/2005	SKIL16	0.56
8/29/2005	SKIL21	0.025
8/30/2005	SKIL20	0.32
8/29/2005	SKIL27	0.99

Table 7. Continuous DO Sonde Calibration Values and Drift Check Results

		Pre-Deployment Calibration	Post-Deployment Drift Check						
Station	Sonde ID	Winkler DO (mg/L)	Water Sample DO (mg/L)	Winkler DO (mg/L)	DO Drift (mg/L)	DO Drift (%)	Hours Deployed	Average Drift/hr (mg/L)	Average Drift/hr (%)
HOD-1	40813	5.3	6.42	6.75	-0.33	-5.0%	26	-0.0127	-0.19%
MAC-7	SS0002	5.425	5.16	6.65	-1.49	-25.2%	27.02	-0.0552	-0.93%
SKIL-4	40813	0.45	0.48	0.6	-0.12	-22.2%	24.75	-0.0048	-0.90%
SKIL-7	40067	4.4	3.23	3.05	0.18	5.7%	42.05	0.00428	0.14%
SKIL-15	SS0002	4.8	3.5	4.2	-0.7	-18.2%	26.58	-0.0263	-0.68%
SKIL-23	40813	3.4	3.74	3.45	0.29	8.1%	23.77	0.0122	0.34%
SKIL-16	40067	3.55	2.41	2.75	-0.34	-13.2%	27.08	-0.0126	-0.49%
SKIL-21	SS0002	5.3	3.72	3.6	0.12	3.3%	26.58	0.00451	0.12%
SKIL-27	40813	4.05	10.37	10.2	0.17	1.7%	44.75	0.0038	0.04%
NFK-3	SS0002	4.15	1.29	0.95	0.34	30.4%	40.58	0.00838	0.75%

Notes: Sonde deployed was Hydrolab MiniSonde 4a

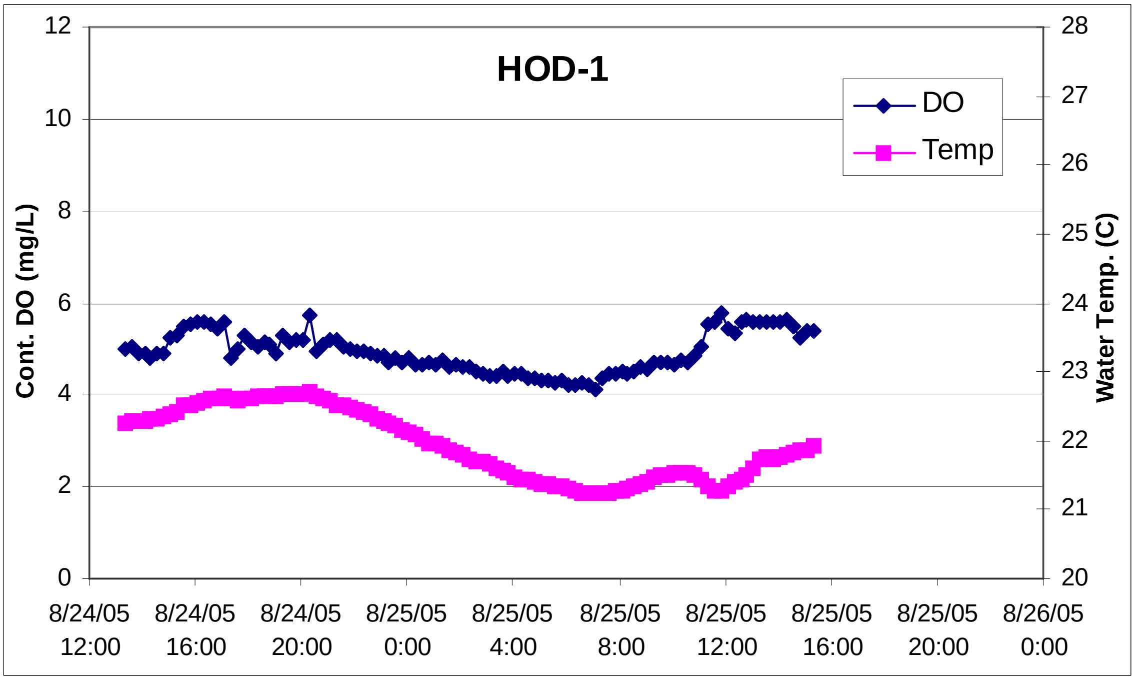

Figure 5. Continuous DO and Temperature at Hodges Creek Station HOD-1

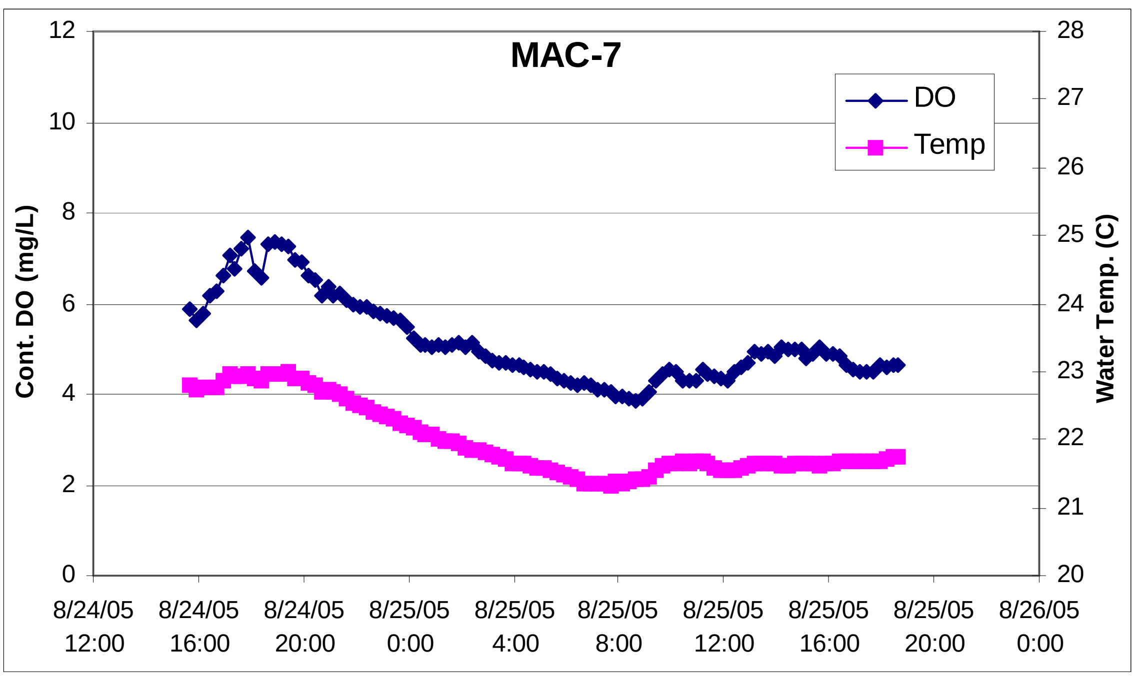

Figure 6. Continuous DO and Temperature at Macoupin Creek Station MAC-7

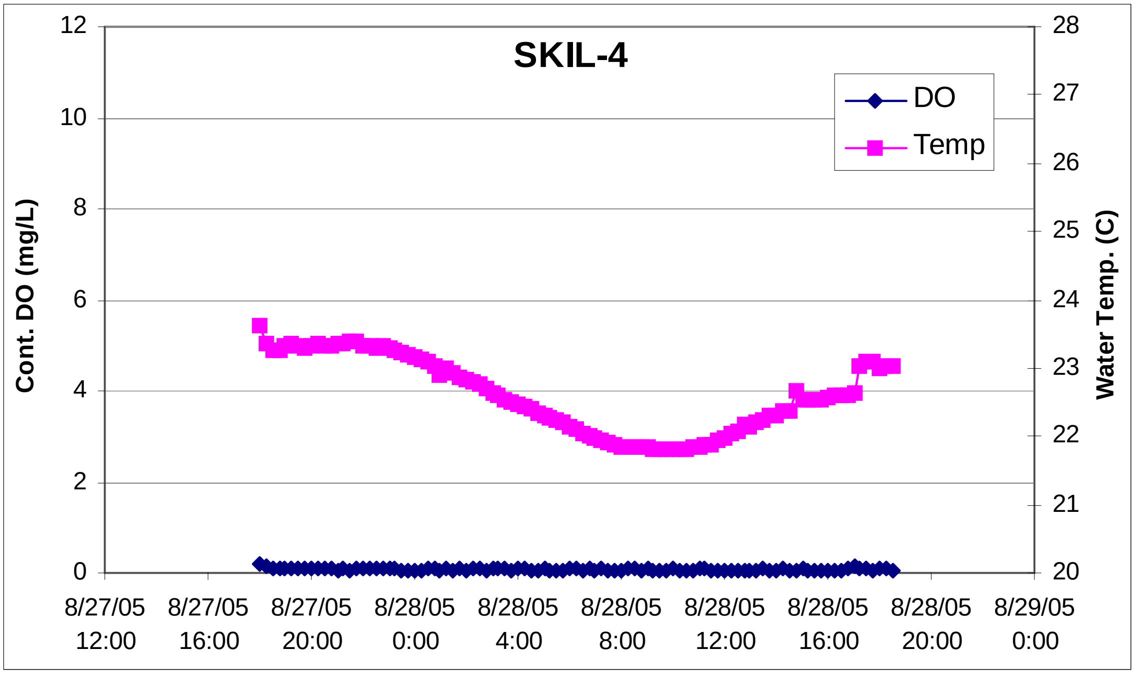

Figure 7. Continuous DO and Temperature at Skillet Fork Station SKIL-4

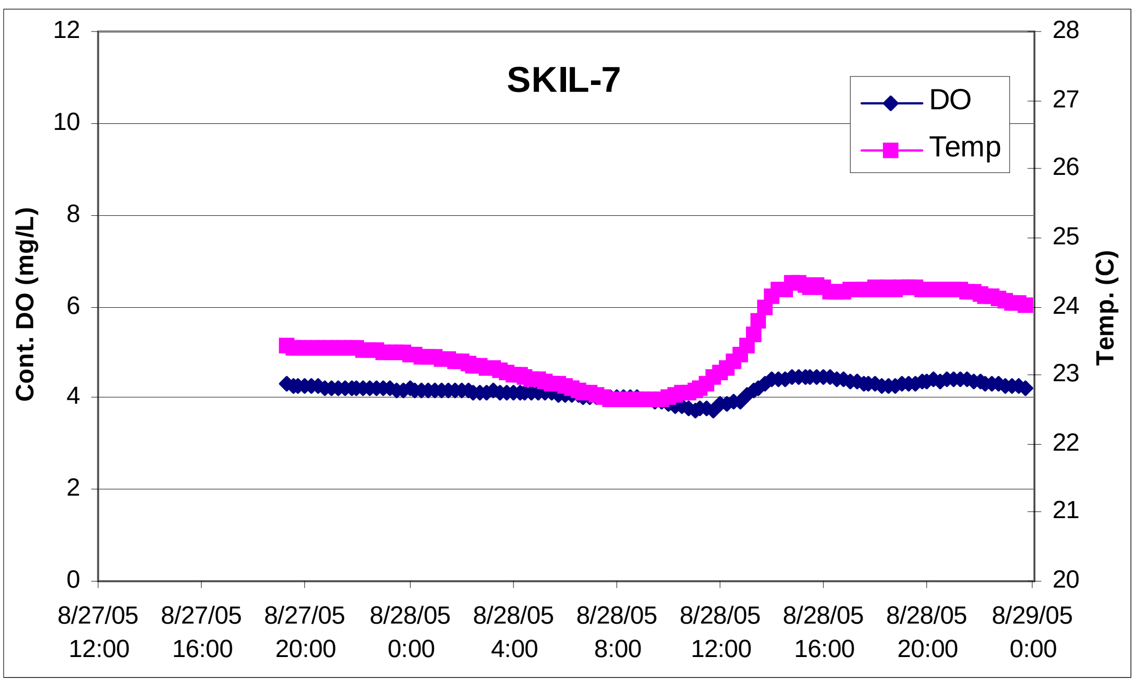

Figure 8. Continuous DO and Temperature at Dums Creek Station SKIL-7

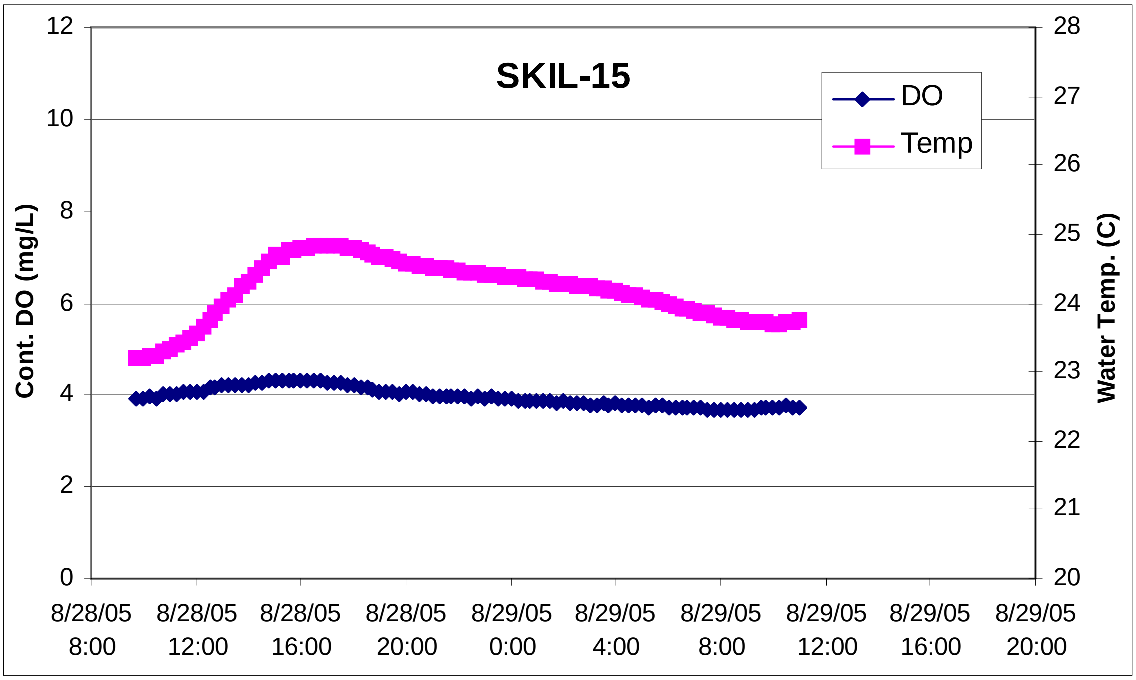

Figure 9. Continuous DO and Temperature at Skillet Fork Station SKIL-15

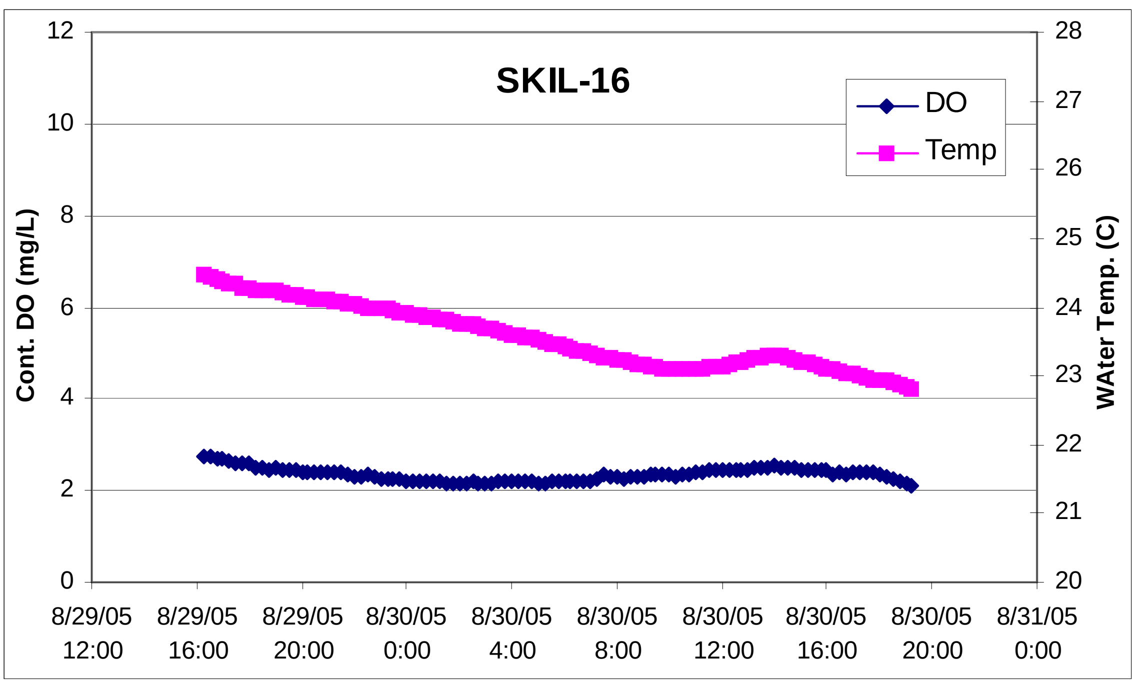

Figure 10. Continuous DO and Temperature at Brush Creek Station SKIL-16

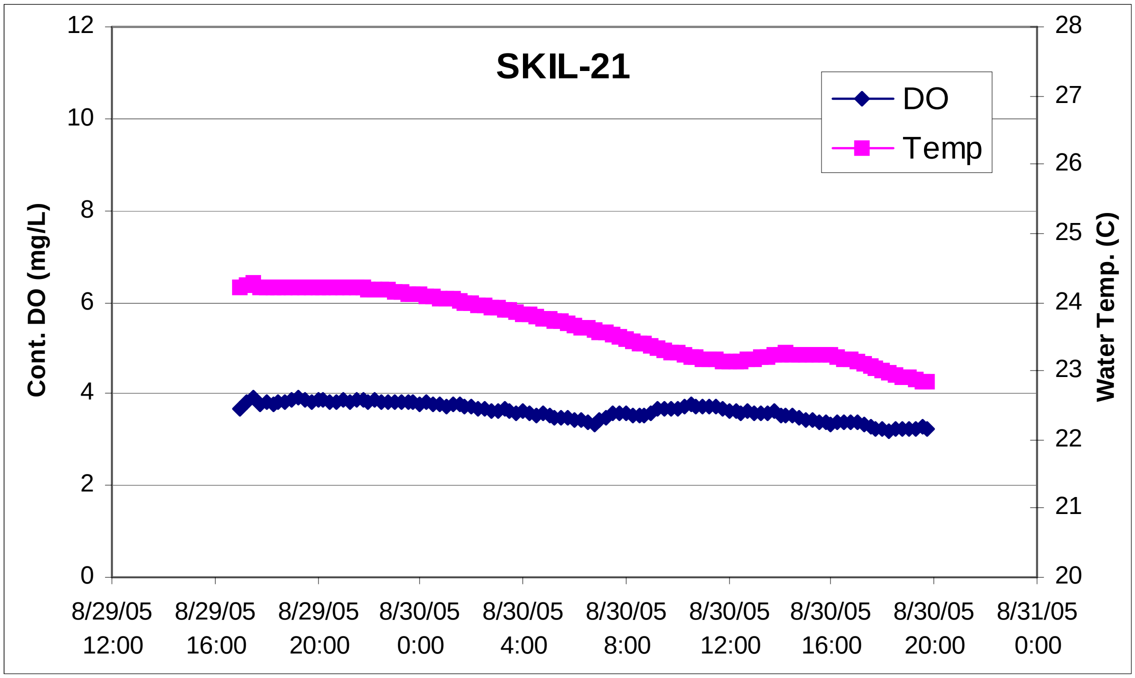

Figure 11. Continuous DO and Temperature at Horse Creek Station SKIL-21

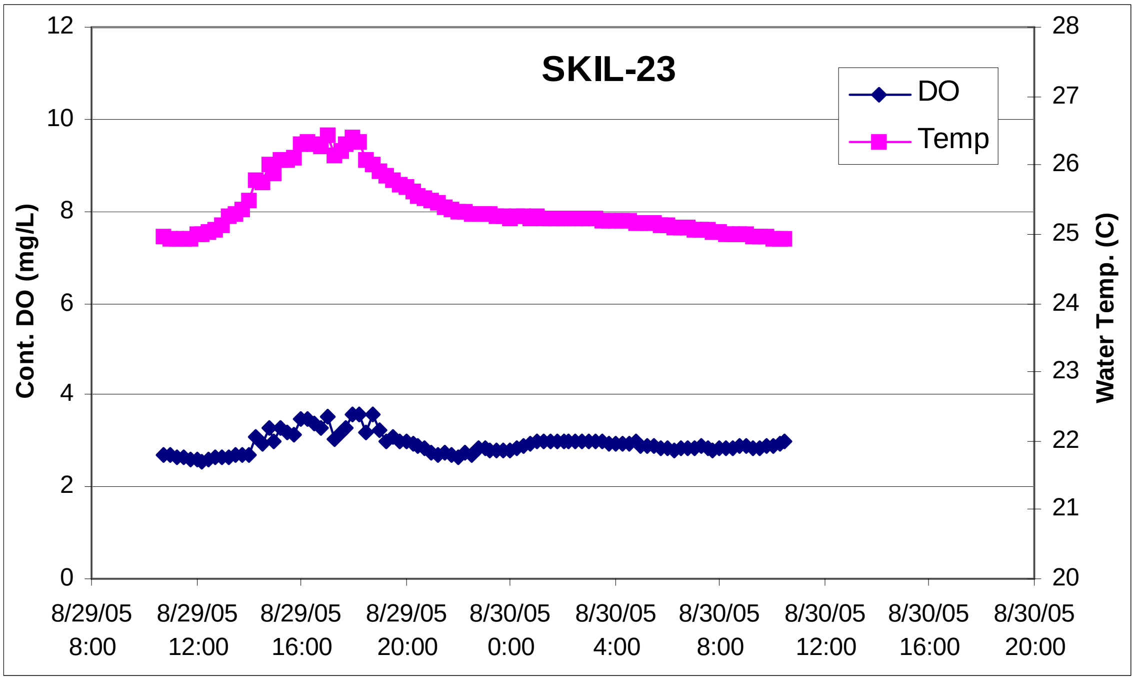

Figure 12. Continuous DO and Temperature at Skillet Fork Station SKIL-23

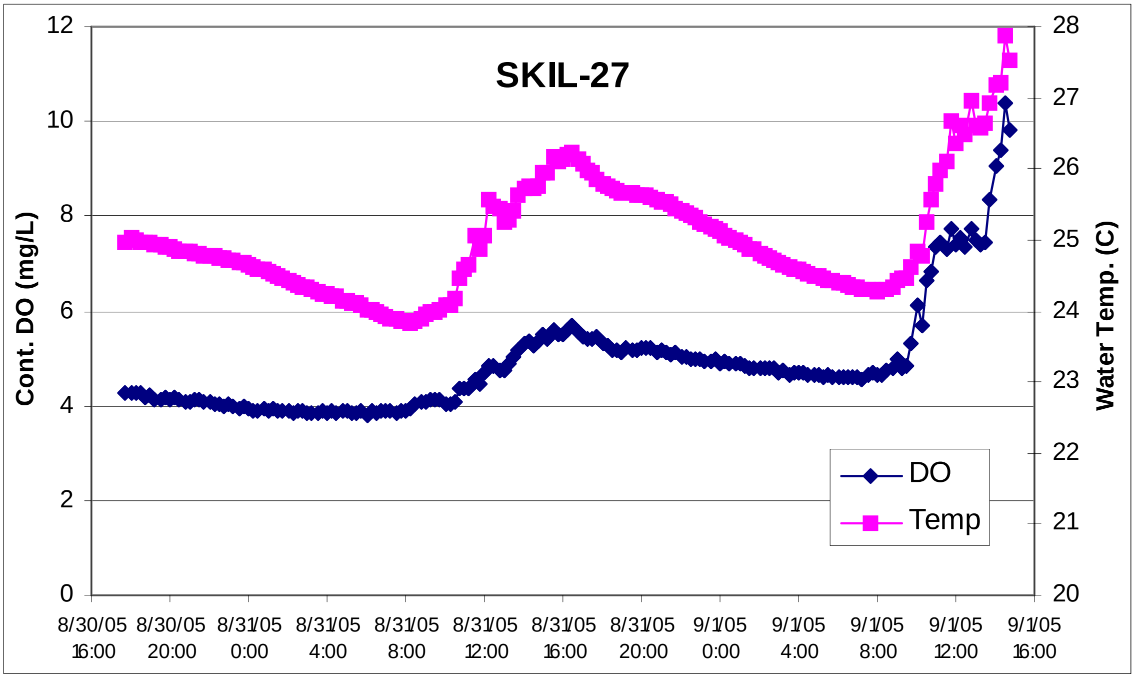

Figure 13. Continuous DO and Temperature at Skillet Fork Station SKIL-27

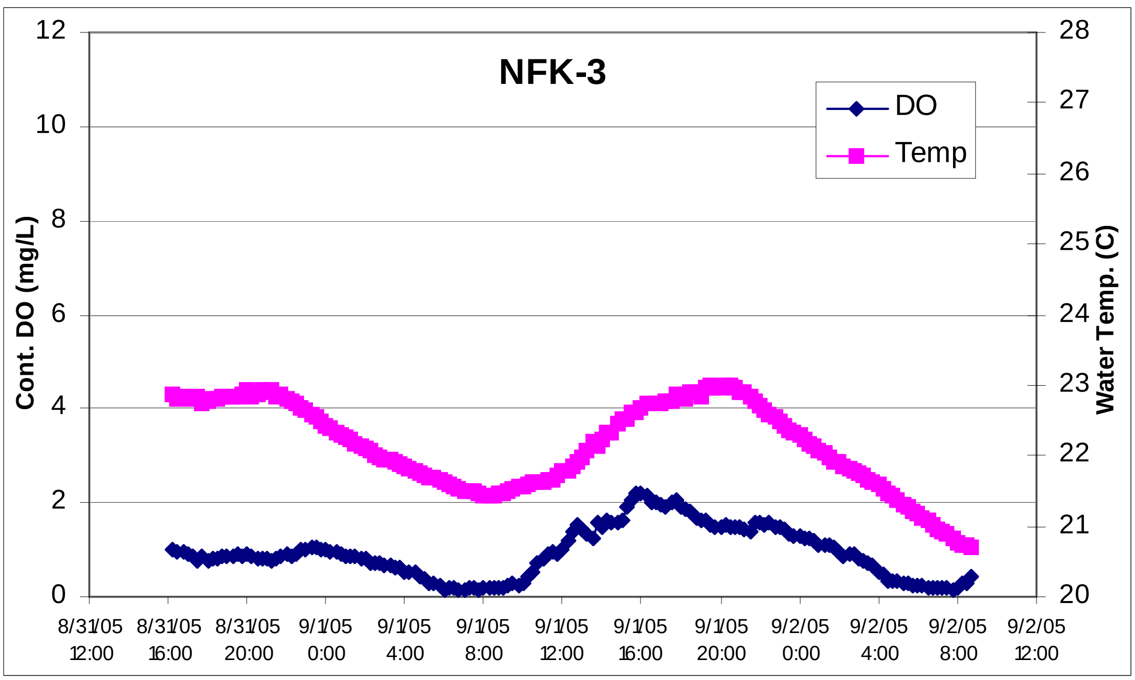

Figure 14. Continuous DO and Temperature at North Fork Kaskaskia River Station NFK-3

QUALITY ASSURANCE REVIEW

A review was conducted to assess the quality and usability of data generated from implementation of the work activities and to assess adherence to protocols specified in the QAPP. Field and laboratory methods were reviewed and found to be in accordance with the QAPP; however, certain changes to sampling and analysis activities were implemented that deviated from the sampling plan presented in the QAPP and are documented in the remainder of this section. Field measurement data and laboratory analytical data were verified and validated in accordance with the QAPP.

Overall, the data generated are of satisfactory quality and suitable for the intended uses, which include stream characterization and modeling for TMDL development. Some of the data, though acceptable for use, are qualified because of deficiencies in field or laboratory quality control procedures or conditions. Other data, though not specifically flagged with a data qualifier, are associated with uncertainties that prompt caution in their use. These are discussed in this section.

The following subsections of this document present the deviations, deficiencies and cautions associated with the data generated during the investigations. These subsections include the sampling plan changes implemented during the course of the investigation and the results of the data verification and data validation activities.

Changes from Sampling Plan (QAPP)

Certain changes were made to the sampling plan or sampling protocols specified in the QAPP as noted in the following list.

- ➢ A number of Round 1 BOD_5 samples were frozen at the lab upon receipt. The result is that the BOD_5 analysis was initiated six days after sample collection. Based on discussions with the lab, which has commonly followed this practice and which has conducted studies to assess the impact of this practice, the effect of freezing the samples has a minimal effect on the results.
- A number of sampling locations were changed from those presented in the QAPP because of difficult access conditions noted during field reconnaissance. The location changes made are documented in Table 1.
- Samples were not collected at stations that were dry. Locations not sampled due to dry conditions are identified in Table 1.
- The QAPP describes one round of pH measurements in the North Fork Kaskaskia River and Skillet Fork watersheds. A second round of pH field measurements was added to the sampling plan to provide additional data for assessment of this parameter at the sampled locations. The Round 1 pH measurements in the North Fork Kaskaskia River watershed were performed by the laboratory using samples submitted for BOD_5 analysis, rather than in the field. pH measurements are presented in Table 3.
- The QAPP describes one round of total iron sampling in the North Fork Kaskaskia River watershed. To better compare iron measurements to the Illinois Water Quality Criteria for iron, which are based on the dissolved fraction, both total and dissolved iron samples were added to Round 2 sampling and analysis

activities. The total iron samples were collected to enable correlation between the solid and dissolved fractions. Iron results are presented in Table 3.

- Manganese measurements were not originally outlined in the QAPP for the Macoupin Creek and North Fork Kaskaskia River watersheds. After discussions with the IL-EPA project manager, the lab was contacted on 10/24/05 and authorized to complete manganese analyses from samples already at the lab. Manganese was analyzed for the North Fork Kaskaskia River using the samples submitted for iron analysis, which were properly preserved with nitric acid. Samples submitted for BOD_5 analysis, which contained no chemical preservative, were used for the Macoupin Creek watershed manganese analyses after discussions with the laboratory regarding the effects of analyzing manganese from improperly preserved samples. The manganese results are presented in Tables 2 and 3.

Data Verification and Validation

The data generated are of overall good quality and acceptable for use with some qualifications as discussed below.

Discharge data. There is uncertainty associated with discharge values generated from flow data for many locations. Results that are negative and very near zero accurately represent the fact that little to no downstream discharge was present, but should be used with caution in terms of defining a specific magnitude of flow. Drought conditions in southern Illinois during summer and fall 2005 created very low water levels and stream velocities. Field observations of “no apparent flow” were common. Uncertainties in the data may be associated with the following:

- Recorded water velocities were very low or negative, often below the sensitivity of the velocity meter (±0.05 feet per second),
- Stream flow was often insufficient to overcome measurement system inertia and accurately orient the velocity sensor in the direction of flow, resulting in inaccurate recordings of flow angle when using a bridgeboard,
- Stream flow was often insufficient to overcome water currents induced by the presence of sampling personnel when measuring velocities while wading in the stream, and
- At the SKIL-15 sampling location, hydraulic conditions were observed that may have been associated with the presence of underwater springs.

The knowledge that little to no downstream discharge was present will be sufficient to satisfy modeling requirements.

Laboratory data. There is uncertainty associated with some of the laboratory data based on results of quality control procedures that are outside of control limits. These data were qualified as estimated (J flag), and are described in additional detail below.

- ***BOD_5 holding times*** - BOD_5 samples arrived at the lab in time for analysis, however, due to arrival on a holiday weekend, the laboratory froze the samples, and analyzed them 6 days after the samples were collected. The holding time for these frozen samples exceeded the method specified holding time of 48 hours from sample collection to analysis. The samples affected are presented below.

- All Round 1 samples collected on 9/1/05 from the Skillet Fork watershed (SKIL-1, SKIL-2, SKIL-3, SKIL-4, SKIL-5, SKIL-6 DUP1, SKIL-6 DUP2, SKIL-7, SKIL-8, SKIL-9, SKIL-10, SKIL-11, SKIL-12, SKIL-14, SKIL-15, SKIL-16, SKIL-17, SKIL-18, SKIL-19 DUP1, SKIL-19 DUP2, SKIL-20, SKIL-21, SKIL-22, SKIL-23, SKIL-24, SKIL-25, SKIL-26, SKIL-27 DUP1, SKIL-27 DUP2, SKIL-28, Rinse Blank, Rinse Blank 2)

The laboratory indicated that they have commonly frozen BOD_5 samples and have previously conducted analyses on split samples to determine the impact of freezing on results. The potential error introduced is between 10 and 30 percent and no significant bias was observed. Because this is consistent with the precision measurement objective as stated in the QAPP and as such these results were not flagged. Furthermore, a review of the BOD_5 results between Round 1 and Round 2, found that the BOD_5 results are similar for the majority of Skillet Fork locations. If appropriate, the BOD_5 inputs to the model may be adjusted within the estimated range of uncertainty, to calibrate the water quality model.

- ***Manganese sample preservation*** – As discussed previously, manganese analyses were added to the project scope after field sampling had been completed. The laboratory was contacted and asked to analyze manganese from the Macoupin watershed water samples remaining from previous BOD_5 analyses. Because these samples were collected for BOD_5 analyses, they did not meet the field preservation specifications for metals (using nitric acid). As a result, these manganese results (detected and non-detected) were qualified as estimated (J flag). It should be noted that the samples were analyzed for manganese within method specified holding times (6 months) for properly preserved samples and the laboratory sample preparation procedures of acid digestion brought back into solution any manganese that was precipitated or adsorbed to the container. However, it is possible that other processes such as volatilization or microbial breakdown may have been present to affect analytical results. The analytical method does not discuss procedures for unpreserved samples. The samples affected are presented below.

  - All Round 1 samples collected on 8/23/05 from the Macoupin Creek watershed (MAC-1, MAC-3, MAC-5, MAC-6, MAC-7, MAC-9, MAC-10, MAC-11, MAC-12)
  - All Round 2 samples collected on 10/11/05 from the Macoupin Creek watershed (MAC-1, MAC-3, MAC-5, MAC-6, MAC-7, MAC-8, MAC-9, MAC-10, MAC-12)

  The effect of the change in sample preservation is expected to be minimal and these data are considered sufficient to support model and TMDL development.

Field QC data. Field quality control (QC) samples were collected to assess bias associated with field and laboratory methods. The field QC samples included 11 field duplicate sample pairs and eight rinse blank samples. The results of these analyses are presented below.

- ***Ammonia contamination in rinse blanks*** - Ammonia was detected in 7 out of 8 rinse blanks analyzed from the Round 1 and Round 2 sampling events. Although no qualifications were made to the sample results based on the presence of rinse blank contamination, the possibility must be acknowledged that sample results with levels near or below those detected in blanks may be attributable to contamination introduced during field sampling and rinsing procedures and not representative of stream quality. Sample containers were all rinsed using station stream water prior to sample collection, rather than the deionized water used for preparation of the rinse blanks; however, caution is indicated. Positive ammonia results for rinse blanks ranged 0.04-0.09 mg/L while positive sample results ranged 0.01-1.8 mg/L.

  Because the sample bottles were all rinsed with stream water prior to sample collection, the ammonia detected in the rinse blanks is not expected to affect the results and the data are suitable for use in model and TMDL development. Additionally, the magnitude of ammonia concentrations observed in the rinse blanks is small, relative to the management concern (i.e., ammonia concentration < 1.0 mg/l isn’t considered a problem).

- ***Field Duplicates*** - Eleven field duplicate pairs were analyzed with the monitoring data. Positive sample results and relative percent differences (RPD) are presented in Table 8 along with the criteria for precision (relative percent difference values). All duplicate recoveries were within acceptable ranges.

Table 8. Field Duplicate Pair Sample Results

Sample ID	Ammonia (mg/L)	BOD_5 (mg/L)	Dissolved Iron (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)
Round 1 Results					
MAC-1 DUP1	<0.01	2.7			0.57 J
MAC-1 DUP2	<0.01	3.2			
RPD (%)		**4.2 b**			
NFK-1 DUP1	0.08	3.2		0.88	0.47
NFK-1 DUP2	0.09	3.2		0.89	
RPD (%)	**2.9 b**	**0.0 b**		**0.3 a**	
SKIL-6 DUP1	0.02	<2 J			
SKIL-6 DUP2	<0.01	<2 J			
RPD (%)	**16.7 b**				
SKIL-19 DUP1	0.08	<2 J			0.58
SKIL-19 DUP2	0.09	<2 J			0.61
RPD (%)	**2.9 b**				**1.3 a**
SKIL-27 DUP1	<0.01	<2 J			0.26
SKIL-27 DUP2	<0.01	<2 J			0.26
RPD (%)					**0.0 a**
Round 2 Results					
HOD-3 DUP1	0.23 J	<2			
HOD-3 DUP2	0.23 J	<2			
RPD (%)	**0.0 b**				
MAC-7 DUP1	0.02 J	2.6			0.21 J
MAC-7 DUP2	0.03 J	<2			
RPD (%)	**10.0 b**	**6.5 b**			
NFK-5 DUP1	0.25	3.7	0.6	2.6	0.89
NFK-5 DUP2	0.22	4.5	0.55	2.8	
RPD (%)	**3.2 b**	**4.9 b**	**2.2 a**	**1.9 a**	
SKIL-6 DUP1	0.16	3.7			
SKIL-6 DUP2	0.02	3			
RPD (%)	**38.9 b**	**5.2 b**			
SKIL-19 DUP1	0.32	<2			
SKIL-19 DUP2	0.36	<2			
RPD (%)	**2.9 b**				
SKIL-27 DUP1	0.01 U	4.1			
SKIL-27DUP2	0.03	4			
RPD (%)	**25.0 b**	**0.6 b**			

a Acceptable metal duplicate; sample results are within +/- the laboratory reporting limit or <= 20% RPD (for aqueous samples).

b Acceptable organic duplicate; sample results are within +/- the laboratory reporting limit or <= 20% RPD (for aqueous samples) or the difference is < a factor of 5X in the concentration.

c One or both results should be considered estimated and have been flagged with a J in the data tables due to the disparity observed between the field duplicate results.

*RPD= |S-D| x100 / (S+D)/2 where S: original sample; D: Duplicate sample

Conformance to Data Quality Objectives. Overall, the data generated during the investigation conformed to the project data quality objectives (DQOs) and are suitable for their intended uses. The monitored parameters were evaluated in terms of minimum measurement criteria, minimum measurement objectives, required detection limits, accuracy, precision and completeness using the DQOs presented in the project QAPP. Table 9 summarizes the results of the DQO quality assurance (QA) check.

The QA check shows apparent deficiencies with minimum measurement criteria for iron results and with completeness criteria for DO, temperature, ammonia and BOD_5. In the case of iron, the method detection limit (0.02 mg/L) did meet its criterion and this value is essentially rounded up to one significant digit from the minimum measurement criterion for iron (0.017 mg/L). The completeness criteria reflect the number of samples and measurements that were originally planned; however, as noted previously, the drought conditions prevalent during the investigations precluded sampling at tributary locations that were dry or had insufficient water. Adjusting the completeness criterion to reflect actual field conditions by eliminating locations that were not possible to sample results in the criterion being met at 100%. The completeness value for pH monitoring exceeds 100% because measurements were obtained during the second round of sampling and at a number of additional locations not present in the original sampling plan.

Table 9. Measurement Objectives and Criteria Check

Parameter	Minimum Measurement Criteria	Minimum Measurement Objectives	Method*; MDL[1]	QA check	MS/MSD * Accuracy (% recovery)	MS/MSD * QA check	MS/MSD * Precision (RPD)	MS/MSD * QA check	LCS * Accuracy (% recovery)	LCS * QA check	Completeness Criteria	QA check
Dissolved Oxygen	NA	0.1 mg/l [s]	Field; NA	S	NA	NA	NA	NA	NA	NA	90%	S[3] (83%)
Water Temperature	NA	0.1 degree C [s]	Field; NA	S	NA	NA	NA	NA	NA	NA	90%	S[3] (83%)
pH	NA	0.1 pH unit[s]	Field; NA	S	NA	NA	NA	NA	NA	NA	90%	S (162%)
Ammonia	15.0 mg/l[G]	3.0 mg/l	EPA 350.1/ 350.3; 0.01/0.03 mg/l	S (0.01 mg/l)	80-120%	S	20%	S	80-120%	S	90%	S[3] (88%)
BOD_5	No Standard	No Standard	EPA 405.1/ SM5210 B; 2 mg/l	S (2 mg/l)	NA	NA	20%	S	NA	NA	90%	S[3] (88%)
Iron, Total & Dissolved	0.017 mg/l[G, 2]	0.005 mg/l	EPA 200.8; 0.02 mg/l	S (0.02 mg/l)	70-130%	S (80-120%)	20%	S	80-120%	S	90%	S (97%)
Manganese, Total	1 mg/l[G]	0.2 mg/l	EPA 200.8 0.02 mg/l	S (0.02 mg/l)	70-130%	S (80-120%)	20%	S	80-120%	S	90%	S (98%)

Notes

1 Method Detection Limit (MDL) from SM and EPA.
2 Calculated acute standard based on a minimum water hardness of 100 mg/L as CaCO3
* Limits are subject to change based upon capabilities of contract labs
G State of Illinois General Use Water Quality Standard
s Required sensitivity
EPA U.S. EPA Methods for Chemical Analysis of Water and Wastes, March 1983
NA Not Applicable
SM Standard Methods of the Examination of Water and Wastewater, 20th Edition
S QA check is satisfactory, criteria met
S[3] QA check is satisfactory for adjusted criteria

Appendix 1. Quality Assurance Project Plan

The QAPP is available upon request from Illinois EPA.

Appendix 2. Continuous Data

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Continuous Dissolved Oxygen (DO) Data - Hodges, Macoupin, North Fork Kaskaskia and Skillet Fork Watersheds

HOD-1			MAC-7			NFK-3			SKIL-4		
Date / Time	Temp [°C]	DO [mg/l]	Date / Time	Temp [°C]	DO [mg/l]	Date / Time	Temp [°C]	DO [mg/l]	Date / Time	Temp [°C]	DO [mg/l]
8/24/2005 13:20	22.26	5.01	8/24/2005 15:40	22.79	5.9	8/31/2005 16:15	22.87	1	8/27/2005 18:00	23.61	0.19
8/24/2005 13:35	22.27	5.03	8/24/2005 15:55	22.72	5.65	8/31/2005 16:30	22.82	0.96	8/27/2005 18:15	23.36	0.14
8/24/2005 13:50	22.28	4.88	8/24/2005 16:10	22.76	5.77	8/31/2005 16:45	22.83	0.94	8/27/2005 18:30	23.26	0.12
8/24/2005 14:05	22.29	4.91	8/24/2005 16:25	22.77	6.17	8/31/2005 17:00	22.79	0.91	8/27/2005 18:45	23.26	0.11
8/24/2005 14:20	22.31	4.78	8/24/2005 16:40	22.78	6.25	8/31/2005 17:15	22.8	0.88	8/27/2005 19:00	23.33	0.09
8/24/2005 14:35	22.33	4.9	8/24/2005 16:55	22.87	6.6	8/31/2005 17:30	22.85	0.77	8/27/2005 19:15	23.35	0.09
8/24/2005 14:50	22.35	4.89	8/24/2005 17:10	22.97	7.07	8/31/2005 17:45	22.75	0.86	8/27/2005 19:30	23.32	0.11
8/24/2005 15:05	22.39	5.25	8/24/2005 17:25	22.94	6.75	8/31/2005 18:00	22.77	0.77	8/27/2005 19:45	23.29	0.1
8/24/2005 15:20	22.42	5.3	8/24/2005 17:40	22.94	7.22	8/31/2005 18:15	22.79	0.79	8/27/2005 20:00	23.34	0.08
8/24/2005 15:35	22.51	5.48	8/24/2005 17:55	22.97	7.44	8/31/2005 18:30	22.82	0.8	8/27/2005 20:15	23.36	0.08
8/24/2005 15:50	22.5	5.55	8/24/2005 18:10	22.89	6.72	8/31/2005 18:45	22.85	0.84	8/27/2005 20:30	23.31	0.09
8/24/2005 16:05	22.56	5.59	8/24/2005 18:25	22.88	6.59	8/31/2005 19:00	22.84	0.88	8/27/2005 20:45	23.34	0.08
8/24/2005 16:20	22.58	5.59	8/24/2005 18:40	22.97	7.29	8/31/2005 19:15	22.83	0.87	8/27/2005 21:00	23.37	0.07
8/24/2005 16:35	22.62	5.52	8/24/2005 18:55	22.97	7.35	8/31/2005 19:30	22.84	0.93	8/27/2005 21:15	23.36	0.09
8/24/2005 16:50	22.62	5.44	8/24/2005 19:10	22.97	7.33	8/31/2005 19:45	22.88	0.88	8/27/2005 21:30	23.4	0.07
8/24/2005 17:05	22.63	5.58	8/24/2005 19:25	22.98	7.27	8/31/2005 20:00	22.92	0.89	8/27/2005 21:45	23.39	0.09
8/24/2005 17:20	22.6	4.82	8/24/2005 19:40	22.91	6.94	8/31/2005 20:15	22.85	0.88	8/27/2005 22:00	23.33	0.09
8/24/2005 17:35	22.58	5.01	8/24/2005 19:55	22.89	6.89	8/31/2005 20:30	22.87	0.8	8/27/2005 22:15	23.34	0.09
8/24/2005 17:50	22.6	5.29	8/24/2005 20:10	22.83	6.62	8/31/2005 20:45	22.92	0.82	8/27/2005 22:30	23.3	0.08
8/24/2005 18:05	22.61	5.12	8/24/2005 20:25	22.8	6.5	8/31/2005 21:00	22.9	0.81	8/27/2005 22:45	23.31	0.09
8/24/2005 18:20	22.65	5.04	8/24/2005 20:40	22.71	6.16	8/31/2005 21:15	22.92	0.76	8/27/2005 23:00	23.28	0.09
8/24/2005 18:35	22.66	5.13	8/24/2005 20:55	22.73	6.37	8/31/2005 21:30	22.85	0.82	8/27/2005 23:15	23.25	0.09
8/24/2005 18:50	22.65	5.07	8/24/2005 21:10	22.7	6.19	8/31/2005 21:45	22.86	0.85	8/27/2005 23:30	23.23	0.06
8/24/2005 19:05	22.65	4.9	8/24/2005 21:25	22.67	6.2	8/31/2005 22:00	22.82	0.9	8/27/2005 23:45	23.2	0.06
8/24/2005 19:20	22.68	5.3	8/24/2005 21:40	22.61	6.06	8/31/2005 22:15	22.76	0.85	8/28/2005 0:00	23.16	0.07
8/24/2005 19:35	22.67	5.13	8/24/2005 21:55	22.54	5.96	8/31/2005 22:30	22.73	0.92	8/28/2005 0:15	23.12	0.06
8/24/2005 19:50	22.69	5.19	8/24/2005 22:10	22.51	5.94	8/31/2005 22:45	22.69	0.99	8/28/2005 0:30	23.09	0.08
8/24/2005 20:05	22.69	5.18	8/24/2005 22:25	22.47	5.93	8/31/2005 23:00	22.64	1.02	8/28/2005 0:45	23.04	0.09
8/24/2005 20:20	22.7	5.75	8/24/2005 22:40	22.41	5.81	8/31/2005 23:15	22.58	1.06	8/28/2005 1:00	22.9	0.06
8/24/2005 20:35	22.65	4.97	8/24/2005 22:55	22.37	5.78	8/31/2005 23:30	22.54	1.03	8/28/2005 1:15	22.98	0.09
8/24/2005 20:50	22.61	5.1	8/24/2005 23:10	22.33	5.75	8/31/2005 23:45	22.49	1.02	8/28/2005 1:30	22.92	0.07
8/24/2005 21:05	22.57	5.19	8/24/2005 23:25	22.29	5.7	9/1/2005 0:00	22.43	1	8/28/2005 1:45	22.88	0.09
8/24/2005 21:20	22.53	5.18	8/24/2005 23:40	22.24	5.62	9/1/2005 0:15	22.38	0.96	8/28/2005 2:00	22.83	0.06
8/24/2005 21:35	22.5	5.06	8/24/2005 23:55	22.2	5.47	9/1/2005 0:30	22.34	0.94	8/28/2005 2:15	22.8	0.08
8/24/2005 21:50	22.48	4.99	8/25/2005 0:10	22.16	5.23	9/1/2005 0:45	22.3	0.93	8/28/2005 2:30	22.76	0.08
8/24/2005 22:05	22.44	4.97	8/25/2005 0:25	22.11	5.1	9/1/2005 1:00	22.25	0.87	8/28/2005 2:45	22.69	0.06
8/24/2005 22:20	22.41	4.94	8/25/2005 0:40	22.08	5.1	9/1/2005 1:15	22.22	0.84	8/28/2005 3:00	22.64	0.08
8/24/2005 22:35	22.37	4.91	8/25/2005 0:55	22.06	5.05	9/1/2005 1:30	22.18	0.85	8/28/2005 3:15	22.6	0.09
8/24/2005 22:50	22.33	4.85	8/25/2005 1:10	22.01	5.09	9/1/2005 1:45	22.15	0.8	8/28/2005 3:30	22.54	0.09
8/24/2005 23:05	22.29	4.86	8/25/2005 1:25	21.99	5.06	9/1/2005 2:00	22.11	0.82	8/28/2005 3:45	22.5	0.07
8/24/2005 23:20	22.25	4.69	8/25/2005 1:40	21.96	5.09	9/1/2005 2:15	22.06	0.74	8/28/2005 4:00	22.46	0.08
8/24/2005 23:35	22.21	4.8	8/25/2005 1:55	21.94	5.16	9/1/2005 2:30	22.02	0.74	8/28/2005 4:15	22.43	0.09
8/24/2005 23:50	22.17	4.72	8/25/2005 2:10	21.88	5.05	9/1/2005 2:45	21.99	0.74	8/28/2005 4:30	22.39	0.06
8/25/2005 0:05	22.12	4.81	8/25/2005 2:25	21.85	5.12	9/1/2005 3:00	21.96	0.66	8/28/2005 4:45	22.35	0.07
8/25/2005 0:20	22.08	4.67	8/25/2005 2:40	21.86	4.96	9/1/2005 3:15	21.93	0.68	8/28/2005 5:00	22.3	0.09
8/25/2005 0:35	22.03	4.65	8/25/2005 2:55	21.82	4.83	9/1/2005 3:30	21.9	0.63	8/28/2005 5:15	22.27	0.06
8/25/2005 0:50	21.96	4.71	8/25/2005 3:10	21.78	4.74	9/1/2005 3:45	21.87	0.63	8/28/2005 5:30	22.24	0.07
8/25/2005 1:05	21.97	4.67	8/25/2005 3:25	21.74	4.69	9/1/2005 4:00	21.84	0.54	8/28/2005 5:45	22.19	0.06
8/25/2005 1:20	21.92	4.74	8/25/2005 3:40	21.7	4.67	9/1/2005 4:15	21.82	0.51	8/28/2005 6:00	22.15	0.08
8/25/2005 1:35	21.87	4.62	8/25/2005 3:55	21.66	4.64	9/1/2005 4:30	21.79	0.51	8/28/2005 6:15	22.1	0.08
8/25/2005 1:50	21.83	4.65	8/25/2005 4:10	21.66	4.62	9/1/2005 4:45	21.76	0.45	8/28/2005 6:30	22.05	0.07
8/25/2005 2:05	21.79	4.59	8/25/2005 4:25	21.63	4.59	9/1/2005 5:00	21.73	0.39	8/28/2005 6:45	22.01	0.08
8/25/2005 2:20	21.74	4.59	8/25/2005 4:40	21.6	4.56	9/1/2005 5:15	21.69	0.3	8/28/2005 7:00	21.97	0.06
8/25/2005 2:35	21.7	4.5	8/25/2005 4:55	21.59	4.49	9/1/2005 5:30	21.68	0.27	8/28/2005 7:15	21.94	0.09
8/25/2005 2:50	21.69	4.45	8/25/2005 5:10	21.57	4.49	9/1/2005 5:45	21.65	0.22	8/28/2005 7:30	21.9	0.06
8/25/2005 3:05	21.65	4.43	8/25/2005 5:25	21.54	4.42	9/1/2005 6:00	21.61	0.15	8/28/2005 7:45	21.88	0.07
8/25/2005 3:20	21.61	4.41	8/25/2005 5:40	21.52	4.34	9/1/2005 6:15	21.58	0.19	8/28/2005 8:00	21.86	0.07
8/25/2005 3:35	21.56	4.49	8/25/2005 5:55	21.49	4.29	9/1/2005 6:30	21.56	0.17	8/28/2005 8:15	21.85	0.08
8/25/2005 3:50	21.53	4.41	8/25/2005 6:10	21.46	4.24	9/1/2005 6:45	21.53	0.13	8/28/2005 8:30	21.84	0.08
8/25/2005 4:05	21.48	4.46	8/25/2005 6:25	21.42	4.2	9/1/2005 7:00	21.51	0.16	8/28/2005 8:45	21.84	0.06
8/25/2005 4:20	21.45	4.45	8/25/2005 6:40	21.36	4.23	9/1/2005 7:15	21.49	0.17	8/28/2005 9:00	21.83	0.08
8/25/2005 4:35	21.43	4.38	8/25/2005 6:55	21.35	4.21	9/1/2005 7:30	21.49	0.18	8/28/2005 9:15	21.82	0.07
8/25/2005 4:50	21.4	4.36	8/25/2005 7:10	21.35	4.12	9/1/2005 7:45	21.47	0.14	8/28/2005 9:30	21.82	0.06
8/25/2005 5:05	21.38	4.33	8/25/2005 7:25	21.34	4.12	9/1/2005 8:00	21.45	0.19	8/28/2005 9:45	21.82	0.06
8/25/2005 5:20	21.36	4.33	8/25/2005 7:40	21.33	4.06	9/1/2005 8:15	21.45	0.18	8/28/2005 10:00	21.82	0.08
8/25/2005 5:35	21.35	4.26	8/25/2005 7:55	21.37	3.97	9/1/2005 8:30	21.44	0.18	8/28/2005 10:15	21.81	0.07
8/25/2005 5:50	21.33	4.31	8/25/2005 8:10	21.36	3.93	9/1/2005 8:45	21.46	0.2	8/28/2005 10:30	21.82	0.07
8/25/2005 6:05	21.32	4.19	8/25/2005 8:25	21.39	3.9	9/1/2005 9:00	21.47	0.17	8/28/2005 10:45	21.83	0.05
8/25/2005 6:20	21.27	4.23	8/25/2005 8:40	21.4	3.85	9/1/2005 9:15	21.5	0.23	8/28/2005 11:00	21.84	0.08
8/25/2005 6:35	21.24	4.24	8/25/2005 8:55	21.41	3.9	9/1/2005 9:30	21.54	0.28	8/28/2005 11:15	21.87	0.08
8/25/2005 6:50	21.24	4.21	8/25/2005 9:10	21.46	4.05	9/1/2005 9:45	21.56	0.26	8/28/2005 11:30	21.89	0.06
8/25/2005 7:05	21.23	4.1	8/25/2005 9:25	21.56	4.31	9/1/2005 10:00	21.55	0.3	8/28/2005 11:45	21.93	0.07
8/25/2005 7:20	21.24	4.37	8/25/2005 9:40	21.6	4.44	9/1/2005 10:15	21.59	0.43	8/28/2005 12:00	21.98	0.05
8/25/2005 7:35	21.25	4.44	8/25/2005 9:55	21.64	4.54	9/1/2005 10:30	21.61	0.54	8/28/2005 12:15	22.03	0.07
8/25/2005 7:50	21.26	4.45	8/25/2005 10:10	21.65	4.47	9/1/2005 10:45	21.63	0.71	8/28/2005 12:30	22.06	0.07
8/25/2005 8:05	21.27	4.52	8/25/2005 10:25	21.68	4.32	9/1/2005 11:00	21.63	0.82	8/28/2005 12:45	22.17	0.07
8/25/2005 8:20	21.29	4.48	8/25/2005 10:40	21.66	4.3	9/1/2005 11:15	21.66	0.91	8/28/2005 13:00	22.15	0.07
8/25/2005 8:35	21.33	4.49	8/25/2005 10:55	21.68	4.31	9/1/2005 11:30	21.67	0.94	8/28/2005 13:15	22.19	0.05
8/25/2005 8:50	21.38	4.59	8/25/2005 11:10	21.68	4.52	9/1/2005 11:45	21.72	0.93	8/28/2005 13:30	22.24	0.08
8/25/2005 9:05	21.42	4.56	8/25/2005 11:25	21.63	4.43	9/1/2005 12:00	21.78	1	8/28/2005 13:45	22.29	0.06
8/25/2005 9:20	21.46	4.72	8/25/2005 11:40	21.59	4.4	9/1/2005 12:15	21.8	1.21	8/28/2005 14:00	22.32	0.07
8/25/2005 9:35	21.49	4.7	8/25/2005 11:55	21.56	4.35	9/1/2005 12:30	21.86	1.4	8/28/2005 14:15	22.36	0.08
8/25/2005 9:50	21.51	4.69	8/25/2005 12:10	21.56	4.29	9/1/2005 12:45	21.9	1.51	8/28/2005 14:30	22.37	0.07
8/25/2005 10:05	21.52	4.64	8/25/2005 12:25	21.55	4.48	9/1/2005 13:00	21.99	1.43	8/28/2005 14:45	22.68	0.07
8/25/2005 10:20	21.53	4.74	8/25/2005 12:40	21.57	4.6	9/1/2005 13:15	22.06	1.34	8/28/2005 15:00	22.55	0.08
8/25/2005 10:35	21.53	4.7	8/25/2005 12:55	21.61	4.7	9/1/2005 13:30	22.19	1.26	8/28/2005 15:15	22.55	0.07
8/25/2005 10:50	21.51	4.86	8/25/2005 13:10	21.65	4.96	9/1/2005 13:45	22.12	1.6	8/28/2005 15:30	22.53	0.05
8/25/2005 11:05	21.45	5.04	8/25/2005 13:25	21.64	4.9	9/1/2005 14:00	22.22	1.49	8/28/2005 15:45	22.55	0.05
8/25/2005 11:20	21.34	5.52	8/25/2005 13:40	21.63	4.96	9/1/2005 14:15	22.34	1.62	8/28/2005 16:00	22.56	0.07
8/25/2005 11:35	21.26	5.59	8/25/2005 13:55	21.64	4.84	9/1/2005 14:30	22.33	1.59	8/28/2005 16:15	22.59	0.05
8/25/2005 11:50	21.27	5.8	8/25/2005 14:10	21.62	5.05	9/1/2005 14:45	22.44	1.56	8/28/2005 16:30	22.61	0.07
8/25/2005 12:05	21.35	5.43	8/25/2005 14:25	21.61	4.97	9/1/2005 15:00	22.51	1.63	8/28/2005 16:45	22.6	0.11
8/25/2005 12:20	21.39	5.34	8/25/2005 14:40	21.65	5.01	9/1/2005 15:15	22.53	1.93	8/28/2005 17:00	22.62	0.17
8/25/2005 12:35	21.44	5.58	8/25/2005 14:55	21.63	4.97	9/1/2005 15:30	22.61	2.04	8/28/2005 17:15	23.04	0.12
8/25/2005 12:50	21.5	5.62	8/25/2005 15:10	21.63	4.79	9/1/2005 15:45	22.62	2.22	8/28/2005 17:30	23.08	0.09
8/25/2005 13:05	21.6	5.59	8/25/2005 15:25	21.63	4.9	9/1/2005 16:00	22.68	2.22	8/28/2005 17:45	23.11	0.07
8/25/2005 13:20	21.72	5.57	8/25/2005 15:40	21.61	5.03	9/1/2005 16:15	22.73	2.16	8/28/2005 18:00	22.98	0.08
8/25/2005 13:35	21.75	5.6	8/25/2005 15:55	21.63	4.89	9/1/2005 16:30	22.75	2.01	8/28/2005 18:15	23.04	0.08
8/25/2005 13:50	21.73	5.57	8/25/2005 16:10	21.63	4.87	9/1/2005 16:45	22.75	2	8/28/2005 18:30	23.04	0.07
8/25/2005 14:05	21.77	5.58	8/25/2005 16:25	21.68	4.83	9/1/2005 17:00	22.74	1.98			
8/25/2005 14:20	21.8	5.63	8/25/2005 16:40	21.68	4.64	9/1/2005 17:15	22.76	1.91			
8/25/2005 14:35	21.82	5.47	8/25/2005 16:55	21.68	4.54	9/1/2005 17:30	22.78	2.03			
8/25/2005 14:50	21.85	5.24	8/25/2005 17:10	21.68	4.49	9/1/2005 17:45	22.86	2.07			
8/25/2005 15:05	21.86	5.4	8/25/2005 17:25	21.69	4.47	9/1/2005 18:00	22.83	1.92			
8/25/2005 15:20	21.93	5.39	8/25/2005 17:40	21.69	4.5	9/1/2005 18:15	22.8	1.88			
			8/25/2005 17:55	21.68	4.62	9/1/2005 18:30	22.9	1.82			
			8/25/2005 18:10	21.7	4.61	9/1/2005 18:45	22.9	1.65			
			8/25/2005 18:25	21.73	4.66	9/1/2005 19:00	22.83	1.64			
			8/25/2005 18:40	21.75	4.64	9/1/2005 19:15	22.97	1.61			
						9/1/2005 19:30	23	1.52			
						9/1/2005 19:45	22.98	1.47			
						9/1/2005 20:00	22.96	1.48			
						9/1/2005 20:15	23	1.55			
						9/1/2005 20:30	23	1.5			
						9/1/2005 20:45	22.96	1.5			
						9/1/2005 21:00	22.89	1.46			
						9/1/2005 21:15	22.89	1.43			
						9/1/2005 21:30	22.83	1.41			
						9/1/2005 21:45	22.77	1.59			
						9/1/2005 22:00	22.71	1.59			
						9/1/2005 22:15	22.66	1.52			
						9/1/2005 22:30	22.59	1.56			
						9/1/2005 22:45	22.55	1.5			
						9/1/2005 23:00	22.48	1.46			
						9/1/2005 23:15	22.43	1.42			
						9/1/2005 23:30	22.37	1.36			
						9/1/2005 23:45	22.32	1.27			
						9/2/2005 0:00	22.28	1.27			
						9/2/2005 0:15	22.23	1.25			
						9/2/2005 0:30	22.17	1.23			
						9/2/2005 0:45	22.12	1.19			
						9/2/2005 1:00	22.08	1.11			
						9/2/2005 1:15	22.03	1.12			
						9/2/2005 1:30	21.98	1.09			
						9/2/2005 1:45	21.92	1.05			
						9/2/2005 2:00	21.9	0.96			
						9/2/2005 2:15	21.86	0.86			
						9/2/2005 2:30	21.81	0.92			
						9/2/2005 2:45	21.77	0.91			
						9/2/2005 3:00	21.74	0.81			
						9/2/2005 3:15	21.71	0.77			
						9/2/2005 3:30	21.67	0.7			
						9/2/2005 3:45	21.62	0.66			
						9/2/2005 4:00	21.58	0.52			
						9/2/2005 4:15	21.53	0.47			
						9/2/2005 4:30	21.48	0.35			
						9/2/2005 4:45	21.43	0.35			
						9/2/2005 5:00	21.38	0.35			
						9/2/2005 5:15	21.32	0.29			
						9/2/2005 5:30	21.27	0.31			
						9/2/2005 5:45	21.22	0.26			
						9/2/2005 6:00	21.17	0.25			
						9/2/2005 6:15	21.11	0.25			
						9/2/2005 6:30	21.07	0.17			
						9/2/2005 6:45	21.01	0.18			
						9/2/2005 7:00	20.96	0.2			
						9/2/2005 7:15	20.92	0.19			
						9/2/2005 7:30	20.89	0.2			
						9/2/2005 7:45	20.84	0.16			
						9/2/2005 8:00	20.78	0.19			
						9/2/2005 8:15	20.74	0.28			
						9/2/2005 8:30	20.72	0.3			
						9/2/2005 8:45	20.69	0.43			

Continuous Dissolved Oxygen (DO) Data - Hodges, Macoupin, North Fork Kaskaskia and Skillet Fork Watersheds

SKIL-7			SKIL-15			SKIL-16			SKIL-21			SKIL-23			SKIL-27		
Date / Time	Temp [°C]	DO [mg/l]	Date / Time	Temp [°C]	DO [mg/l]	Date / Time	Temp [°C]	DO [mg/l]	Date / Time	Temp [°C]	DO [mg/l]	Date / Time	Temp [°C]	DO [mg/l]	Date / Time	Temp [°C]	DO [mg/l]
8/27/2005 19:15	23.42	4.33	8/28/2005 9:45	23.2	3.93	8/29/2005 16:15	24.48	2.72	8/29/2005 17:00	24.22	3.66	8/29/2005 10:45	24.95	2.69	8/30/2005 17:45	24.97	4.27
8/27/2005 19:30	23.41	4.28	8/28/2005 10:00	23.21	3.92	8/29/2005 16:30	24.44	2.73	8/29/2005 17:15	24.23	3.82	8/29/2005 11:00	24.94	2.69	8/30/2005 18:00	25.02	4.25
8/27/2005 19:45	23.41	4.28	8/28/2005 10:15	23.23	3.97	8/29/2005 16:45	24.4	2.7	8/29/2005 17:30	24.29	3.91	8/29/2005 11:15	24.92	2.63	8/30/2005 18:15	25.01	4.29
8/27/2005 20:00	23.41	4.26	8/28/2005 10:30	23.24	3.93	8/29/2005 17:00	24.37	2.68	8/29/2005 17:45	24.21	3.76	8/29/2005 11:30	24.93	2.63	8/30/2005 18:30	24.98	4.28
8/27/2005 20:15	23.41	4.25	8/28/2005 10:45	23.3	4	8/29/2005 17:15	24.34	2.63	8/29/2005 18:00	24.2	3.8	8/29/2005 11:45	24.94	2.59	8/30/2005 18:45	24.95	4.18
8/27/2005 20:30	23.41	4.25	8/28/2005 11:00	23.32	4	8/29/2005 17:30	24.33	2.62	8/29/2005 18:15	24.2	3.79	8/29/2005 12:00	24.98	2.6	8/30/2005 19:00	24.95	4.23
8/27/2005 20:45	23.41	4.23	8/28/2005 11:15	23.38	4.01	8/29/2005 17:45	24.29	2.59	8/29/2005 18:30	24.2	3.84	8/29/2005 12:15	24.99	2.57	8/30/2005 19:15	24.92	4.14
8/27/2005 21:00	23.41	4.23	8/28/2005 11:30	23.44	4.06	8/29/2005 18:00	24.27	2.61	8/29/2005 18:45	24.2	3.83	8/29/2005 12:30	25.03	2.6	8/30/2005 19:30	24.92	4.14
8/27/2005 21:15	23.4	4.22	8/28/2005 11:45	23.5	4.07	8/29/2005 18:15	24.26	2.51	8/29/2005 19:00	24.22	3.87	8/29/2005 12:45	25.07	2.63	8/30/2005 19:45	24.9	4.17
8/27/2005 21:30	23.4	4.22	8/28/2005 12:00	23.55	4.07	8/29/2005 18:30	24.25	2.5	8/29/2005 19:15	24.22	3.9	8/29/2005 13:00	25.14	2.64	8/30/2005 20:00	24.89	4.12
8/27/2005 21:45	23.39	4.21	8/28/2005 12:15	23.66	4.08	8/29/2005 18:45	24.24	2.47	8/29/2005 19:30	24.22	3.88	8/29/2005 13:15	25.26	2.64	8/30/2005 20:15	24.86	4.17
8/27/2005 22:00	23.38	4.21	8/28/2005 12:30	23.75	4.15	8/29/2005 19:00	24.23	2.48	8/29/2005 19:45	24.21	3.8	8/29/2005 13:30	25.29	2.7	8/30/2005 20:30	24.85	4.11
8/27/2005 22:15	23.37	4.2	8/28/2005 12:45	23.85	4.15	8/29/2005 19:15	24.21	2.46	8/29/2005 20:00	24.22	3.88	8/29/2005 13:45	25.34	2.69	8/30/2005 20:45	24.85	4.1
8/27/2005 22:30	23.36	4.2	8/28/2005 13:00	23.96	4.19	8/29/2005 19:30	24.19	2.45	8/29/2005 20:15	24.22	3.89	8/29/2005 14:00	25.47	2.71	8/30/2005 21:00	24.84	4.08
8/27/2005 22:45	23.36	4.19	8/28/2005 13:15	24.04	4.22	8/29/2005 19:45	24.18	2.43	8/29/2005 20:30	24.22	3.83	8/29/2005 14:15	25.77	3.08	8/30/2005 21:15	24.81	4.13
8/27/2005 23:00	23.34	4.19	8/28/2005 13:30	24.11	4.19	8/29/2005 20:00	24.16	2.42	8/29/2005 20:45	24.21	3.84	8/29/2005 14:30	25.76	2.96	8/30/2005 21:30	24.81	4.12
8/27/2005 23:15	23.33	4.2	8/28/2005 13:45	24.25	4.22	8/29/2005 20:15	24.15	2.42	8/29/2005 21:00	24.21	3.85	8/29/2005 14:45	26	3.28	8/30/2005 21:45	24.79	4.06
8/27/2005 23:30	23.32	4.17	8/28/2005 14:00	24.31	4.2	8/29/2005 20:30	24.13	2.4	8/29/2005 21:15	24.21	3.81	8/29/2005 15:00	25.89	2.97	8/30/2005 22:00	24.78	4.07
8/27/2005 23:45	23.32	4.18	8/28/2005 14:15	24.41	4.24	8/29/2005 20:45	24.12	2.39	8/29/2005 21:30	24.21	3.86	8/29/2005 15:15	26.07	3.26	8/30/2005 22:15	24.76	4.02
8/28/2005 0:00	23.31	4.19	8/28/2005 14:30	24.51	4.26	8/29/2005 21:00	24.1	2.41	8/29/2005 21:45	24.2	3.85	8/29/2005 15:30	26.06	3.18	8/30/2005 22:30	24.74	4.01
8/28/2005 0:15	23.29	4.17	8/28/2005 14:45	24.59	4.29	8/29/2005 21:15	24.08	2.42	8/29/2005 22:00	24.19	3.83	8/29/2005 15:45	26.09	3.13	8/30/2005 22:45	24.73	3.99
8/28/2005 0:30	23.28	4.16	8/28/2005 15:00	24.7	4.3	8/29/2005 21:30	24.07	2.38	8/29/2005 22:15	24.18	3.85	8/29/2005 16:00	26.29	3.46	8/30/2005 23:00	24.7	4.01
8/28/2005 0:45	23.27	4.17	8/28/2005 15:15	24.68	4.31	8/29/2005 21:45	24.06	2.35	8/29/2005 22:30	24.18	3.83	8/29/2005 16:15	26.34	3.46	8/30/2005 23:15	24.7	4
8/28/2005 1:00	23.25	4.15	8/28/2005 15:30	24.76	4.3	8/29/2005 22:00	24.05	2.31	8/29/2005 22:45	24.17	3.84	8/29/2005 16:30	26.29	3.39	8/30/2005 23:30	24.68	3.93
8/28/2005 1:15	23.24	4.16	8/28/2005 15:45	24.78	4.31	8/29/2005 22:15	24.03	2.31	8/29/2005 23:00	24.15	3.8	8/29/2005 16:45	26.28	3.28	8/30/2005 23:45	24.67	3.97
8/28/2005 1:30	23.22	4.14	8/28/2005 16:00	24.81	4.31	8/29/2005 22:30	24	2.34	8/29/2005 23:15	24.14	3.82	8/29/2005 17:00	26.42	3.51	8/31/2005 0:00	24.65	3.93
8/28/2005 1:45	23.2	4.15	8/28/2005 16:15	24.81	4.3	8/29/2005 22:45	24	2.3	8/29/2005 23:30	24.13	3.8	8/29/2005 17:15	26.15	3.05	8/31/2005 0:15	24.62	3.9
8/28/2005 2:00	23.19	4.15	8/28/2005 16:30	24.83	4.32	8/29/2005 23:00	23.99	2.27	8/29/2005 23:45	24.11	3.82	8/29/2005 17:30	26.2	3.17	8/31/2005 0:30	24.59	3.91
8/28/2005 2:15	23.17	4.15	8/28/2005 16:45	24.84	4.3	8/29/2005 23:15	23.97	2.25	8/30/2005 0:00	24.1	3.78	8/29/2005 17:45	26.31	3.28	8/31/2005 0:45	24.57	3.94
8/28/2005 2:30	23.15	4.13	8/28/2005 17:00	24.84	4.28	8/29/2005 23:30	23.95	2.24	8/30/2005 0:15	24.09	3.8	8/29/2005 18:00	26.39	3.57	8/31/2005 1:00	24.55	3.91
8/28/2005 2:45	23.13	4.12	8/28/2005 17:15	24.83	4.27	8/29/2005 23:45	23.93	2.24	8/30/2005 0:30	24.07	3.78	8/29/2005 18:15	26.33	3.6	8/31/2005 1:15	24.52	3.92
8/28/2005 3:00	23.1	4.12	8/28/2005 17:30	24.82	4.24	8/30/2005 0:00	23.91	2.22	8/30/2005 0:45	24.05	3.77	8/29/2005 18:30	26.07	3.17	8/31/2005 1:30	24.49	3.88
8/28/2005 3:15	23.09	4.14	8/28/2005 17:45	24.8	4.19	8/30/2005 0:15	23.9	2.21	8/30/2005 1:00	24.04	3.73	8/29/2005 18:45	26.01	3.58	8/31/2005 1:45	24.46	3.9
8/28/2005 3:30	23.07	4.13	8/28/2005 18:00	24.79	4.19	8/30/2005 0:30	23.88	2.21	8/30/2005 1:15	24.04	3.79	8/29/2005 19:00	25.9	3.22	8/31/2005 2:00	24.43	3.89
8/28/2005 3:45	23.04	4.11	8/28/2005 18:15	24.76	4.15	8/30/2005 0:45	23.86	2.2	8/30/2005 1:30	24.02	3.76	8/29/2005 19:15	25.83	3.01	8/31/2005 2:15	24.39	3.83
8/28/2005 4:00	23.02	4.11	8/28/2005 18:30	24.74	4.16	8/30/2005 1:00	23.84	2.21	8/30/2005 1:45	23.99	3.74	8/29/2005 19:30	25.79	3.09	8/31/2005 2:30	24.36	3.88
8/28/2005 4:15	23.01	4.1	8/28/2005 18:45	24.71	4.11	8/30/2005 1:15	23.83	2.18	8/30/2005 2:00	23.98	3.71	8/29/2005 19:45	25.72	3	8/31/2005 2:45	24.33	3.87
8/28/2005 4:30	22.97	4.09	8/28/2005 19:00	24.67	4.08	8/30/2005 1:30	23.81	2.15	8/30/2005 2:15	23.96	3.67	8/29/2005 20:00	25.68	2.98	8/31/2005 3:00	24.32	3.82
8/28/2005 4:45	22.95	4.12	8/28/2005 19:15	24.66	4.05	8/30/2005 1:45	23.79	2.15	8/30/2005 2:30	23.95	3.68	8/29/2005 20:15	25.62	2.92	8/31/2005 3:15	24.29	3.86
8/28/2005 5:00	22.93	4.11	8/28/2005 19:30	24.63	4.06	8/30/2005 2:00	23.77	2.16	8/30/2005 2:45	23.93	3.64	8/29/2005 20:30	25.56	2.89	8/31/2005 3:30	24.27	3.84
8/28/2005 5:15	22.9	4.1	8/28/2005 19:45	24.6	4.02	8/30/2005 2:15	23.75	2.16	8/30/2005 3:00	23.91	3.62	8/29/2005 20:45	25.51	2.84	8/31/2005 3:45	24.25	3.89
8/28/2005 5:30	22.87	4.1	8/28/2005 20:00	24.57	4.05	8/30/2005 2:30	23.74	2.18	8/30/2005 3:15	23.9	3.65	8/29/2005 21:00	25.49	2.75	8/31/2005 4:00	24.23	3.84
8/28/2005 5:45	22.86	4.07	8/28/2005 20:15	24.56	4.05	8/30/2005 2:45	23.71	2.17	8/30/2005 3:30	23.87	3.63	8/29/2005 21:15	25.44	2.71	8/31/2005 4:15	24.21	3.88
8/28/2005 6:00	22.83	4.05	8/28/2005 20:30	24.55	4	8/30/2005 3:00	23.7	2.15	8/30/2005 3:45	23.85	3.59	8/29/2005 21:30	25.4	2.73	8/31/2005 4:30	24.19	3.86
8/28/2005 6:15	22.8	4.07	8/28/2005 20:45	24.53	4	8/30/2005 3:15	23.68	2.16	8/30/2005 4:00	23.82	3.62	8/29/2005 21:45	25.36	2.7	8/31/2005 4:45	24.15	3.88
8/28/2005 6:30	22.77	4.08	8/28/2005 21:00	24.52	3.99	8/30/2005 3:30	23.65	2.19	8/30/2005 4:15	23.81	3.59	8/29/2005 22:00	25.33	2.65	8/31/2005 5:00	24.13	3.87
8/28/2005 6:45	22.75	4.04	8/28/2005 21:15	24.49	3.97	8/30/2005 3:45	23.63	2.2	8/30/2005 4:30	23.79	3.55	8/29/2005 22:15	25.31	2.73	8/31/2005 5:15	24.11	3.84
8/28/2005 7:00	22.73	4.04	8/28/2005 21:30	24.49	3.98	8/30/2005 4:00	23.6	2.19	8/30/2005 4:45	23.77	3.57	8/29/2005 22:30	25.3	2.7	8/31/2005 5:30	24.1	3.86
8/28/2005 7:15	22.7	4.03	8/28/2005 21:45	24.47	3.97	8/30/2005 4:15	23.58	2.19	8/30/2005 5:00	23.75	3.55	8/29/2005 22:45	25.3	2.83	8/31/2005 5:45	24.07	3.89
8/28/2005 7:30	22.68	4.03	8/28/2005 22:00	24.46	3.95	8/30/2005 4:30	23.56	2.19	8/30/2005 5:15	23.73	3.46	8/29/2005 23:00	25.3	2.83	8/31/2005 6:00	24.03	3.81
8/28/2005 7:45	22.66	4.03	8/28/2005 22:15	24.44	3.95	8/30/2005 4:45	23.55	2.18	8/30/2005 5:30	23.72	3.5	8/29/2005 23:15	25.28	2.81	8/31/2005 6:15	24.03	3.88
8/28/2005 8:00	22.65	4.03	8/28/2005 22:30	24.44	3.94	8/30/2005 5:00	23.53	2.17	8/30/2005 5:45	23.69	3.47	8/29/2005 23:30	25.27	2.79	8/31/2005 6:30	23.99	3.83
8/28/2005 8:15	22.64	4.03	8/28/2005 22:45	24.43	3.95	8/30/2005 5:15	23.5	2.17	8/30/2005 6:00	23.67	3.44	8/29/2005 23:45	25.26	2.8	8/31/2005 6:45	23.96	3.88
8/28/2005 8:30	22.63	4.02	8/28/2005 23:00	24.41	3.94	8/30/2005 5:30	23.47	2.18	8/30/2005 6:15	23.64	3.43	8/30/2005 0:00	25.24	2.8	8/31/2005 7:00	23.93	3.88
8/28/2005 8:45	22.63	4.01	8/28/2005 23:15	24.4	3.96	8/30/2005 5:45	23.45	2.18	8/30/2005 6:30	23.62	3.37	8/30/2005 0:15	25.25	2.84	8/31/2005 7:15	23.9	3.89
8/28/2005 9:00	22.63	3.99	8/28/2005 23:30	24.4	3.93	8/30/2005 6:00	23.42	2.2	8/30/2005 6:45	23.6	3.33	8/30/2005 0:30	25.25	2.9	8/31/2005 7:30	23.88	3.84
8/28/2005 9:15	22.63	3.96	8/28/2005 23:45	24.37	3.9	8/30/2005 6:15	23.4	2.18	8/30/2005 7:00	23.57	3.44	8/30/2005 0:45	25.24	2.93	8/31/2005 7:45	23.86	3.87
8/28/2005 9:30	22.64	3.93	8/29/2005 0:00	24.37	3.92	8/30/2005 6:30	23.37	2.18	8/30/2005 7:15	23.55	3.47	8/30/2005 1:00	25.25	2.99	8/31/2005 8:00	23.86	3.91
8/28/2005 9:45	22.66	3.91	8/29/2005 0:15	24.36	3.88	8/30/2005 6:45	23.36	2.19	8/30/2005 7:30	23.53	3.56	8/30/2005 1:15	25.24	2.97	8/31/2005 8:15	23.84	3.94
8/28/2005 10:00	22.69	3.88	8/29/2005 0:30	24.35	3.88	8/30/2005 7:00	23.33	2.22	8/30/2005 7:45	23.49	3.58	8/30/2005 1:30	25.24	2.98	8/31/2005 8:30	23.86	4.01
8/28/2005 10:15	22.71	3.83	8/29/2005 0:45	24.34	3.88	8/30/2005 7:15	23.3	2.26	8/30/2005 8:00	23.46	3.57	8/30/2005 1:45	25.24	2.99	8/31/2005 8:45	23.88	4.06
8/28/2005 10:30	22.74	3.81	8/29/2005 1:00	24.33	3.86	8/30/2005 7:30	23.28	2.33	8/30/2005 8:15	23.43	3.55	8/30/2005 2:00	25.23	3	8/31/2005 9:00	23.94	4.08
8/28/2005 10:45	22.75	3.79	8/29/2005 1:15	24.31	3.87	8/30/2005 7:45	23.26	2.29	8/30/2005 8:30	23.4	3.53	8/30/2005 2:15	25.23	3.01	8/31/2005 9:15	23.97	4.12
8/28/2005 11:00	22.78	3.74	8/29/2005 1:30	24.3	3.85	8/30/2005 8:00	23.24	2.28	8/30/2005 8:45	23.38	3.54	8/30/2005 2:30	25.23	2.98	8/31/2005 9:30	23.99	4.11
8/28/2005 11:15	22.8	3.77	8/29/2005 1:45	24.29	3.82	8/30/2005 8:15	23.22	2.27	8/30/2005 9:00	23.36	3.59	8/30/2005 2:45	25.22	2.97	8/31/2005 9:45	24.03	4.13
8/28/2005 11:30	22.86	3.76	8/29/2005 2:00	24.28	3.85	8/30/2005 8:30	23.2	2.29	8/30/2005 9:15	23.32	3.67	8/30/2005 3:00	25.22	2.98	8/31/2005 10:00	24.08	4.05
8/28/2005 11:45	22.98	3.74	8/29/2005 2:15	24.27	3.84	8/30/2005 8:45	23.18	2.3	8/30/2005 9:30	23.3	3.67	8/30/2005 3:15	25.21	2.98	8/31/2005 10:15	24.08	4.02
8/28/2005 12:00	23.04	3.86	8/29/2005 2:30	24.26	3.82	8/30/2005 9:00	23.17	2.32	8/30/2005 9:45	23.27	3.68	8/30/2005 3:30	25.2	2.98	8/31/2005 10:30	24.16	4.09
8/28/2005 12:15	23.09	3.89	8/29/2005 2:45	24.23	3.81	8/30/2005 9:15	23.14	2.36	8/30/2005 10:00	23.25	3.69	8/30/2005 3:45	25.19	2.92	8/31/2005 10:45	24.45	4.34
8/28/2005 12:30	23.21	3.94	8/29/2005 3:00	24.23	3.79	8/30/2005 9:30	23.12	2.36	8/30/2005 10:15	23.23	3.74	8/30/2005 4:00	25.19	2.93	8/31/2005 11:00	24.58	4.35
8/28/2005 12:45	23.31	3.91	8/29/2005 3:15	24.21	3.79	8/30/2005 9:45	23.1	2.34	8/30/2005 10:30	23.21	3.75	8/30/2005 4:15	25.19	2.94	8/31/2005 11:15	24.65	4.37
8/28/2005 13:00	23.44	4.05	8/29/2005 3:30	24.2	3.8	8/30/2005 10:00	23.1	2.36	8/30/2005 10:45	23.19	3.74	8/30/2005 4:30	25.18	2.92	8/31/2005 11:30	25.07	4.55
8/28/2005 13:15	23.58	4.14	8/29/2005 3:45	24.19	3.77	8/30/2005 10:15	23.1	2.32	8/30/2005 11:00	23.18	3.73	8/30/2005 4:45	25.17	2.97	8/31/2005 11:45	24.87	4.45
8/28/2005 13:30	23.78	4.21	8/29/2005 4:00	24.17	3.81	8/30/2005 10:30	23.09	2.33	8/30/2005 11:15	23.16	3.74	8/30/2005 5:00	25.16	2.9	8/31/2005 12:00	25.07	4.69
8/28/2005 13:45	23.97	4.33	8/29/2005 4:15	24.15	3.76	8/30/2005 10:45	23.1	2.34	8/30/2005 11:30	23.16	3.71	8/30/2005 5:15	25.16	2.91	8/31/2005 12:15	25.56	4.82
8/28/2005 14:00	24.15	4.43	8/29/2005 4:30	24.12	3.77	8/30/2005 11:00	23.09	2.38	8/30/2005 11:45	23.15	3.69	8/30/2005 5:30	25.15	2.89	8/31/2005 12:30	25.47	4.84
8/28/2005 14:15	24.26	4.43	8/29/2005 4:45	24.11	3.77	8/30/2005 11:15	23.1	2.42	8/30/2005 12:00	23.15	3.63	8/30/2005 5:45	25.13	2.84	8/31/2005 12:45	25.44	4.76
8/28/2005 14:30	24.26	4.42	8/29/2005 5:00	24.08	3.75	8/30/2005 11:30	23.12	2.44	8/30/2005 12:15	23.15	3.64	8/30/2005 6:00	25.12	2.82	8/31/2005 13:00	25.25	4.76
8/28/2005 14:45	24.33	4.45	8/29/2005 5:15	24.06	3.74	8/30/2005 11:45	23.13	2.45	8/30/2005 12:30	23.15	3.59	8/30/2005 6:15	25.11	2.81	8/31/2005 13:15	25.28	4.88
8/28/2005 15:00	24.33	4.44	8/29/2005 5:30	24.04	3.76	8/30/2005 12:00	23.14	2.45	8/30/2005 12:45	23.16	3.63	8/30/2005 6:30	25.11	2.82	8/31/2005 13:30	25.41	5.04
8/28/2005 15:15	24.3	4.46	8/29/2005 5:45	24.01	3.76	8/30/2005 12:15	23.16	2.46	8/30/2005 13:00	23.17	3.6	8/30/2005 6:45	25.08	2.85	8/31/2005 13:45	25.63	5.19
8/28/2005 15:30	24.29	4.46	8/29/2005 6:00	23.98	3.74	8/30/2005 12:30	23.19	2.47	8/30/2005 13:15	23.19	3.59	8/30/2005 7:00	25.07	2.85	8/31/2005 14:00	25.73	5.29
8/28/2005 15:45	24.32	4.44	8/29/2005 6:15	23.95	3.74	8/30/2005 12:45	23.19	2.45	8/30/2005 13:30	23.2	3.58	8/30/2005 7:15	25.06	2.87	8/31/2005 14:15	25.77	5.36
8/28/2005 16:00	24.27	4.44	8/29/2005 6:30	23.92	3.74	8/30/2005 13:00	23.22	2.47	8/30/2005 13:45	23.22	3.61	8/30/2005 7:30	25.06	2.82	8/31/2005 14:30	25.71	5.26
8/28/2005 16:15	24.21	4.46	8/29/2005 6:45	23.92	3.73	8/30/2005 13:15	23.25	2.49	8/30/2005 14:00	23.23	3.54	8/30/2005 7:45	25.04	2.8	8/31/2005 14:45	25.74	5.34
8/28/2005 16:30	24.2	4.4	8/29/2005 7:00	23.88	3.72	8/30/2005 13:30	23.27	2.51	8/30/2005 14:15	23.25	3.53	8/30/2005 8:00	25.02	2.84	8/31/2005 15:00	25.95	5.52
8/28/2005 16:45	24.22	4.42	8/29/2005 7:15	23.86	3.7	8/30/2005 13:45	23.29	2.52	8/30/2005 14:30	23.24	3.52	8/30/2005 8:15	25	2.83	8/31/2005 15:15	25.95	5.42
8/28/2005 17:00	24.23	4.37	8/29/2005 7:30	23.84	3.69	8/30/2005 14:00	23.29	2.53	8/30/2005 14:45	23.23	3.48	8/30/2005 8:30	25.01	2.84	8/31/2005 15:30	26.16	5.6
8/28/2005 17:15	24.23	4.36	8/29/2005 7:45	23.82	3.69	8/30/2005 14:15	23.29	2.52	8/30/2005 15:00	23.23	3.44	8/30/2005 8:45	24.98	2.87	8/31/2005 15:45	26.11	5.52
8/28/2005 17:30	24.25	4.33	8/29/2005 8:00	23.8	3.68	8/30/2005 14:30	23.26	2.5	8/30/2005 15:15	23.23	3.41	8/30/2005 9:00	24.98	2.88	8/31/2005 16:00	26.13	5.5
8/28/2005 17:45	24.25	4.32	8/29/2005 8:15	23.78	3.68	8/30/2005 14:45	23.23	2.49	8/30/2005 15:30	23.24	3.4	8/30/2005 9:15	24.96	2.86	8/31/2005 16:15	26.2	5.62
8/28/2005 18:00	24.28	4.32	8/29/2005 8:30	23.75	3.67	8/30/2005 15:00	23.21	2.47	8/30/2005 15:45	23.23	3.37	8/30/2005 9:30	24.95	2.85	8/31/2005 16:30	26.24	5.69
8/28/2005 18:15	24.26	4.28	8/29/2005 8:45	23.75	3.67	8/30/2005 15:15	23.2	2.45	8/30/2005 16:00	23.22	3.35	8/30/2005 9:45	24.95	2.91	8/31/2005 16:45	26.13	5.53
8/28/2005 18:30	24.27	4.27	8/29/2005 9:00	23.73	3.67	8/30/2005 15:30	23.16	2.45	8/30/2005 16:15	23.21	3.39	8/30/2005 10:00	24.93	2.87	8/31/2005 17:00	26.06	5.46
8/28/2005 18:45	24.26	4.28	8/29/2005 9:15	23.72	3.69	8/30/2005 15:45	23.14	2.43	8/30/2005 16:30	23.17	3.36	8/30/2005 10:15	24.93	2.96	8/31/2005 17:15	25.99	5.4
8/28/2005 19:00	24.27	4.31	8/29/2005 9:30	23.71	3.7	8/30/2005 16:00	23.1	2.44	8/30/2005 16:45	23.16	3.4	8/30/2005 10:30	24.92	2.99	8/31/2005 17:30	25.96	5.43
8/28/2005 19:15	24.27	4.3	8/29/2005 9:45	23.71	3.72	8/30/2005 16:15	23.09	2.37	8/30/2005 17:00	23.14	3.37				8/31/2005 17:45	25.86	5.45
8/28/2005 19:30	24.27	4.33	8/29/2005 10:00	23.7	3.71	8/30/2005 16:30	23.06	2.4	8/30/2005 17:15	23.11	3.32				8/31/2005 18:00	25.8	5.33
8/28/2005 19:45	24.26	4.35	8/29/2005 10:15	23.7	3.7	8/30/2005 16:45	23.05	2.36	8/30/2005 17:30	23.08	3.29				8/31/2005 18:15	25.74	5.28
8/28/2005 20:00	24.25	4.35	8/29/2005 10:30	23.71	3.75	8/30/2005 17:00	23.03	2.4	8/30/2005 17:45	23.05	3.21				8/31/2005 18:30	25.71	5.19
8/28/2005 20:15	24.25	4.39	8/29/2005 10:45	23.71	3.7	8/30/2005 17:15	23.02	2.4	8/30/2005 18:00	23.02	3.22				8/31/2005 18:45	25.68	5.17
8/28/2005 20:30	24.24	4.38	8/29/2005 11:00	23.74	3.71	8/30/2005 17:30	22.97	2.41	8/30/2005 18:15	22.98	3.2				8/31/2005 19:00	25.67	5.11
8/28/2005 20:45	24.24	4.41				8/30/2005 17:45	22.95	2.4	8/30/2005 18:30	22.95	3.24				8/31/2005 19:15	25.66	5.21
8/28/2005 21:00	24.24	4.4				8/30/2005 18:00	22.94	2.34	8/30/2005 18:45	22.92	3.21				8/31/2005 19:30	25.67	5.16
8/28/2005 21:15	24.23	4.42				8/30/2005 18:15	22.93	2.29	8/30/2005 19:00	22.9	3.25				8/31/2005 19:45	25.64	5.16
8/28/2005 21:30	24.22	4.39				8/30/2005 18:30	22.9	2.24	8/30/2005 19:15	22.88	3.24				8/31/2005 20:00	25.63	5.24
8/28/2005 21:45	24.2	4.35				8/30/2005 18:45	22.86	2.19	8/30/2005 19:30	22.85	3.26				8/31/2005 20:15	25.62	5.22
8/28/2005 22:00	24.18	4.36				8/30/2005 19:00	22.84	2.15	8/30/2005 19:45	22.83	3.23				8/31/2005 20:30	25.6	5.2
8/28/2005 22:15	24.16	4.33				8/30/2005 19:15	22.81	2.11							8/31/2005 20:45	25.58	5.13
8/28/2005 22:30	24.14	4.32													8/31/2005 21:00	25.54	5.17
8/28/2005 22:45	24.13	4.29													8/31/2005 21:15	25.52	5.14
8/28/2005 23:00	24.09	4.27													8/31/2005 21:30	25.49	5.09
8/28/2005 23:15	24.06	4.26													8/31/2005 21:45	25.44	5.11
8/28/2005 23:30	24.04	4.24													8/31/2005 22:00	25.4	5.05
8/28/2005 23:45	24.02	4.2													8/31/2005 22:15	25.36	5.05
															8/31/2005 22:30	25.35	4.99
															8/31/2005 22:45	25.3	4.99
															8/31/2005 23:00	25.26	4.98
															8/31/2005 23:15	25.22	4.92
															8/31/2005 23:30	25.17	4.92
															8/31/2005 23:45	25.14	4.96
															9/1/2005 0:00	25.11	4.89
															9/1/2005 0:15	25.07	4.91
															9/1/2005 0:30	25.03	4.89
															9/1/2005 0:45	24.99	4.9
															9/1/2005 1:00	24.96	4.88
															9/1/2005 1:15	24.93	4.82
															9/1/2005 1:30	24.88	4.78
															9/1/2005 1:45	24.86	4.8
															9/1/2005 2:00	24.82	4.78
															9/1/2005 2:15	24.78	4.8
															9/1/2005 2:30	24.74	4.79
															9/1/2005 2:45	24.72	4.77
															9/1/2005 3:00	24.69	4.71
															9/1/2005 3:15	24.66	4.72
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															9/1/2005 3:45	24.6	4.71
															9/1/2005 4:00	24.58	4.71
															9/1/2005 4:15	24.55	4.69
															9/1/2005 4:30	24.53	4.67
															9/1/2005 4:45	24.5	4.67
															9/1/2005 5:00	24.49	4.66
															9/1/2005 5:15	24.46	4.62
															9/1/2005 5:30	24.44	4.66
															9/1/2005 5:45	24.42	4.61
															9/1/2005 6:00	24.41	4.62
															9/1/2005 6:15	24.38	4.62
															9/1/2005 6:30	24.37	4.6
															9/1/2005 6:45	24.34	4.61
															9/1/2005 7:00	24.32	4.59
															9/1/2005 7:15	24.31	4.56
															9/1/2005 7:30	24.3	4.63
															9/1/2005 7:45	24.29	4.69
															9/1/2005 8:00	24.28	4.63
															9/1/2005 8:15	24.29	4.64
															9/1/2005 8:30	24.3	4.74
															9/1/2005 8:45	24.34	4.81
															9/1/2005 9:00	24.43	4.99
															9/1/2005 9:15	24.45	4.81
															9/1/2005 9:30	24.47	4.85
															9/1/2005 9:45	24.63	5.32
															9/1/2005 10:00	24.84	6.11
															9/1/2005 10:15	24.77	5.67
															9/1/2005 10:30	25.26	6.66
															9/1/2005 10:45	25.56	6.82
															9/1/2005 11:00	25.78	7.36
															9/1/2005 11:15	25.97	7.47
															9/1/2005 11:30	26.11	7.3
															9/1/2005 11:45	26.67	7.75
															9/1/2005 12:00	26.36	7.38
															9/1/2005 12:15	26.6	7.52
															9/1/2005 12:30	26.49	7.36
															9/1/2005 12:45	26.97	7.72
															9/1/2005 13:00	26.61	7.48
															9/1/2005 13:15	26.58	7.4
															9/1/2005 13:30	26.65	7.46
															9/1/2005 13:45	26.93	8.34
															9/1/2005 14:00	27.18	9.08
															9/1/2005 14:15	27.22	9.37
															9/1/2005 14:30	27.86	10.37
															9/1/2005 14:45	27.51	9.84

FINAL APPROVED TMDL
Skillet Fork Watershed

Prepared for Illinois Environmental Protection Agency
For US EPA Final Approval

December 2006

Skillet Fork (IL_CA-03): Fecal Coliform
Sam Dale Lake (IL_RBF): Phosphorus
Stephen A. Forbes Lake (IL_RCD): Phosphorus
Wayne City Side Channel Reservoir (IL_RCT): Manganese

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INTRODUCTION

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the 2006 303(d) list, which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

Skillet Fork (IL_CA-03), Stephen A. Forbes Lake (IL_RCD), Sam Dale Lake (IL_RBF), and Wayne City Side Channel Reservoir (IL_RCT) are listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as waterbodies that are not meeting their designated uses. As such, they have been targeted as high priority waterbodies for TMDL development. This document presents the TMDLs designed to allow these waterbodies to fully support their designated uses. The report covers each step of the TMDL process and is organized as follows:

- Problem Identification
- Required TMDL Elements
- Watershed Characterization
- Description of Applicable Standards and Numeric Targets
- Development of Water Quality Model
- TMDL Development
- Public Participation and Involvement
- Adaptive Implementation Process

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1 PROBLEM IDENTIFICATION

The impairments in waters of the Skillet Fork Watershed addressed in this report are summarized below, with the parameters (causes) that they are listed for, and the impairment status of each designated use, as identified in the 303(d) list (IEPA, 2006). This report includes a fecal coliform TMDL for Skillet Fork, phosphorus TMDLs for Sam Dale Lake and Stephen A. Forbes Lake, and a manganese TMDL for Wayne City Side Channel Reservoir. The pollutants addressed in this TMDL are indicated in bold in the table below. Other TMDLs for Skillet Fork, Horse Creek, Brush Creek, and Dums Creek will be conducted in a separate report. While TMDLs are currently only being developed for pollutants that have numerical water quality standards, many controls that are implemented to address TMDLs for these pollutants will reduce other pollutants as well. For example, any controls to reduce phosphorus loads from watershed sources (stream bank erosion, runoff, etc.) would also serve to reduce sediment loads to a lake, as phosphorus Best Management Practices (BMPs) are often the same or similar to sediment BMPs. Furthermore, any reduction of phosphorus loads, either through implementation of watershed controls or dredging of in-lake sediments, is expected to work towards reducing algae concentrations, as phosphorus is the nutrient most responsible for limiting algal growth.

Skillet Fork	
Assessment Unit ID	IL_CA-03
Size (length)	7.2
Listed For	**Fecal Coliform,** manganese, pH, dissolved oxygen, total suspended solids, habitat assessment (streams), sedimentation/siltation, total phosphorus, PCBs
Use Support[1]	Aquatic life (N), fish consumption (N), primary contact (N), secondary contact (X), aesthetic quality (X)

[1]F=full support, P=partial support, N=nonsupport, X=not assessed

Sam Dale Lake	
Assessment Unit ID	IL_RBF
Size (Acres)	194
Listed For	**Phosphorus**, total suspended solids, aquatic algae
Use Support[1]	Aquatic life (F), fish consumption (X), primary contact (X), secondary contact (X), aesthetic quality (N)

[1]F=full support, P=partial support, N=nonsupport, X=not assessed

Stephen A. Forbes Lake	
Assessment Unit ID	IL_RCD
Size (Acres)	525
Listed For	**Phosphorus**, total suspended solids, aquatic algae
Use Support[1]	Aquatic life (F), fish consumption (F), primary contact (X), secondary contact (X), aesthetic quality (N)

[1]F=full support, P=partial support, N=nonsupport, X=not assessed

Wayne City Side Channel Reservoir	
Assessment Unit ID	IL_RCT
Size (Acres)	8
Listed For	**Manganese**, total suspended solids, aquatic algae
Use Support[1]	Aquatic life (F), fish consumption (X), public and food processing water supplies (N), primary contact (X), secondary contact (X), aesthetic quality (N)

[1]F=full support, P=partial support, N=nonsupport, X=not assessed

2 REQUIRED TMDL ELEMENTS

USEPA Region 5 guidance for TMDL development requires TMDLs to contain eleven specific components. Each of those components is summarized below, by waterbody.

Skillet Fork (IL_CA-03)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Skillet Fork, HUC 0512011506. The pollutant of concern addressed in this TMDL is **fecal coliform**. Potential sources contributing to the listing of Skillet Fork include: runoff from agricultural lands, failing septic systems, municipal point sources and wildlife. Skillet Fork is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Because this watershed has a public water supply use impaired, it was ranked as high priority on the 303(d) list for TMDL development.

2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The IEPA guidelines (IEPA, 2006) for identifying fecal coliform as a cause of impairment in streams state that fecal coliform is a potential cause of impairment of the primary contact use if the geometric mean of all samples collected during May through October (minimum five samples) is greater than 200 colony forming units (cfu)/100 ml, or if greater than 10% of all samples exceed 400 cfu/100 ml. For the Skillet Fork TMDL for fecal coliform, the target is set at 200 cfu/100 ml across the entire flow regime during May-October.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** A load capacity calculation was completed to determine the maximum fecal coliform loads that will maintain compliance with the fecal coliform target for May through October under a range of flow conditions:

Skillet Fork Flow (cfs)	Allowable Load (cfu/day)
5	2.45E+10
10	4.89E+10
50	2.45E+11
100	4.89E+11
200	9.79E+11
400	1.96E+12
600	2.94E+12
800	3.91E+12
1000	4.89E+12

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDL are as follows for May-October:

Skillet Fork Flow (cfs)	Load Allocation (LA) (cfu/day)
5	1.99E+10
10	4.43E+10
50	2.40E+11
100	4.85E+11
200	9.74E+11
400	1.95E+12
600	2.93E+12
800	3.91E+12
1000	4.89E+12

5. **Wasteload Allocations (WLA):** There are 14 point source dischargers of fecal coliform in the Skillet Fork watershed. The WLA for these dischargers was calculated from their average permitted design flows and a concentration of 200 cfu/100ml, consistent with meeting water quality standards at the downstream end of their exempted reach. The WLA for these facilities equals 4.6E+09 cfu/day.

6. **Margin of Safety:** The TMDL contains an implicit margin of safety for fecal coliform, through the use of multiple conservative assumptions. The TMDL target (no more than 200 cfu/100 ml at any time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 ml for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load.

7. **Seasonal Variation:** This TMDL was conducted with an explicit consideration of seasonal variation. The load duration curve approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur at any given point in the season where the standard applies.

8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA has the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permit for the point source dischargers in the watershed will be modified if necessary as

part of the permit review process (typically every 5 years) to ensure that they are consistent with the applicable wasteload allocation.

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.

10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.

11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (summarized in Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. In March 2005, a public meeting was conducted in Wayne City, Illinois to present the Stage 1 findings. A second public meeting was held in Wayne City, Illinois in July 2006 to present the Stage 3 (TMDL) results. One additional public meeting will be held at a later date to present the implementation plan.

Sam Dale Lake (IL_RBF)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Sam Dale Lake, HUC 0512011502. The pollutant of concern addressed in this report is **total phosphorus.** Potential sources contributing to the listing of Sam Dale Lake include: Agricultural runoff, sediment phosphorus release during seasonal hypolimnetic anoxia, and failing septic systems. Sam Dale Lake is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Because this watershed has a public water supply use impaired, it was ranked as high priority on the 303(d) list for TMDL development.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **total phosphorus**

to protect aquatic life and aesthetic quality uses in Illinois lakes is 0.05 mg-P/l. For the Sam Dale Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the maximum tributary phosphorus load that will maintain compliance with the phosphorus standard is 53 kg-P/month (1.77 kg-P/day) between March and August, with the total load not to exceed 317.8 kg over this period.

4. **Load Allocations (LA):** The Load Allocation designed to achieve compliance with the above TMDL is 47.7 kg-P/month (1.59 kg-P/day) for the period March-August.

5. **Wasteload Allocations (WLA):** There are no point source dischargers in the Sam Dale Lake watershed, so no wasteload allocations are required.

6. **Margin of Safety:** The TMDL contains an explicit margin of safety of 10% for total phosphorus, corresponding to 5.3 kg-P/month (0.177 kg-P/day). This value was set to reflect the uncertainty in the BATHTUB model predictions.

7. **Seasonal Variation:** The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for the phosphorus TMDL is designed to evaluate seasonal to annual loads. The seasonal loading analysis that was used is appropriate due to the long response time between phosphorus loading and biotic response. The March-August duration for the seasonal loading was determined based on a calculation of a phosphorus residence time on the order of weeks to a few months in Sam Dale Lake.

8. **Reasonable Assurances:** There are no permitted point sources in this watershed, so reasonable assurances for point sources are not discussed. In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

   Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.

10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.

11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in the Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. In March 2005, a public meeting was conducted in Wayne City, Illinois to present the Stage 1 findings. A second public meeting was held in Wayne City, Illinois in July 2006 to present the Stage 3 (TMDL) results. One additional public meeting will be held at a later date to present the implementation plan.

Stephen A. Forbes Lake (IL_RCD)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Stephen A. Forbes Lake, HUC 0512011502. The pollutant of concern addressed in this report is **total phosphorus.** Potential sources contributing to the listing of Stephen A. Forbes Lake include: Agricultural runoff, sediment phosphorus release during seasonal hypolimnetic anoxia and failing septic systems. Stephen A. Forbes Lake is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Because this watershed has a public water supply use impaired, it was ranked as high priority on the 303(d) list for TMDL development.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **total phosphorus** to protect aquatic life and aesthetic quality uses in Illinois lakes is 0.05 mg-P/l. For the Stephen A. Forbes Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the maximum phosphorus load that will maintain compliance with the phosphorus standard is 108.8 kg/month (3.63 kg-P/day) between March and August, with the total load not to exceed 653 kg over this period.
4. **Load Allocations (LA):** The Load Allocation designed to achieve compliance with the above TMDL is 95.6 kg/month (3.19 kg-P/day) for the period March-August.
5. **Wasteload Allocations (WLA):** There are two point source dischargers in the Stephen A. Forbes Lake watershed. The WLA for these facilities was set at estimated existing loading conditions (2.32 kg-P/month or 0.08 kg-P/day). This allocation assumes that these facilities discharge continuously at their permitted design average flow. It is known, however that these facilities rarely discharge, and so this allocation is conservative.

6. **Margin of Safety:** The TMDL contains an explicit margin of safety of 10% for total phosphorus, corresponding to 10.88 kg/month (0.36 kg-P/day). This value was set to reflect the uncertainty in the BATHTUB model predictions.

7. **Seasonal Variation:** The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for the phosphorus TMDL is designed to evaluate seasonal to annual loads. The seasonal loading analysis that was used is appropriate due to the long response time between phosphorus loading and biotic response. The March - August duration for the seasonal loading was determined based on a calculation of a phosphorus residence time in Stephen A. Forbes Lake on the order of weeks to months.

8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA has the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permits for the two point source dischargers in the watershed will be modified if necessary as part of the permit review process (typically every five years) to ensure that they are consistent with the applicable wasteload allocation.

   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

   Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.

10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.

11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. In March 2005, a public meeting was conducted in Wayne City, Illinois to present the Stage 1 findings. A second public meeting was held in Wayne City, Illinois in July 2006 to present the Stage 3 (TMDL) results. One additional public meeting will be held at a later date to present the implementation plan.

Wayne City Side Channel Reservoir (IL_RCT)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Wayne City Side Channel Reservoir, HUC 0512011506. The pollutant of concern addressed in this report is manganese. Potential sources contributing to the listing of Wayne City Side Channel Reservoir include: natural background sources and sediment manganese release during seasonal hypolimnetic anoxia. Wayne City Side Channel Reservoir is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Because this watershed has a public water supply use impaired, it was ranked as high priority on the 303(d) list for TMDL development.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **manganese** in Illinois waters designated as public and food processing water supplies is 150 ug/l. For the Wayne City Side Channel Reservoir TMDL, the objective is maintenance of hypolimnetic dissolved oxygen concentrations above zero, because the only controllable source of manganese to the lake is the release of manganese from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. The lack of dissolved oxygen in lake bottom waters is presumed to be due to sediment oxygen demand resulting from the effects of nutrient enrichment, as there are no point source discharges to the lake or the segment from which water is pumped to the lake. Additionally, no other significant sources of oxygen demanding materials identified in the watershed characterization. For this reason, attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese is therefore set as a total phosphorus concentration of 0.05 mg-P/l.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the maximum tributary phosphorus load that will eliminate the excess release of manganese from lake sediments is 1.84 kg-P/month (0.061 kg-P/day), with the total load for the March to August period not to exceed 11 kg phosphorus.
4. **Load Allocations (LA):** The Load Allocation designed to achieve compliance with the above TMDL is 1.656 kg-P/month (0.054 kg-P/day) for the March-August period.
5. **Wasteload Allocations (WLA):** There are no point sources that discharge directly to the Wayne City Side Channel Reservoir or the Skillet Fork segment (IL_CA-05) from which water is pumped to this reservoir. The WLA for this watershed was therefore set at zero.

6. **Margin of Safety:** The TMDL contains an explicit margin of safety corresponding to 10% of the phosphorus loading capacity, or 0.184 kg P/month (0.006 kg P/day). This value was set to reflect the uncertainty in the BATHTUB model predictions.
7. **Seasonal Variation:** The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for the phosphorus TMDL is designed to evaluate seasonal to annual loads. The seasonal loading analysis that was used is appropriate due to the long response time between phosphorus loading and biotic response. The March-August duration for the seasonal loading was determined based on a calculation of a phosphorus residence time on the order of a few months in Wayne City Side Channel Reservoir.
8. **Reasonable Assurances:** There are no permitted point sources that discharge directly to the lake or the Skillet Fork segment from which this lake receives water, so reasonable assurances for point sources are not discussed. In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:
   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

   Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.
9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.
10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.
11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in the Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. In March 2005, a public meeting was conducted in Wayne City, Illinois to present the Stage 1 findings. A second public meeting was held in Wayne City, Illinois in July 2006 to present the Stage 3 (TMDL) results. One additional public meeting will be held at a later date to present the implementation plan.

3 WATERSHED CHARACTERIZATION

The Stage 1 Report presents and discusses information describing the Skillet Fork watershed to support the identification of sources contributing to the listed impairments as applicable. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including geology and soils, climate, land cover, hydrology, urbanization and population growth, point source discharges and watershed activities.

The impaired waterbodies addressed in this report are all located within the Skillet Fork watershed. This watershed is located in Southeastern Illinois, approximately 10 miles east of the city of Mount Vernon and the intersection of Interstates 57 and 64. Skillet Fork is a tributary to the Little Wabash River, with its confluence located three miles northeast of Carmi, Illinois, near river mile 39. Portions of the Skillet Fork watershed lie in Clay, Marion, Wayne, Jefferson, White and Hamilton counties. The watershed is approximately 672,425 acres (1,051 square miles) in size, and there are about 1,720 miles of streams in the watershed. The main stem of the Skillet Fork River is approximately 97 miles long (54 miles are listed as being impaired). The waterbodies of concern are Skillet Fork (IL_CA-03), Stephen A. Forbes Lake (IL_RCD), Sam Dale Lake (IL_RBF), and Wayne City Side Channel Reservoir (IL_RCT).

Figure 1 shows a map of the watershed, and includes some key features such as waterways, impaired waterbodies, public water intakes and other key features. The map also shows the locations of point source discharges that have a permit to discharge under the National Pollutant Discharge Elimination System (NPDES).

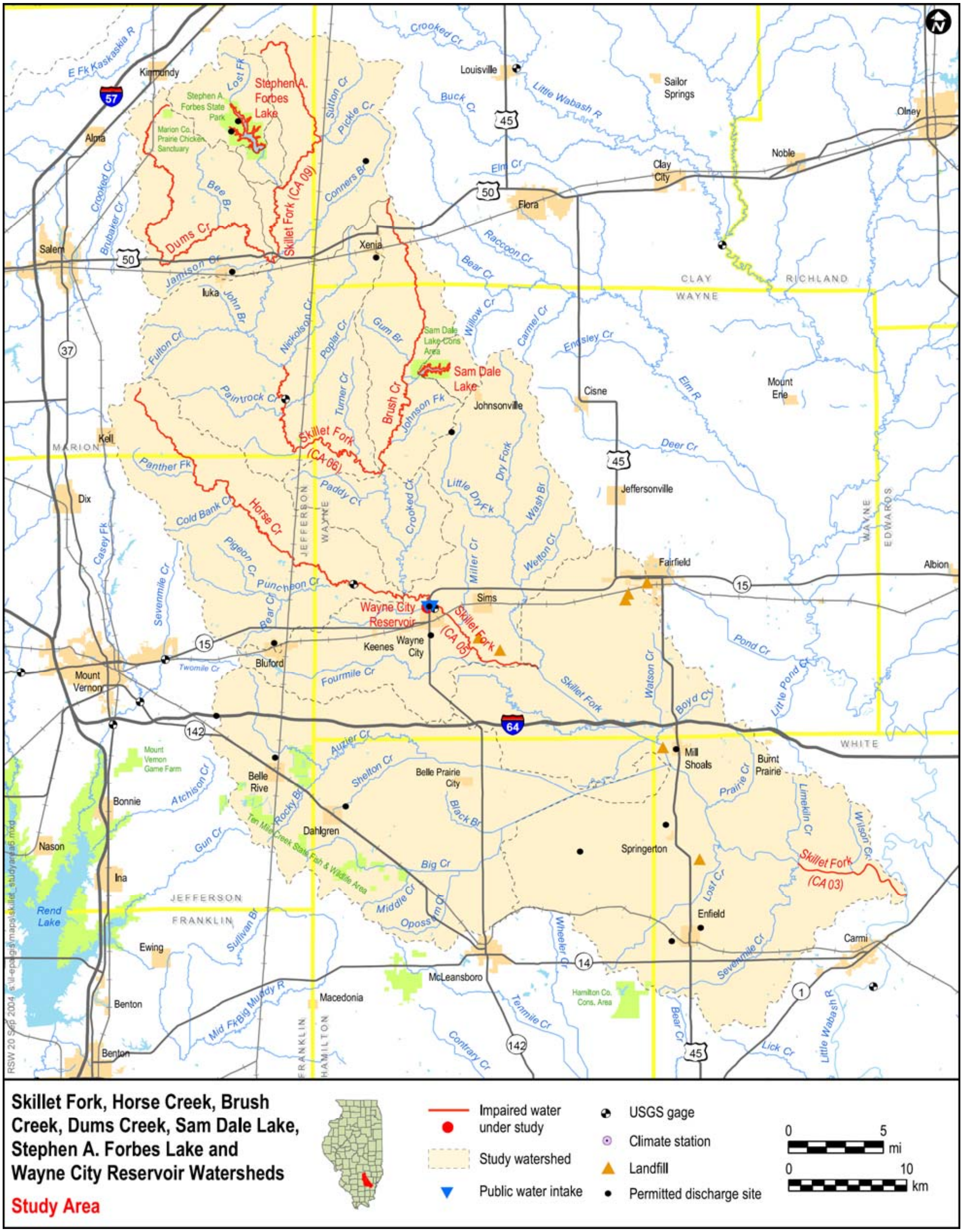

Figure 1. Base Map of Skillet Fork Watershed

4 DESCRIPTION OF APPLICABLE STANDARDS AND NUMERIC TARGETS

A water quality standard includes the designated uses of the waterbody, water quality criteria to protect designated uses, and an antidegradation policy to maintain and protect existing uses and high quality waters. Water quality criteria are sometimes in a form that are not directly amenable for use in TMDL development and may need to be translated into a target value for TMDLs. This section discusses the applicable designated uses, use support, criteria and TMDL targets for waterbodies in the Skillet Fork watershed that are addressed in this report.

4.1 DESIGNATED USES AND USE SUPPORT

Water quality assessments in Illinois are based on a combination of chemical (water, sediment and fish tissue), physical (habitat and flow discharge), and biological (macroinvertebrate and fish) data. Illinois EPA conducts its assessment of water bodies using a set of seven designated uses: aquatic life, aesthetic quality, indigenous aquatic life (for specific Chicago-area waterbodies), primary contact (swimming), secondary contact, public and food processing water supply, and fish consumption (IEPA, 2006). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of two possible "use-support" levels:

- Fully Supporting (the water body attains the designated use); or
- Not Supporting (the water body does not attain the designated use).

Water bodies assessed as "Not Supporting" for any designated use are identified as impaired. Waters identified as impaired based on biological (macroinvertebrate, macrophyte, algal and fish), chemical (water, sediment and fish tissue), and/or physical (habitat and flow discharge) monitoring data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters (IEPA, 2006).

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized on a watershed basis. Illinois EPA watershed boundaries are based on the USGS ten-digit hydrologic units to provide the state with the ability to address watershed issues at a manageable level and document improvements to a watershed's health (IEPA, 2006).

4.2 WATER QUALITY CRITERIA

Illinois has established water quality criteria and guidelines for allowable concentrations of fecal coliform, manganese, and total phosphorus under its CWA Section 305(b) program, as summarized below. A comparison of available water quality data to these criteria is provided in the Stage 1 Report.

4.2.1 Fecal Coliform

The IEPA guidelines (IEPA, 2006) for identifying fecal coliform as a cause of impairment in streams state that fecal coliform is a potential cause of impairment of the primary contact use if the geometric mean of all samples collected during May through October (minimum five samples) is greater than 200 cfu/100 ml, or if greater than 10% of all samples exceed 400 cfu/100 ml. The available data support the listing of fecal coliform as a cause of impairment in Skillet Fork, as discussed in the Stage 1 Report.

4.2.2 Manganese

The water quality standard for manganese in Illinois waters designated as public and food processing water supplies is 150 ug/l. The public and food processing water supply guideline for inland lakes indicates impairment if more than 10% of the observations measured since 1999 exceed 150 ug/L. The available data confirm that the listing of Wayne City Side Channel Reservoir for manganese is appropriate based on IEPA's guidelines, as discussed in the Stage 1 Report.

4.2.3 Total Phosphorus

The IEPA guidelines (IEPA, 2006) for identifying total phosphorus as a cause of impairment in lakes greater than 20 acres in size, state that phosphorus is a potential cause of impairment of the aesthetic quality use if there is at least one exceedance of the applicable standard (0.05 mg-P/L) during the most recent year of data from the Ambient Lake Monitoring Program or the Illinois Clean Lakes Program. The available data support the listing of phosphorus as a cause of impairment in Sam Dale Lake and Stephen A. Forbes Lake, as discussed in the Stage 1 Report.

4.3 DEVELOPMENT OF TMDL TARGETS

The TMDL target is a numeric endpoint specified to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint. When appropriate numeric standards do not exist, surrogate parameters must be selected to represent the designated use.

4.3.1 Fecal Coliform

For the Skillet Fork fecal coliform TMDL, the target was set at 200 cfu/100 ml.

4.3.2 Total Phosphorus

For the Sam Dale Lake and Stephen A. Forbes Lake phosphorus TMDLs, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

4.3.3 Manganese

A surrogate parameter (total phosphorus concentration) was selected as the TMDL target for manganese for Wayne City Side Channel Reservoir. The linkage between the TMDL target (total phosphorus) and manganese is explained as follows. First, phosphorus loadings to lakes can stimulate excess algal growth. When the algae die and decompose, they then settle to the lake bottom where they contribute to anoxic (i.e. lacking dissolved oxygen) conditions at depth. Under anoxic conditions, manganese is released from the lake sediments.

The primary sources of manganese are naturally elevated concentrations in groundwater and release from lake bottom sediments during anoxic conditions. Thus, the only controllable source of manganese to the lake is the release of manganese from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. For the Wayne City Side Channel Reservoir manganese TMDL, the objective is to maintain hypolimnetic dissolved oxygen concentrations above zero. The lack of dissolved oxygen in lake bottom waters is presumed to be due to sediment oxygen demand resulting from the effects of nutrient enrichment, as there are no point source discharges to the lake or the segment from which the lake receives water. Additionally, no other significant sources of oxygen demanding materials were identified in the watershed characterization. For this reason, attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese is therefore set as a total phosphorus concentration of 0.05 mg-P/l.

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5 DEVELOPMENT OF WATER QUALITY MODELS

Water quality models are used to define the relationship between pollutant loading and the resulting water quality. The TMDLs for phosphorus are based upon the BATHTUB model. The TMDL for fecal coliform applies the Load Duration Curve method. The development of the BATHTUB model and Load Duration Curve approach is described in the following sections, including information on:

- Model selection
- Modeling approach
- Model inputs
- Model calibration/analysis

5.1 BATHTUB MODEL

The BATHTUB water quality model was used to define the relationship between external phosphorus loads and the resulting concentrations of total phosphorus and manganese in the three lakes.

5.1.1 Model Selection

A detailed discussion of the model selection process for the Skillet Fork watershed is provided in the Stage 1 Report.

Of the models discussed, the BATHTUB model (Walker, 1985) was selected to address phosphorus impairments to Sam Dale Lake and Stephen A. Forbes Lake, and manganese impairments to Wayne City Side Channel Reservoir. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed lake data. BATHTUB has been used previously for several reservoir TMDLs in Illinois, and has been cited as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited (Ernst et al., 1994).

The BATHTUB model does not directly model manganese concentrations, but it is still appropriate for TMDL application for Wayne City Side Channel Reservoir. The only controllable source of manganese to the lake is that which enters from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. This source of manganese can be controlled by reducing phosphorus loads to the lake, which will reduce algal growth and increase hypolimnetic dissolved oxygen concentrations.

The model was used to predict the relationship between phosphorus load and resulting in-lake phosphorus concentrations, as well as the resulting potential for oxygen depletion and manganese release from sediments.

5.1.2 Modeling Approach

The approach selected for the manganese and phosphorus TMDLs is based upon discussions with IEPA and the Scientific Advisory Committee. The approach consists of using existing empirical data to define current loads to the lake, and using the BATHTUB model to define the extent to which these loads must be reduced to meet water quality standards. This approach corresponds to Alternative 1 in the detailed discussion of the model selection process provided in the Stage 1 Report. The dominant land use in the watershed is agriculture. Implementation plans for agricultural sources will require voluntary controls, applied on an incremental basis. The approach taken for these TMDLs, which requires no additional data collection and can be conducted immediately, will expedite these implementation efforts.

Determination of existing loading sources and prioritization of restoration alternatives may be conducted by local experts as part of the implementation process (see Section 8). Based upon their recommendations, a voluntary implementation plan could be developed that includes both accountability and the potential for adaptive management.

5.1.3 Model Inputs

This section provides an overview of the model inputs required for BATHTUB application, and how they were derived. The following categories of inputs are required for BATHTUB:

- Model Options
- Global Variables
- Reservoir Segmentation
- Tributary Loads

5.1.3.1 Model Options

BATHTUB provides a multitude of model options to estimate nutrient concentrations in a reservoir. Model options were entered as shown in Table 1, with the rationale for these options discussed below. No conservative substance was being simulated, so this option was not needed. The second order available phosphorus option was selected for phosphorus, as it is the default option for BATHTUB. Nitrogen was not simulated, because phosphorus is the nutrient of concern in the three lakes. Similarly, chlorophyll a and transparency were not simulated. The Fischer numeric dispersion model was selected, which is the default approach in BATHTUB for defining mixing between lake segments. Phosphorus calibrations were based on lake concentrations. The use of availability factors was not required, and estimated concentrations were used to generate mass balance tables.

Table 1. BATHTUB Model Options for Sam Dale Lake, Stephen A. Forbes Lake, and Wayne City Side Channel Reservoir

MODEL	MODEL OPTION
Conservative substance	Not computed
Total phosphorus	2nd order, available phosphorus
Total nitrogen	Not computed
Chlorophyll-a	Not computed
Transparency	Not computed
Longitudinal dispersion	Fischer-numeric
Phosphorus calibration	Concentrations
Nitrogen calibration	None
Error analysis	Not computed
Availability factors	Ignored
Mass-balance tables	Use estimated concentrations

5.1.3.2 Global Variables

The global variables required by BATHTUB consist of:

- The averaging period for the analysis
- Precipitation, evaporation, and change in lake levels
- Atmospheric phosphorus loads

BATHTUB is a steady state model, whose predictions represent concentrations averaged over a period of time. A key decision in the application of BATHTUB is the selection of the length of time over which inputs and outputs should be modeled. The length of the appropriate averaging period for BATHTUB application depends upon the nutrient residence time, which is the average length of time that phosphorus spends in the water column before settling or flushing out of the lake. Guidance for the BATHTUB model recommends that the averaging period used for the analysis be at least twice as large as nutrient residence time for the lake of interest. For lakes with a nutrient residence time on the order of weeks to a few months, a seasonal (e.g. spring-summer) averaging period is recommended. The averaging period for the three lakes was selected as follows:

- The nutrient residence time for Sam Dale Lake was on the order of weeks to a few months. Therefore the averaging period for this analysis was set to the seasonal period March – August.
- The nutrient residence time for Stephen A. Forbes Lake was on the order of weeks to a few months. Therefore the averaging period for this analysis was set to the seasonal period March – August.
- The nutrient residence time for Wayne City Side Channel Reservoir is on the order of a few months. Therefore the averaging period for this analysis was set to the seasonal period March – August.

Precipitation inputs for the three lakes were taken from the observed precipitation data for the calibration year, scaled to the appropriate simulation period. This resulted in a precipitation value of 23.6 inches for Sam Dale Lake, of 27.9 inches for Stephen A. Forbes Lake and 19.6 in for Wayne City Side Channel Reservoir. Evaporation was set equal to precipitation and there was no assumed increase in storage during the modeling period, to represent steady state conditions. The values selected for precipitation and change in lake levels have little influence on model predictions. Atmospheric phosphorus loads were specified using default values provided by BATHTUB.

5.1.3.3 Reservoir Segmentation

BATHTUB provides the capability to divide the reservoir under study into a number of individual segments, allowing prediction of the change in phosphorus concentrations over the length of the reservoir. The segmentation scheme selected for the lakes was designed to provide one segment for each of the primary lake sampling stations. Sam Dale Lake was divided into the segments shown in Figure 2, Stephen A. Forbes Lake was divided into the segments shown in Figure 3, and as shown in Figure 4, the Wayne City Side Channel Reservoir had only a single segment. The areas of segments and watersheds for each segment were determined by Geographic Information System (GIS).

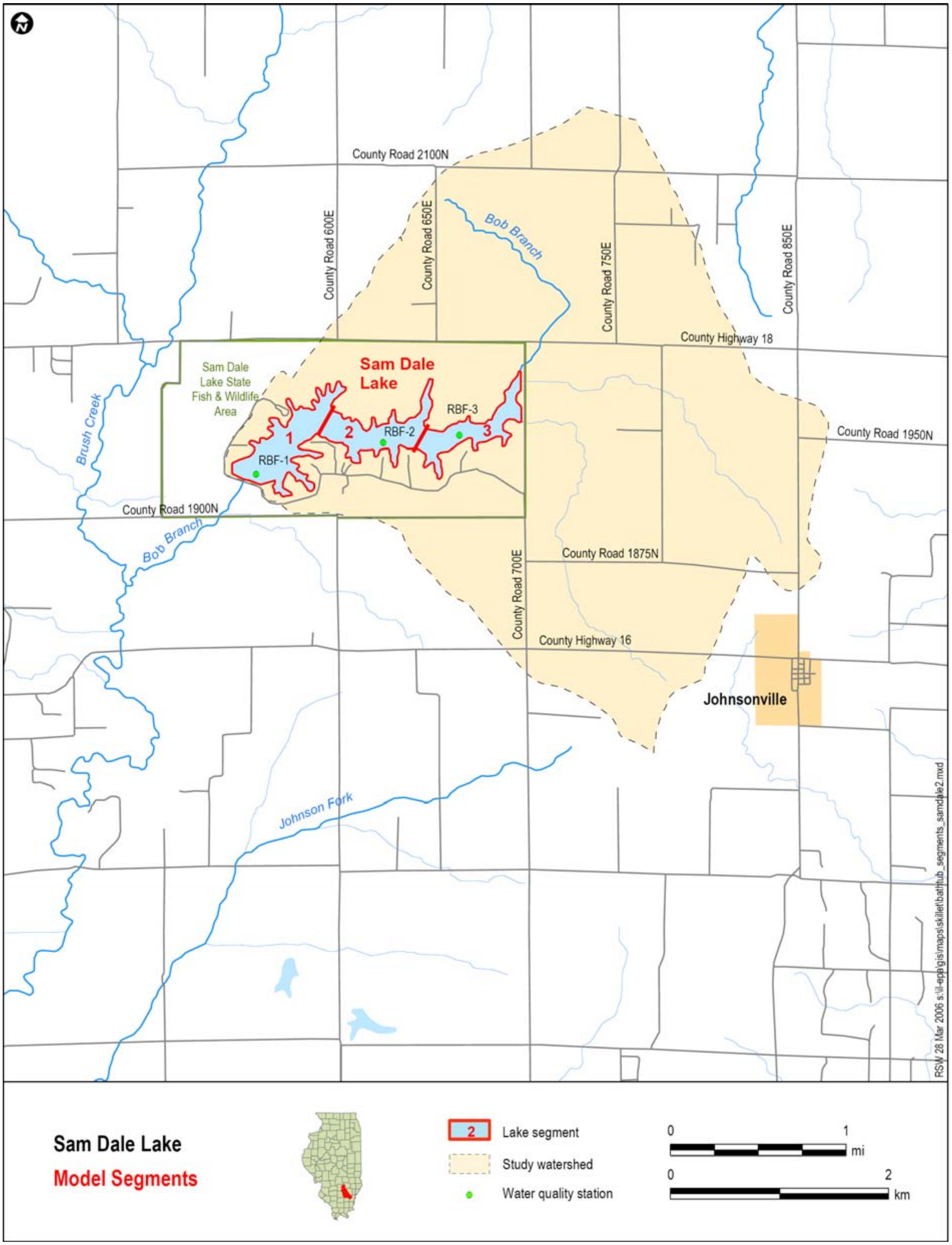

Figure 2. Sam Dale Lake Segmentation Used in BATHTUB

Figure 3. Stephen A. Forbes Lake Segmentation Used in BATHTUB

Figure 4. Wayne City Side Channel Reservoir Segmentation Used in BATHTUB

BATHTUB requires that a range of inputs be specified for each segment. These include segment surface area, length, total water depth, and depth of thermocline and mixed layer. Segment-specific values for segment depths were calculated from lake monitoring data, while segment lengths and surface areas were calculated using GIS. A complete listing of all segment-specific inputs is provided in Attachments 1-3.

5.1.3.4 Tributary Loads

BATHTUB requires information describing tributary flow and nutrient concentrations into each reservoir segment. The approach used to estimate flows is discussed below. Total phosphorus concentrations for each major lake tributary were based upon springtime measurements taken near the headwaters of the lake. In the case of the Wayne City Side Channel Reservoir, the springtime concentration in Skillet Fork segment IL_CA-05 was used as water is pumped from this segment to the reservoir. Concentrations for small tributaries were set equal to the assumed concentration for the major tributary. A complete listing of all segment-specific flows and tributary concentrations is provided in Attachments 1-3.

For Sam Dale Lake and Stephen A. Forbes Lake, flows to each segment were estimated using observed flows at USGS gaging stations adjusted through the use of drainage area ratios as follows:

Flow into segment = Flow at USGS gage x Segment-specific drainage area ratio

$$\text{Drainage area ratio} = \frac{\text{Drainage area of watershed contributing to model segment}}{\text{Drainage area of watershed contributing to USGS gage}}$$

The USGS gage on Skillet Fork at Wayne City, IL (#03380500) was used in this analysis.

For the Wayne City Side Channel Reservoir, flows were based on pumping rates from Skillet Fork to the reservoir, because flow to this reservoir is dependent on water pumped from Skillet Fork, rather than streamflow.

Segment-specific drainage area ratios were calculated using watershed boundaries provided in GIS.

5.1.3.5 Point Source Loads

There are two permitted point source dischargers in the Stephen A. Forbes Lake watershed. These are the Stephen Forbes State Park shower building STP (IL0068977) and the Stephen Forbes State Park concessions building (IL0073903). Within the model these two dischargers were simulated as discharging continuously at their average design flow (0.00406 MGD for the shower building and 0.006 MGD for the concessions building) assuming an effluent phosphorus concentration of 12 mg-P/l, which is reflective of raw sewage (Metcalf and Eddy, 1979). Using this worse case scenario for loading from these dischargers, they contribute less than 1% of the total current load to the lake. It should be noted that the current loads from these facilities are much less, as discharge from these facilities is rarely observed (USEPA, 2004 and 2004a).

5.1.4 BATHTUB Calibration

BATHTUB model calibration consists of:

1. Applying the model with all inputs specified as above
2. Comparing model results to observed phosphorus data
3. Adjusting model coefficients to provide the best comparison between model predictions and observed phosphorus data.

Separate discussions of the BATHTUB model calibration for Sam Dale Lake, Stephen A. Forbes Lake and Wayne City Side Channel Reservoir are provided below.

5.1.4.1 Sam Dale Lake

The BATHTUB model was initially applied with the model inputs as specified above. Observed data for the year 2002 were used for calibration purposes, as this year provided the most robust data set. The August in-lake data from this year were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was first calibrated to match the observed reservoir-average total phosphorus concentrations. Model results in all three segments initially under-predicted the observed phosphorus data. Phosphorus loss rates in BATHTUB rates reflect a typical “net settling rate” (i.e. settling minus sediment release) observed over a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data were corrected during the calibration process via the addition of an internal phosphorus load of 600 mg-P/m^2/day in segment 1. The resulting predicted lake average total phosphorus concentration was 557 ug-P/l, compared to an observed average of 565 ug-P/l. This comparison represents an acceptable model calibration. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 1.

5.1.4.2 Stephen A. Forbes Lake

The BATHTUB model was initially applied with the model inputs as specified above. Observed data for the years 1998 and 2001 were used for calibration purposes, as these years provided the most robust data set. The August in-lake data from this year were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was first calibrated to match the observed reservoir-average total phosphorus concentrations. Model results in all three segments initially under-predicted the observed phosphorus data. Phosphorus loss rates in BATHTUB rates reflect a typical “net settling rate” (i.e. settling minus sediment release) observed over a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data were corrected during the calibration process via the addition of an internal phosphorus load of 100 mg-P/m^2/day in segment 1. The resulting predicted lake average total phosphorus concentration was 127.6 ug-P/l, compared to an observed average of 129.6 ug-P/l. This comparison represents an acceptable model calibration. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 2.

5.1.4.3 Wayne City Side Channel Reservoir

The BATHTUB model was initially applied with the model inputs as specified above. Observed data for the year 2001 were used for calibration purposes, as this year provided the most robust data set. The August in-lake data from this year were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was calibrated to match the observed reservoir-average total phosphorus concentrations. In this case, the reservoir-average total phosphorus concentration is the same as the average segment 1 concentration, as the lake only has one segment. Model results initially under-predicted the observed phosphorus data. Phosphorus loss rates in BATHTUB rates reflect a typical “net settling rate” (i.e. settling minus sediment release) observed over a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data were corrected during the calibration process via the addition of an internal phosphorus load of 4 mg-P/m^2/day in segment 1. The resulting predicted lake average total phosphorus concentration was 79.5 ug-P/l, compared to an observed average of 80 ug-P/l. This comparison represents an acceptable model calibration. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 3.

5.2 LOAD DURATION CURVE ANALYSIS

A load duration curve approach was used in the fecal coliform analysis for Skillet Fork. A load-duration curve is a graphical representation of observed pollutant load compared to maximum allowable load over the entire range of flow conditions. The load duration curve provides information to:

- Help identify the issues surrounding the problem and differentiate between point and nonpoint source problems, as discussed immediately below;
- Address frequency of deviations (how many samples lie above the curve vs. those that plot below); and
- Aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards for different flow conditions.

5.2.1 Model Selection

A detailed discussion of the model selection process for Skillet Fork is provided in the Stage 1 Report. The alternative approach considered for this TMDL consists of applying the HSPF model to define watershed loads for all fecal coliform sources and using the water quality component of this model to simulate in-stream concentrations and water quality response. This approach, coupled with intensive monitoring, would define specific sources of bacteria and identify detailed control strategies necessary to attain water quality standards. The load-duration curve approach was selected over HSPF because it is a simpler approach that requires less data, while supporting the selected level of TMDL implementation for this TMDL. The load-duration curve approach identifies broad categories of fecal coliform sources and the extent of control required from these source categories to attain water quality standards.

5.2.2 Approach

The load duration curve approach uses stream flows for the period of record to gain insight into the flow conditions under which exceedances of the water quality standard occur. A load-duration curve is developed by: 1) ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results; 2) translating the flow duration curve (produced in step 1) into a load duration curve by multiplying the flows by the water quality standard; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph. Observed loads that fall above the load duration curve exceed the maximum allowable load, while those that fall on or below the line do not exceed the maximum allowable load. An analysis of the observed loads relative to the load duration curve provides information on whether the pollutant source is point or nonpoint in nature. A more complete description of the load duration curve approach is provided in the Stage 1 Report.

5.2.3 Data inputs

The load duration curve approach requires a long-term flow record and concentration measurements that are paired to flows. Fecal coliform data collected by IEPA between 1994 and 2004 were used in the analysis. The data were collected as part of IEPA's ambient water quality monitoring program. Only data for the months of May-October were used because the water quality standard applies during this period. Daily flow measurements are available for the USGS gage on Skillet Fork (USGS gage number 03380500 at Wayne City, IL) for the period from 1908 through 2004. The flows were adjusted for the size of the drainage area (i.e., they were multiplied by 2.26 because the watershed for IL_CA-03 is 2.26 times the size of the watershed at the Skillet Fork gage).

5.2.4 Analysis

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. A load duration curve for fecal coliform was generated by multiplying the flows in the duration curve by the TMDL target of 200 cfu/100 ml for fecal coliform bacteria. This is shown with a solid line in Figure 5. Observed pollutant loads for the May through October period (measured concentrations multiplied by corresponding stream flow), were plotted on the same graph. The worksheet for this analysis is provided in Attachment 4.

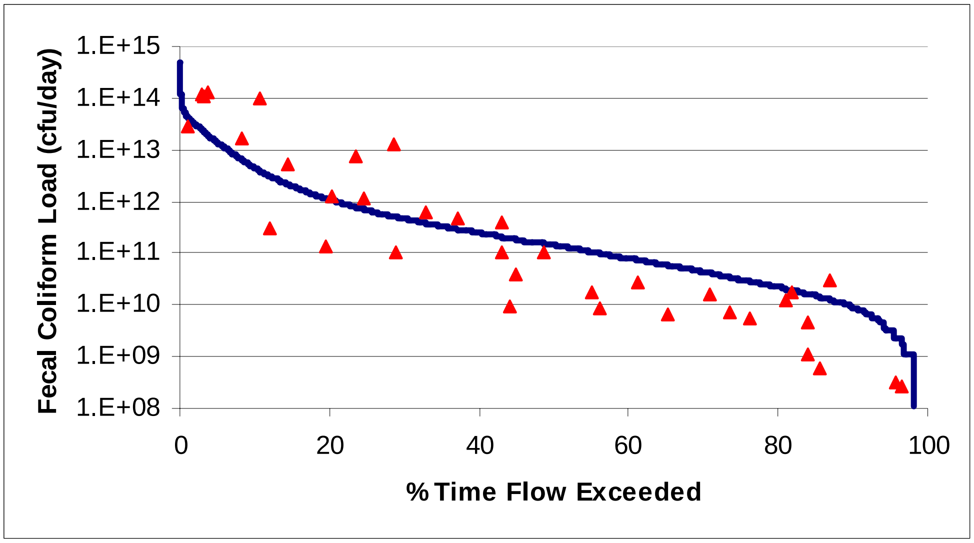

Figure 5. Fecal Coliform Load Duration Curve for Skillet Fork with Observed Loads (triangles)

Figure 5 indicates that observed loads at low and medium flows (in the area of the plot where flows are defined as being exceeded approximately 30 to 99 percent of the time) fall below or very near the line, suggesting that dry weather point sources are not significant contributors to fecal coliform exceedances in this segment. In the higher range of flows from 0 to 30% exceedance, some loads fall above the line, indicating that nonpoint sources are contributors to fecal coliform exceedances during wet weather conditions. These results are consistent with the evidence of wet weather sources of fecal coliform including runoff carrying bacteria from wildlife and livestock, as discussed in the Stage 1 Report.

6 TMDL DEVELOPMENT

This section presents the development of the total maximum daily load for the impaired waterbodies in Skillet Fork watershed. It begins with a description of how the total loading capacity was calculated, and then describes how the loading capacity is allocated among point sources, non-point sources, and the margin of safety. A discussion of critical conditions and seasonality considerations is also provided.

6.1 PHOSPHORUS (SAM DALE, S.A. FORBES) AND MANGANESE (WAYNE CITY SIDE CHANNEL RESERVOIR)

6.1.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. For the three lakes, the loading capacity was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations for each simulation until model results demonstrated attainment of the TMDL target. The maximum tributary concentration that results in compliance with water quality standards was used as the basis for determining the lake's loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

Specific results are discussed below by waterbody.

6.1.1.1 Sam Dale Lake

Initial BATHTUB load reduction simulations indicated that Sam Dale Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional sediment phosphorus source for scenarios where tributary phosphorus concentrations were less than 65 ug-P/l. The resulting tributary phosphorus load that led to compliance with water quality standards was 53 kg phosphorus/month (1.77 kg/day), with the total load for the March-August period not to exceed 317.8 kg. This allowable load corresponds to an approximately 62% reduction from existing tributary loads (estimated as 826.4 kg for the March to August period). Loads are expressed on a seasonal basis because model results indicate that the phosphorus residence time in Sam Dale Lake in on the order of weeks to several months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.1.1.2 Stephen A. Forbes Lake

Initial BATHTUB load reduction simulations indicated that Stephen A. Forbes Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional sediment phosphorus source for scenarios where tributary phosphorus concentrations were less than 65 ug-P/l. The resulting tributary phosphorus load that led to compliance with water quality standards was 108.8 kg phosphorus/month (3.63 kg/day) between March and August, with the total load for this period not to exceed 653 kg. This allowable load corresponds to an approximately 51% reduction from existing tributary loads (estimated as 1,336 kg phosphorus over the March to August period). Loads are expressed on a seasonal basis because model results indicate that the phosphorus residence time in Stephen A. Forbes Lake is on the order of weeks to a few months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.1.1.3 Wayne City Side Channel Reservoir

Initial BATHTUB load reduction simulations indicated that Wayne City Side Channel Reservoir phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was assumed to respond linearly to reductions in tributary phosphorus loads. The resulting tributary phosphorus load that led to compliance with water quality standards was 1.84 kg phosphorus/month (0.06 kg/day) for the March-August period, with the total load for this period not to exceed 11 kg. This allowable load corresponds to an approximately 56% reduction from existing tributary loads (estimated as 25.1 kg phosphorus for the March-August period). Internal phosphorus loads were also reduced by 56% to meet the target concentration. Loads are expressed on a seasonal basis because model results indicate that the phosphorus residence time in Wayne City Side Channel Reservoir in on the order of several months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.1.2 Allocation

6.1.2.1 Sam Dale Lake

There are no NPDES permitted point source dischargers in the Sam Dale Lake watershed. Therefore the WLA is not calculated. The loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 53 kg-P/month (1.77 kg-P/day), a WLA of 0 kg-P/month (0 kg-P/day), and an explicit margin of safety of 10% (discussed below), this results in a load allocation for Sam Dale Lake of 47.7 kg-P/month (1.59 kg-P/day).

6.1.2.2 Stephen A. Forbes Lake

There are two small NPDES permitted point source dischargers in the watershed. These are the Stephen Forbes State Park concession building and the Stephen Forbes State Park shower building. The effluent from these facilities, when discharging, is not monitored for phosphorus. In order to determine if these facilities merit a reduction in phosphorus loads, a very conservative estimate of upper bound loads from these facilities was calculated. This calculation shows that the two facilities combined, at most contribute only 6% of the loading capacity and don't merit reduction. This conservative estimate was calculated using the permitted average design flow rates (0.006 MGD for the concessions building and 0.00406 for the shower building), an assumption that the facilities discharge continuously, and an average estimated phosphorus concentration in the effluent of 12 mg/l, which is representative of raw sewage (Metcalf and Eddy, 1979).

A more realistic estimate of the current load from these facilities was calculated for the WLA. This load assumes the facilities discharge continuously at their average design flow and the effluent concentration equals 4 mg/l, which is reflective of a weak concentration in untreated domestic wastewater. This is a conservative estimate, as these facilities do not discharge continuously. The WLAs for these facilities are calculated as:

- 1.38 kg phosphorus/month (0.05 kg-P/day) for the concessions building (IL0073903)
- 0.94 kg phosphorus/month (0.03 kg-P/day) for the shower building (IL0068977).

The permits for these two facilities will not be changed at this time. Nonpoint sources are responsible for the majority of the phosphorus load; therefore, phosphorus will not be added to the permit limits for the two facilities until substantial work has been done to decrease nonpoint source loads.

The remainder of the loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 108.8 kg-P/month (3.63 kg-P/day), a WLA of 2.32 kg-P/month (0.08 kg-P/day), and an explicit margin of safety of 10% (discussed below), this results in a load allocation for Stephen A. Forbes Lake of 95.6 kg-P/month (3.19 kg-P/day).

6.1.2.3 Wayne City Side Channel Reservoir

There are no NPDES permitted point sources that discharge to either the Wayne City Side Channel Reservoir or the Skillet Fork stream segment (IL_CA-05) from which water is pumped to this reservoir. The WLA for point sources in this watershed is therefore not calculated. The loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 1.84 kg-P/month (0.06 kg-P/day), a WLA of 0 kg-P/month (0 kg-P/day), and an explicit margin of safety of 10% (discussed below), this results in a load allocation for Wayne City Side Channel Reservoir of 1.656 kg-P/month (0.054 kg-P/day).

6.1.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. In terms of loading, spring runoff periods are considered critical because wet weather events can transport significant quantities of nonpoint source loads to the lake. However, the water quality ramifications of these nutrient loads are most severe during middle or late summer. All three of the TMDLs (Sam Dale Lake, Stephen A. Forbes Lake and Wayne City Side Channel Reservoir) are based upon a seasonal period that takes into account both spring loads and summer water quality in order to effectively consider these critical conditions.

6.1.4 Seasonality

These TMDLs were conducted with an explicit consideration of seasonal variation. The BATHTUB model used for these TMDLs is designed to evaluate loads over a seasonal to annual averaging period. Model results indicate that the phosphorus residence times in all three lakes are on the order of weeks to months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.1.5 Margin of Safety

The phosphorus TMDL for the protection of phosphorus and manganese contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit phosphorus loads allocated to the margin of safety are:

- 5.3 kg-P/month (0.177 kg-P/day) for Sam Dale Lake
- 10.88 kg-P/month (0.36 kg-P/day) for Stephen A. Forbes Lake
- 0.184 kg-P/month (0.006 kg-P/day) for Wayne City Side Channel Reservoir

6.2 FECAL COLIFORM (SKILLET FORK, IL_CA-03)

A load capacity calculation approach was applied to support development of a fecal coliform TMDL for Skillet Fork (IL_CA-03).

6.2.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. The loading capacity was defined over a range of specified flows based on expected Skillet Fork flows. The allowable loading capacity was computed by multiplying flow by the TMDL target (200 cfu/100 ml). The fecal coliform loading capacity is presented in Table 2.

Table 2. Fecal Coliform Load Capacity

Skillet Fork Flow (cfs)	Allowable Load (cfu/day)
5	2.45E+10
10	4.89E+10
50	2.45E+11
100	4.89E+11
200	9.79E+11
400	1.96E+12
600	2.94E+12
800	3.91E+12
1000	4.89E+12

The maximum fecal coliform concentrations recorded between May and October were examined for each flow duration interval, as shown in Table 3, in order to estimate the percent reduction in existing loads required to meet the 200 cfu/100 ml target. As shown in Table 3, a greater reduction is needed at higher river flows to meet the target. During these higher flow periods, fecal coliform measurements were observed to exceed 200 cfu/100 ml more frequently.

Table 3. Required Reductions in Existing Loads under Different Flow Conditions

Flow Percentile Interval	Skillet Fork Flow (cfs)	# samples > 200/# samples	Maximum fecal coliform concentration (cfu/100 ml)	Percent Reduction to Meet Target
0-30	93-100,000	10/14	5200	96%
30-60	16 – 93	3/9	410	51%
60-100	0 – 16	1/14	510	61%

6.2.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

The WLA for the 14 point source discharges in the watershed for segment IL_CA-03 was calculated based on the permitted design flow for these dischargers and a fecal coliform concentration that is consistent with meeting the TMDL target (200 cfu/100ml). For those facilities with disinfection exemptions, the WLA is based on the dischargers meeting 200 cfu/100 ml at the downstream end of their exempted reach. WLAs are presented in Table 4.

Table 4. Permitted Dischargers and WLAs

NPDES ID	Facility Name	Disinfection exemption?	Average design flow (MGD)	Permit expiration date	WLA (cfu/day)
IL0024643	Beaver Creek School STP	Year-round since 1994	0.0125	9-30-10	9.5E+07
IL0046957	Bluford STP	Year-round since 1989	0.06	12-31-10	4.5E+08
IL0054496	Springerton STP	Year-round since 2002	0.02	11-30-07	1.5E+08
IL0068977	IL DNR-Stephen Forbes State Park Shower Bldg STP	No	0.004	7-31-10	3.0E+07
IL0073903	IL DNR Stephen Forbes State Park Concession Bldg.	No	0.006	8-31-10	4.5E+07
ILG580029	Xenia STP	Year-round since 1990	0.055	12-31-07	4.2E+08
ILG580080	Dahlgren STP	Year-round since 1991	0.05	12-31-07	3.8E+08
ILG580105	Enfield West STP	Year-round since 1990	0.025	12-31-07	1.9E+08
ILG580108	Enfield East STP	Year-round since 1990	0.05	12-31-07	3.8E+08
ILG580129	Belle Rive STP	Year-round since 1989	0.048	12-31-07	3.6E+08
ILG580146	Iuka STP	Year-round since 1993	0.043	12-31-07	3.3E+08
ILG580195	Mill Shoals STP	Year-round since 1989	0.0382	12-31-07	2.9E+08
ILG580220	Wayne City South STP	Year-round since 1994	0.19	12-31-07	1.4E+09
IL0068829	IL DOT-I64 Jefferson Co West STD (Goshen Rd West Rest Area)	Year-round since 2001	0.006	2-28-09	4.5E+07

The total WLA for the fourteen (14) point source dischargers is 4.6E+09 cfu/day.

The remainder of the loading capacity is given to the load allocation for nonpoint sources as an implicit MOS was used in this TMDL (Table 5). The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall fecal coliform load.

Table 5. Fecal Coliform TMDL for Segment IL_CA-03 Skillet Fork[1]

Flow (cfs)	Allowable Load (cfu/day)	Wasteload Allocation (WLA) (cfu/day)	Load Allocation (LA) (cfu/day)
5	2.45E+10	4.60E+09	1.99E+10
10	4.89E+10	4.60E+09	4.43E+10
50	2.45E+11	4.60E+09	2.40E+11
100	4.89E+11	4.60E+09	4.85E+11
200	9.79E+11	4.60E+09	9.74E+11
400	1.96E+12	4.60E+09	1.95E+12
600	2.94E+12	4.60E+09	2.93E+12
800	3.91E+12	4.60E+09	3.91E+12
1000	4.89E+12	4.60E+09	4.89E+12

[1]This TMDL has an implicit Margin of Safety, so MOS is not included in this table.

6.2.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Figure 5 provides a graphical depiction of the data compared to the load capacity, showing that exceedances of the TMDL target occur over the full range of flow conditions. TMDL development utilizing the load-duration approach applies to the full range of flow conditions; therefore critical conditions were addressed during TMDL development.

6.2.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The load capacity calculation approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in any given point in the season where the standard applies.

6.2.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The fecal coliform TMDL contains an implicit margin of safety, through the use of multiple conservative assumptions. First, the TMDL target (no more than 200 cfu/100 ml at any point in time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 ml for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. This margin of safety can be reviewed in the future as new data are developed.

7 PUBLIC PARTICIPATION AND INVOLVEMENT

The TMDL process included numerous opportunities for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to notify stakeholders about the upcoming TMDLs, and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (see the Stage 1 Report). As quarterly progress reports were produced during the first stage of the TMDL process, the Agency posted them to their website for public review.

The draft Stage 1 Report for this watershed was available to the public for review beginning in December 2004. In February 2005, a public meeting was announced for presentation of the Stage 1 findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Monday, March 14, 2005 in Wayne City, Illinois at the Community Center. In addition to the meeting's sponsors, 18 individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage 1 findings by Limno-Tech, Inc. This was followed by a general question and answer session.

In July 2006, a public meeting was announced for presentation of the Stage Three TMDL findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:00 pm on Monday July 31, 2006 in Wayne City, Illinois at the Community Center. Attendees registered and listened to a presentation on the Stage Three findings by Limno-Tech, Inc. This was followed by a general question and answer session.

A responsiveness summary is included in Attachment 5. This responsiveness summary addresses substantive questions and comments received during the public comment period.

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8 ADAPTIVE IMPLEMENTATION PROCESS

The approach to be taken for TMDL implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply relatively simple models (e.g. BATHTUB) to define the load-response relationship and define the maximum allowable pollutant load that the lake can assimilate and still attain water quality standards
3. Compare the maximum allowable load to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.
5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. Finally, the adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps 1-3 correspond to TMDL development and have been completed, as described in Section 5 of this document. Steps 4 and 5 correspond to implementation.

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Attachment 1

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Sam Dale Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 4 Area-Wtd Mean

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	556.7		99.7%	565.2		99.7%
CHL-A MG/M3				124.2		100.0%
SECCHI M				0.4		7.0%
ANTILOG PC-1				7717.4		99.6%
ANTILOG PC-2				15.4		95.2%
TURBIDITY 1/M	1.9		90.6%	1.9		90.6%
ZMIX * TURBIDITY	4.2		64.7%	4.2		64.7%
ZMIX / SECCHI				6.5		70.1%
CHL-A * SECCHI				43.7		98.0%
CHL-A / TOTAL P				0.3		67.0%
FREQ(CHL-a>10) %				100.0		100.0%
FREQ(CHL-a>20) %				99.6		100.0%
FREQ(CHL-a>30) %				97.6		100.0%
FREQ(CHL-a>40) %				93.5		100.0%
FREQ(CHL-a>50) %				87.6		100.0%
FREQ(CHL-a>60) %				80.5		100.0%
CARLSON TSI-P	94.6		99.7%	94.2		99.7%
CARLSON TSI-CHLA				77.9		100.0%
CARLSON TSI-SEC				75.1		93.0%

Segment: 1 Segment 1

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	752.1		99.9%	847.0		99.9%
CHL-A MG/M3				130.0		100.0%
SECCHI M				0.4		7.9%
ANTILOG PC-1				7632.0		99.6%
ANTILOG PC-2				16.6		96.4%
TURBIDITY 1/M	1.7		88.2%	1.7		88.2%
ZMIX * TURBIDITY	6.9		84.4%	6.9		84.4%
ZMIX / SECCHI				10.8		91.9%
CHL-A * SECCHI				48.1		98.6%
CHL-A / TOTAL P				0.2		35.0%
FREQ(CHL-a>10) %				100.0		100.0%
FREQ(CHL-a>20) %				99.7		100.0%
FREQ(CHL-a>30) %				98.0		100.0%
FREQ(CHL-a>40) %				94.4		100.0%
FREQ(CHL-a>50) %				89.1		100.0%
FREQ(CHL-a>60) %				82.6		100.0%
CARLSON TSI-P	99.7		99.9%	101.4		99.9%
CARLSON TSI-CHLA				78.4		100.0%
CARLSON TSI-SEC				74.3		92.1%

Sam Dale Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **2** **Segment 2**

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	450.6		99.4%	327.0		98.4%
CHL-A MG/M3				119.0		100.0%
SECCHI M				0.4		7.9%
ANTILOG PC-1				7017.8		99.5%
ANTILOG PC-2				15.6		95.4%
TURBIDITY 1/M	1.8		89.2%	1.8		89.2%
ZMIX * TURBIDITY	3.6		57.4%	3.6		57.4%
ZMIX / SECCHI				5.4		58.8%
CHL-A * SECCHI				44.0		98.1%
CHL-A / TOTAL P				0.4		83.5%
FREQ(CHL-a>10) %				100.0		100.0%
FREQ(CHL-a>20) %				99.5		100.0%
FREQ(CHL-a>30) %				97.2		100.0%
FREQ(CHL-a>40) %				92.6		100.0%
FREQ(CHL-a>50) %				86.2		100.0%
FREQ(CHL-a>60) %				78.7		100.0%
CARLSON TSI-P	92.3		99.4%	87.6		98.4%
CARLSON TSI-CHLA				77.5		100.0%
CARLSON TSI-SEC				74.3		92.1%

Segment: **3** **Segment 3**

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	370.9		98.9%	397.0		99.1%
CHL-A MG/M3				121.0		100.0%
SECCHI M				0.3		4.6%
ANTILOG PC-1				8668.8		99.7%
ANTILOG PC-2				13.4		91.9%
TURBIDITY 1/M	2.4		94.2%	2.4		94.2%
ZMIX * TURBIDITY	0.7		2.2%	0.7		2.2%
ZMIX / SECCHI				0.9		0.2%
CHL-A * SECCHI				36.3		96.4%
CHL-A / TOTAL P				0.3		75.6%
FREQ(CHL-a>10) %				100.0		100.0%
FREQ(CHL-a>20) %				99.5		100.0%
FREQ(CHL-a>30) %				97.4		100.0%
FREQ(CHL-a>40) %				93.0		100.0%
FREQ(CHL-a>50) %				86.8		100.0%
FREQ(CHL-a>60) %				79.4		100.0%
CARLSON TSI-P	89.5		98.9%	90.4		99.1%
CARLSON TSI-CHLA				77.6		100.0%
CARLSON TSI-SEC				77.3		95.4%

Sam Dale Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component:		**TOTAL P**		**Segment:**	**1**	**Segment 1**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
3	1	Segment 1 Direct Drainage	0.8	7.7%	131.8	0.2%	169
PRECIPITATION			0.5	4.5%	11.4	0.0%	25
INTERNAL LOAD			0.0	0.0%	83277.0	95.2%	
TRIBUTARY INFLOW			0.8	7.7%	131.8	0.2%	169
ADVECTIVE INFLOW			8.9	87.8%	4019.0	4.6%	451
***TOTAL INFLOW			10.2	100.0%	87439.2	100.0%	8610
ADVECTIVE OUTFLOW			9.7	95.5%	7295.7	8.3%	752
NET DIFFUSIVE OUTFLOW			0.0	0.0%	12339.0	14.1%	
***TOTAL OUTFLOW			9.7	95.5%	19634.7	22.5%	2024
***EVAPORATION			0.5	4.5%	0.0	0.0%	
***RETENTION			0.0	0.0%	67804.6	77.5%	

Hyd. Residence Time =	0.1624	yrs
Overflow Rate =	25.5	m/yr
Mean Depth =	4.1	m

Component:		**TOTAL P**		**Segment:**	**2**	**Segment 2**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
2	1	Segment 2 Direct Drainage	0.9	10.2%	158.9	1.2%	169
PRECIPITATION			0.3	3.6%	8.4	0.1%	25
TRIBUTARY INFLOW			0.9	10.2%	158.9	1.2%	169
ADVECTIVE INFLOW			8.0	86.2%	2960.1	23.3%	371
NET DIFFUSIVE INFLOW			0.0	0.0%	9585.8	75.4%	
***TOTAL INFLOW			9.3	100.0%	12713.2	100.0%	1374
ADVECTIVE OUTFLOW			8.9	96.4%	4019.0	31.6%	451
***TOTAL OUTFLOW			8.9	96.4%	4019.0	31.6%	451
***EVAPORATION			0.3	3.6%	0.0	0.0%	
***RETENTION			0.0	0.0%	8694.2	68.4%	

Hyd. Residence Time =	0.0631	yrs
Overflow Rate =	31.9	m/yr
Mean Depth =	2.0	m

Sam Dale Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component:		**TOTAL P**	**Segment:**		**3**	**Segment 3**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
1	1	Inlet Tributary	8.0	96.5%	1348.6	32.8%	169
PRECIPITATION			0.3	3.5%	7.2	0.2%	25
TRIBUTARY INFLOW			8.0	96.5%	1348.6	32.8%	169
NET DIFFUSIVE INFLOW			0.0	0.0%	2753.2	67.0%	
***TOTAL INFLOW			8.3	100.0%	4109.0	100.0%	497
ADVECTIVE OUTFLOW			8.0	96.5%	2960.1	72.0%	371
***TOTAL OUTFLOW			8.0	96.5%	2960.1	72.0%	371
***EVAPORATION			0.3	3.5%	0.0	0.0%	
***RETENTION			0.0	0.0%	1148.9	28.0%	

Hyd. Residence Time =	0.0138	yrs
Overflow Rate =	33.3	m/yr
Mean Depth =	0.5	m

Sam Dale Lake

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 0.50 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	3	Inlet Tributary	14.4	8.0	0.00E+00	0.00	0.55
2	1	2	Segment 2 Direct Drainage	1.7	0.9	0.00E+00	0.00	0.55
3	1	1	Segment 1 Direct Drainage	1.4	0.8	0.00E+00	0.00	0.55
PRECIPITATION				0.9	1.1	0.00E+00	0.00	1.20
TRIBUTARY INFLOW				17.6	9.7	0.00E+00	0.00	0.55
***TOTAL INFLOW				18.5	10.8	0.00E+00	0.00	0.58
ADVECTIVE OUTFLOW				18.5	9.7	0.00E+00	0.00	0.53
***TOTAL OUTFLOW				18.5	9.7	0.00E+00	0.00	0.53
***EVAPORATION					1.1	0.00E+00	0.00	

Overall Mass Balance Based Upon Component: **Predicted TOTAL P** — **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	3	Inlet Tributary	1348.6	1.6%	0.00E+00		0.00	169.0	93.3
2	1	2	Segment 2 Direct Drainage	158.9	0.2%	0.00E+00		0.00	169.0	93.4
3	1	1	Segment 1 Direct Drainage	131.8	0.2%	0.00E+00		0.00	169.0	92.8
PRECIPITATION				27.0	0.0%	0.00E+00		0.00	25.0	30.0
INTERNAL LOAD				83277.0	98.0%	0.00E+00		0.00		
TRIBUTARY INFLOW				1639.3	1.9%	0.00E+00		0.00	169.0	93.3
***TOTAL INFLOW				84943.3	100.0%	0.00E+00		0.00	7880.1	4599.0
ADVECTIVE OUTFLOW				7295.7	8.6%	0.00E+00		0.00	752.1	395.0
***TOTAL OUTFLOW				7295.7	8.6%	0.00E+00		0.00	752.1	395.0
***RETENTION				77647.6	91.4%	0.00E+00		0.00		

Overflow Rate (m/yr)	10.8	Nutrient Resid. Time (yrs)	0.0147
Hydraulic Resid. Time (yrs)	0.2317	Turnover Ratio	33.9
Reservoir Conc (mg/m3)	557	Retention Coef.	0.914

Sam Dale Lake

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	0	9.7	0.1624	25.5	5.9	28.4	2.8	0.0
2	Segment 2	1	8.9	0.0631	31.9	15.1	72.8	7.2	40.9
3	Segment 3	2	8.0	0.0138	33.3	96.0	612.4	63.4	34.6

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1	0.4	4.1	4.0	0.9	1.6	0.4	2.4
2	Segment 2	0.3	2.0	2.0	0.9	0.6	0.3	3.2
3	Segment 3	0.2	0.5	0.3	1.3	0.1	0.2	7.3
Totals		0.9	2.5			2.2		

Sam Dale Lake

Segment & Tributary Network

--------Segment:	1	Segment 1		
Outflow Segment:	0	Out of Reservoir		
Tributary:	3	Segment 1 Direct Drainage	Type:	Monitored Inflow
--------Segment:	2	Segment 2		
Outflow Segment:	1	Segment 1		
Tributary:	2	Segment 2 Direct Drainage	Type:	Monitored Inflow
--------Segment:	3	Segment 3		
Outflow Segment:	2	Segment 2		
Tributary:	1	Inlet Tributary	Type:	Monitored Inflow

Sam Dale Lake

Description:

Single reservoir (221 acres (from GIS))
3 segments

Global Variables	Mean	CV
Averaging Period (yrs)	0.5	0.0
Precipitation (m)	0.599694	0.0
Evaporation (m)	0.599694	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.00
Total N	0	0.00
Ortho P	0	0.00
Inorganic N	0	0.00

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	0	NONE
Error Analysis	0	NOT COMPUTED
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1	0	1	0.38	4.145	0.95	3.99	0.12	2.7	0	1.73	0	0	0	600	0	0	0
2	Segment 2	1	1	0.28	2.01	0.95	2.01	0.12	0	0	1.81	0	0	0	0	0	0	0
3	Segment 3	2	1	0.24	0.4572	1.32	0.27	0.12	0	0	2.43	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	847	0	0	0	130	0	0.37	0	0	0	0	0	0	0	0	0
2	0	0	327	0	0	0	119	0	0.37	0	0	0	0	0	0	0	0	0
3	0	0	397	0	0	0	121	0	0.3	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Inlet Tributary	3	1	14.45	7.98	0	0	0	169	0	0	0	0	0	0	0
2	Segment 2 Direct Drainage	2	1	1.7	0.94	0	0	0	169	0	0	0	0	0	0	0
3	Segment 1 Direct Drainage	1	1	1.42	0.78	0	0	0	169	0	0	0	0	0	0	0

Sam Dale Lake

Non-Point Source Export Coefficients

Categ	Land Use Name	Runoff (m/yr) Mean	CV	Conserv. Subs. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Row Crop	0.331	0	0	0	140	0	0	0	0	0	0	0
2	Grassland	0.331	0	0	0	140	0	0	0	0	0	0	0
3	Forest	0.331	0	0	0	140	0	0	0	0	0	0	0
4	Urban	0.331	0	0	0	140	0	0	0	0	0	0	0
5	Wetland	0.331	0	0	0	140	0	0	0	0	0	0	0
6	Other	0.331	0	0	0	140	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.007	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	1.000	0
Avail. Factor - Ortho P	0.000	0
Avail. Factor - Total N	0.000	0
Avail. Factor - Inorganic N	0.000	0

Attachment 2

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SA Forbes Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 4 Area-Wtd Mean

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	127.6		86.2%	129.6		86.6%
CHL-A MG/M3				35.3		95.7%
SECCHI M				0.7		25.5%
TP-ORTHO-P MG/M3				11.0		14.6%
ANTILOG PC-1				1507.8		91.7%
ANTILOG PC-2				10.6		82.9%
TURBIDITY 1/M	1.5		85.6%	1.5		85.6%
ZMIX * TURBIDITY	6.7		83.6%	6.7		83.6%
ZMIX / SECCHI				7.4		77.2%
CHL-A * SECCHI				23.0		87.4%
CHL-A / TOTAL P				0.4		87.5%
FREQ(CHL-a>10) %				95.4		95.7%
FREQ(CHL-a>20) %				72.0		95.7%
FREQ(CHL-a>30) %				47.6		95.7%
FREQ(CHL-a>40) %				30.3		95.7%
FREQ(CHL-a>50) %				19.2		95.7%
FREQ(CHL-a>60) %				12.3		95.7%
CARLSON TSI-P	73.3		86.2%	70.3		86.6%
CARLSON TSI-CHLA				65.5		95.7%
CARLSON TSI-SEC				67.0		74.5%

Segment: 1 Segment 1

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	211.5		95.1%	325.0		98.3%
CHL-A MG/M3				42.0		97.4%
SECCHI M				0.8		31.6%
TP-ORTHO-P MG/M3				10.0		12.4%
ANTILOG PC-1				1352.0		90.4%
ANTILOG PC-2				13.4		92.0%
TURBIDITY 1/M	1.2		77.4%	1.2		77.4%
ZMIX * TURBIDITY	6.9		84.3%	6.9		84.3%
ZMIX / SECCHI				7.8		80.0%
CHL-A * SECCHI				31.5		94.4%
CHL-A / TOTAL P				0.1		25.6%
FREQ(CHL-a>10) %				97.7		97.4%
FREQ(CHL-a>20) %				81.2		97.4%
FREQ(CHL-a>30) %				59.2		97.4%
FREQ(CHL-a>40) %				40.8		97.4%
FREQ(CHL-a>50) %				27.7		97.4%
FREQ(CHL-a>60) %				18.8		97.4%
CARLSON TSI-P	81.4		95.1%	87.6		98.3%
CARLSON TSI-CHLA				67.3		97.4%
CARLSON TSI-SEC				64.1		68.4%

SA Forbes Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **2** **Segment 2**

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	103.9		80.5%	60.0		59.9%
CHL-A MG/M3				32.0		94.4%
SECCHI M				0.7		30.9%
TP-ORTHO-P MG/M3				9.5		11.3%
ANTILOG PC-1				1057.6		86.8%
ANTILOG PC-2				11.1		85.0%
TURBIDITY 1/M	1.4		81.9%	1.4		81.9%
ZMIX * TURBIDITY	7.0		85.0%	7.0		85.0%
ZMIX / SECCHI				7.0		74.4%
CHL-A * SECCHI				23.7		88.3%
CHL-A / TOTAL P				0.5		94.2%
FREQ(CHL-a>10) %				94.1		94.4%
FREQ(CHL-a>20) %				67.3		94.4%
FREQ(CHL-a>30) %				41.8		94.4%
FREQ(CHL-a>40) %				25.1		94.4%
FREQ(CHL-a>50) %				15.2		94.4%
FREQ(CHL-a>60) %				9.3		94.4%
CARLSON TSI-P	71.1		80.5%	63.2		59.9%
CARLSON TSI-CHLA				64.6		94.4%
CARLSON TSI-SEC				64.3		69.1%

Segment: **3** **Segment 3**

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	96.3		78.1%	101.0		79.6%
CHL-A MG/M3				37.0		96.3%
SECCHI M				0.3		3.4%
TP-ORTHO-P MG/M3				17.0		27.5%
ANTILOG PC-1				3106.4		97.4%
ANTILOG PC-2				5.6		39.3%
TURBIDITY 1/M	2.6		95.0%	2.6		95.0%
ZMIX * TURBIDITY	5.6		77.0%	5.6		77.0%
ZMIX / SECCHI				8.0		81.1%
CHL-A * SECCHI				10.0		48.8%
CHL-A / TOTAL P				0.4		83.7%
FREQ(CHL-a>10) %				96.4		96.3%
FREQ(CHL-a>20) %				75.2		96.3%
FREQ(CHL-a>30) %				51.1		96.3%
FREQ(CHL-a>40) %				33.1		96.3%
FREQ(CHL-a>50) %				21.3		96.3%
FREQ(CHL-a>60) %				13.8		96.3%
CARLSON TSI-P	70.0		78.1%	70.7		79.6%
CARLSON TSI-CHLA				66.0		96.3%
CARLSON TSI-SEC				78.9		96.6%

SA Forbes Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component:		**TOTAL P**		**Segment:**	**1**	**Segment 1**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
3	1	Segment 1 Direct Drainage	0.4	2.1%	57.9	0.3%	133
PRECIPITATION			0.8	3.7%	16.2	0.1%	21
INTERNAL LOAD			0.0	0.0%	19723.5	90.4%	
TRIBUTARY INFLOW			0.4	2.1%	57.9	0.3%	133
ADVECTIVE INFLOW			19.5	94.2%	2024.9	9.3%	104
***TOTAL INFLOW			20.7	100.0%	21822.5	100.0%	1054
ADVECTIVE OUTFLOW			19.9	96.3%	4216.3	19.3%	212
NET DIFFUSIVE OUTFLOW			0.0	0.0%	5661.4	25.9%	
***TOTAL OUTFLOW			19.9	96.3%	9877.7	45.3%	496
***EVAPORATION			0.8	3.7%	0.0	0.0%	
***RETENTION			0.0	0.0%	11944.7	54.7%	

Hyd. Residence Time = 0.2002 yrs
Overflow Rate = 36.9 m/yr
Mean Depth = 7.4 m

Component:		**TOTAL P**		**Segment:**	**2**	**Segment 2**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
2	1	Segment 2 Direct Drainage	6.7	31.4%	893.8	11.4%	133
5	3	Pt source to seg 2	0.0	0.0%	33.6	0.4%	12000
PRECIPITATION			1.9	8.9%	40.2	0.5%	21
TRIBUTARY INFLOW			6.7	31.4%	893.8	11.4%	133
POINT-SOURCE INFLOW			0.0	0.0%	33.6	0.4%	12000
ADVECTIVE INFLOW			12.8	59.7%	1229.8	15.7%	96
NET DIFFUSIVE INFLOW			0.0	0.0%	5619.0	71.9%	
***TOTAL INFLOW			21.4	100.0%	7816.3	100.0%	365
ADVECTIVE OUTFLOW			19.5	91.1%	2024.9	25.9%	104
***TOTAL OUTFLOW			19.5	91.1%	2024.9	25.9%	104
***EVAPORATION			1.9	8.9%	0.0	0.0%	
***RETENTION			0.0	0.0%	5791.4	74.1%	

Hyd. Residence Time = 0.4117 yrs
Overflow Rate = 14.5 m/yr
Mean Depth = 6.0 m

SA Forbes Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component:		**TOTAL P**		**Segment:**	**3**	**Segment 3**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
1	1	Inlet Tributary	12.8	95.4%	1698.4	94.2%	133
4	3	Pt source to segment 3	0.0	0.0%	49.2	2.7%	12000
PRECIPITATION			0.6	4.5%	12.9	0.7%	21
TRIBUTARY INFLOW			12.8	95.4%	1698.4	94.2%	133
POINT-SOURCE INFLOW			0.0	0.0%	49.2	2.7%	12000
NET DIFFUSIVE INFLOW			0.0	0.0%	42.5	2.4%	
***TOTAL INFLOW			13.4	100.0%	1803.0	100.0%	135
ADVECTIVE OUTFLOW			12.8	95.5%	1229.8	68.2%	96
***TOTAL OUTFLOW			12.8	95.5%	1229.8	68.2%	96
***EVAPORATION			0.6	4.5%	0.0	0.0%	
***RETENTION			0.0	0.0%	573.2	31.8%	

Hyd. Residence Time =	0.0724	yrs
Overflow Rate =	29.7	m/yr
Mean Depth =	2.2	m

SA Forbes Lake

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 0.50 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	3	Inlet Tributary	35.4	12.8	0.00E+00	0.00	0.36
2	1	2	Segment 2 Direct Drainage	18.6	6.7	0.00E+00	0.00	0.36
3	1	1	Segment 1 Direct Drainage	1.2	0.4	0.00E+00	0.00	0.36
4	3	3	Pt source to segment 3		0.0	0.00E+00	0.00	
5	3	2	Pt source to seg 2		0.0	0.00E+00	0.00	
PRECIPITATION				2.3	3.3	0.00E+00	0.00	1.42
TRIBUTARY INFLOW				55.2	19.9	0.00E+00	0.00	0.36
POINT-SOURCE INFLOW					0.0	0.00E+00	0.00	
***TOTAL INFLOW				57.5	23.2	0.00E+00	0.00	0.40
ADVECTIVE OUTFLOW				57.5	19.9	0.00E+00	0.00	0.35
***TOTAL OUTFLOW				57.5	19.9	0.00E+00	0.00	0.35
***EVAPORATION					3.3	0.00E+00	0.00	

Overall Mass Balance Based Upon **Predicted** **Outflow & Reservoir Concentrations**
Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	3	Inlet Tributary	1698.4	7.5%	0.00E+00		0.00	133.0	48.0
2	1	2	Segment 2 Direct Drainage	893.8	4.0%	0.00E+00		0.00	133.0	48.1
3	1	1	Segment 1 Direct Drainage	57.9	0.3%	0.00E+00		0.00	133.0	48.2
4	3	3	Pt source to segment 3	49.2	0.2%	0.00E+00		0.00	12000.0	
5	3	2	Pt source to seg 2	33.6	0.1%	0.00E+00		0.00	12000.0	
PRECIPITATION				69.3	0.3%	0.00E+00		0.00	21.2	30.0
INTERNAL LOAD				19723.5	87.6%	0.00E+00		0.00		
TRIBUTARY INFLOW				2650.0	11.8%	0.00E+00		0.00	133.0	48.1
POINT-SOURCE INFLOW				82.8	0.4%	0.00E+00		0.00	12000.0	
***TOTAL INFLOW				22525.6	100.0%	0.00E+00		0.00	970.8	392.0
ADVECTIVE OUTFLOW				4216.3	18.7%	0.00E+00		0.00	211.5	73.4
***TOTAL OUTFLOW				4216.3	18.7%	0.00E+00		0.00	211.5	73.4
***RETENTION				18309.3	81.3%	0.00E+00		0.00		

Overflow Rate (m/yr)	8.6	Nutrient Resid. Time (yrs)	0.0733
Hydraulic Resid. Time (yrs)	0.6493	Turnover Ratio	6.8
Reservoir Conc (mg/m3)	128	Retention Coef.	0.813

SA Forbes Lake

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	0	19.9	0.2002	36.9	5.2	26.1	2.7	0.0
2	Segment 2	1	19.5	0.4117	14.5	5.6	41.8	6.5	52.6
3	Segment 3	2	12.8	0.0724	29.7	30.1	61.6	32.8	5.6

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1	0.5	7.4	5.8	1.0	4.0	0.5	2.0
2	Segment 2	1.3	6.0	5.2	2.3	8.0	0.6	4.0
3	Segment 3	0.4	2.2	2.2	2.2	0.9	0.2	11.1
Totals		2.3	5.6			12.9		

SA Forbes Lake

Segment & Tributary Network

--------Segment:	1	Segment 1		
Outflow Segment:	0	Out of Reservoir		
Tributary:	3	Segment 1 Direct Drainage	Type:	Monitored Inflow
--------Segment:	2	Segment 2		
Outflow Segment:	1	Segment 1		
Tributary:	2	Segment 2 Direct Drainage	Type:	Monitored Inflow
Tributary:	5	Pt source to seg 2	Type:	Point Source
--------Segment:	3	Segment 3		
Outflow Segment:	2	Segment 2		
Tributary:	1	Inlet Tributary	Type:	Monitored Inflow
Tributary:	4	Pt source to segment 3	Type:	Point Source

SA Forbes Lake

Description:

Single reservoir (572 acres (from GIS))
3 segments

Global Variables	Mean	CV
Averaging Period (yrs)	0.5	0.0
Precipitation (m)	0.708	0.0
Evaporation (m)	0.708	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.00
Total N	0	0.00
Ortho P	0	0.00
Inorganic N	0	0.00

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	0	NONE
Error Analysis	0	NOT COMPUTED
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1	0	1	0.54	7.39	1.04	5.84	0.12	4.57	0	1.18	0	0	0	100	0	0	0
2	Segment 2	1	1	1.34	5.99	2.32	5.17	0.12	3.66	0	1.36	0	0	0	0	0	0	0
3	Segment 3	2	1	0.43	2.15	2.18	2.15	0.12	0	0	2.6	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	325	0	0	0	42	0	0.75	0	0	0	10	0	0	0	0	0
2	0	0	60	0	0	0	32	0	0.74	0	0	0	9.5	0	0	0	0	0
3	0	0	101	0	0	0	37	0	0.27	0	0	0	17	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

SA Forbes Lake

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	**Trib Name**	**Segment**	**Type**	**km^2**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	Inlet Tributary	3	1	35.36	12.77	0	0	0	133	0	0	0	0	0	0	0
2	Segment 2 Direct Drainage	2	1	18.59	6.72	0	0	0	133	0	0	0	0	0	0	0
3	Segment 1 Direct Drainage	1	1	1.2	0.435	0	0	0	133	0	0	0	0	0	0	0
4	Pt source to segment 3	3	3	0	0.0041	0	0	0	12000	0	0	0	0	0	0	0
5	Pt source to seg 2	2	3	0	0.0028	0	0	0	12000	0	0	0	0	0	0	0

Tributary Non-Point Source Drainage Areas (km^2)

		Land Use Category--->							
Trib	**Trib Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Inlet Tributary	32.44	1.8	2.51	0.23	0.53	0.45	0	0
2	Segment 2 Direct Drainage	4.26	0.35	1.26	0.09	0.28	0.67	0	0
3	Segment 1 Direct Drainage	1.16	0.21	0.51	0.13	0.29	0.6	0	0
4	Pt source to segment 3	0	0	0	0	0	0	0	0
5	Pt source to seg 2	0	0	0	0	0	0	0	0

Non-Point Source Export Coefficients

		Runoff (m/yr)		Conserv. Subs.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Categ	**Land Use Name**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	Row Crop	0.331	0	0	0	140	0	0	0	0	0	0	0
2	Grassland	0.331	0	0	0	140	0	0	0	0	0	0	0
3	Forest	0.331	0	0	0	140	0	0	0	0	0	0	0
4	Urban	0.331	0	0	0	140	0	0	0	0	0	0	0
5	Wetland	0.331	0	0	0	140	0	0	0	0	0	0	0
6	Other	0.331	0	0	0	140	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0	0	0	0	0

Model Coefficients	**Mean**	**CV**
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.007	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	1.000	0
Avail. Factor - Ortho P	0.000	0
Avail. Factor - Total N	0.000	0
Avail. Factor - Inorganic N	0.000	0

Attachment 3

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Wayne City Side Channel Reservoir

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 1 Segment 1

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	79.5		71.3%	80.0		71.6%
CHL-A MG/M3				32.0		94.4%
SECCHI M				0.7		30.9%
ANTILOG PC-1				1057.6		86.8%
ANTILOG PC-2				11.1		85.0%
TURBIDITY 1/M	1.1		75.2%	1.1		75.2%
ZMIX * TURBIDITY	4.9		71.4%	4.9		71.4%
ZMIX / SECCHI				5.9		64.8%
CHL-A * SECCHI				23.7		88.3%
CHL-A / TOTAL P				0.4		86.9%
FREQ(CHL-a>10) %				94.1		94.4%
FREQ(CHL-a>20) %				67.3		94.4%
FREQ(CHL-a>30) %				41.8		94.4%
FREQ(CHL-a>40) %				25.1		94.4%
FREQ(CHL-a>50) %				15.2		94.4%
FREQ(CHL-a>60) %				9.3		94.4%
CARLSON TSI-P	67.2		71.3%	67.3		71.6%
CARLSON TSI-CHLA				64.6		94.4%
CARLSON TSI-SEC				64.3		69.1%

Wayne City Side Channel Reservoir

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Segment 1**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Inlet Tributary	0.4	87.9%	49.7	36.9%	120
PRECIPITATION			0.1	12.1%	1.7	1.3%	30
INTERNAL LOAD			0.0	0.0%	83.3	61.8%	
TRIBUTARY INFLOW			0.4	87.9%	49.7	36.9%	120
***TOTAL INFLOW			0.5	100.0%	134.7	100.0%	286
ADVECTIVE OUTFLOW			0.4	87.9%	33.0	24.5%	80
***TOTAL OUTFLOW			0.4	87.9%	33.0	24.5%	80
***EVAPORATION			0.1	12.1%	0.0	0.0%	
***RETENTION			0.0	0.0%	101.8	75.5%	

Hyd. Residence Time = 0.6463 yrs
Overflow Rate = 7.3 m/yr
Mean Depth = 4.7 m

Wayne City Side Channel Reservoir

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 0.50 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	Inlet Tributary	1202.0	0.4	0.00E+00	0.00	0.00
PRECIPITATION				0.1	0.1	0.00E+00	0.00	1.00
TRIBUTARY INFLOW				1202.0	0.4	0.00E+00	0.00	0.00
***TOTAL INFLOW				1202.1	0.5	0.00E+00	0.00	0.00
ADVECTIVE OUTFLOW				1202.1	0.4	0.00E+00	0.00	0.00
***TOTAL OUTFLOW				1202.1	0.4	0.00E+00	0.00	0.00
***EVAPORATION					0.1	0.00E+00	0.00	

Overall Mass Balance Based Upon Component: **Predicted TOTAL P** — **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Inlet Tributary	49.7	36.9%	0.00E+00		0.00	120.0	0.0
PRECIPITATION				1.7	1.3%	0.00E+00		0.00	30.1	30.0
INTERNAL LOAD				83.3	61.8%	0.00E+00		0.00		
TRIBUTARY INFLOW				49.7	36.9%	0.00E+00		0.00	120.0	0.0
***TOTAL INFLOW				134.7	100.0%	0.00E+00		0.00	285.8	0.1
ADVECTIVE OUTFLOW				33.0	24.5%	0.00E+00		0.00	79.5	0.0
***TOTAL OUTFLOW				33.0	24.5%	0.00E+00		0.00	79.5	0.0
***RETENTION				101.8	75.5%	0.00E+00		0.00		

Overflow Rate (m/yr)	7.3	Nutrient Resid. Time (yrs)	0.1581
Hydraulic Resid. Time (yrs)	0.6463	Turnover Ratio	3.2
Reservoir Conc (mg/m3)	80	Retention Coef.	0.755

Wayne City Side Channel Reservoir

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	0	0.4	0.6463	7.3	1.0	2.3	0.0	0.0

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1	0.1	4.7	4.4	0.2	0.3	0.3	0.7
Totals		0.1	4.7			0.3		

Wayne City Side Channel Reservoir

Segment & Tributary Network

--------Segment:	1	Segment 1		
Outflow Segment:	0	Out of Reservoir		
Tributary:	1	Inlet Tributary	Type:	Monitored Inflow

Wayne City Side Channel Reservoir

Description:

Single reservoir (14 acres (from GIS))
1segment

Global Variables	Mean	CV
Averaging Period (yrs)	0.5	0.0
Precipitation (m)	0.499	0.0
Evaporation (m)	0.499	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.00
Total N	0	0.00
Ortho P	0	0.00
Inorganic N	0	0.00

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	0	NONE
Error Analysis	0	NOT COMPUTED
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1	0	1	0.057	4.7	0.198	4.4	0.12	2.13	0	1.11	0	0	0	4	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	80	0	0	0	32	0	0.74	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Inlet Tributary	1	1	1202	0.4145	0	0	0	120	0	0	0	0	0	0	0

Tributary Non-Point Source Drainage Areas (km^2)

		Land Use Category--->							
Trib	Trib Name	1	2	3	4	5	6	7	8
1	Inlet Tributary	32.44	1.8	2.51	0.23	0.53	0.45	0	0

Wayne City Side Channel Reservoir

Non-Point Source Export Coefficients

		Runoff (m/yr)		Conserv. Subs.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Categ	**Land Use Name**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	Row Crop	0.331	0	0	0	140	0	0	0	0	0	0	0
2	Grassland	0.331	0	0	0	140	0	0	0	0	0	0	0
3	Forest	0.331	0	0	0	140	0	0	0	0	0	0	0
4	Urban	0.331	0	0	0	140	0	0	0	0	0	0	0
5	Wetland	0.331	0	0	0	140	0	0	0	0	0	0	0
6	Other	0.331	0	0	0	140	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0	0	0	0	0

Model Coefficients	**Mean**	**CV**
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.007	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	1.000	0
Avail. Factor - Ortho P	0.000	0
Avail. Factor - Total N	0.000	0
Avail. Factor - Inorganic N	0.000	0

Attachment 4

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Data for fecal coliform load duration curve

Skillet Fork Flow (cfs)	% of Time Exceeded	Fecal load (cfu/day)
0.00	99.99	0.00E+00
0.18	98.06	8.87E+08
0.23	97.44	1.11E+09
0.23	96.81	1.11E+09
0.45	96.19	2.22E+09
0.48	95.56	2.33E+09
0.68	94.94	3.33E+09
0.68	94.32	3.33E+09
0.91	93.69	4.43E+09
1.13	93.07	5.54E+09
1.29	92.44	6.32E+09
1.36	91.82	6.65E+09
1.59	91.19	7.76E+09
1.79	90.57	8.76E+09
1.81	89.94	8.87E+09
2.04	89.32	9.98E+09
2.20	88.69	1.08E+10
2.27	88.07	1.11E+10
2.49	87.44	1.22E+10
2.72	86.82	1.33E+10
2.72	86.20	1.33E+10
2.94	85.57	1.44E+10
3.17	84.95	1.55E+10
3.17	84.32	1.55E+10
3.40	83.70	1.66E+10
3.62	83.07	1.77E+10
3.85	82.45	1.88E+10
3.85	81.82	1.88E+10
4.08	81.20	2.00E+10
4.30	80.57	2.11E+10
4.53	79.95	2.22E+10
4.76	79.32	2.33E+10
4.98	78.70	2.44E+10
5.21	78.07	2.55E+10
5.44	77.45	2.66E+10
5.66	76.83	2.77E+10
5.89	76.20	2.88E+10
6.12	75.58	2.99E+10
6.34	74.95	3.10E+10
6.57	74.33	3.21E+10
6.80	73.70	3.33E+10
7.25	73.08	3.55E+10
7.47	72.45	3.66E+10
7.93	71.83	3.88E+10
8.15	71.20	3.99E+10
8.61	70.58	4.21E+10

Observed Data

Date	Skillet Fork Flow (cfs)	Fecal coliform (cfu/100 ml)	Percentile	Fecal load (cfu/day)
5/15/1997	101.9	40	28.82	9.98E+10
5/29/1996	3895.9	1350	3.79	1.29E+14
5/24/1995	634.2	20	12.04	3.10E+11
6/3/1998	77.0	340	32.91	6.41E+11
6/19/1997	4824.6	1000	3.05	1.18E+14
6/22/1995	104.2	5200	28.50	1.33E+13
7/9/1998	4734.0	900	3.12	1.04E+14
7/28/1997	36.2	43	44.97	3.81E+10
7/3/1996	12.0	23	65.11	6.76E+09
8/13/1998	1302.4	540	8.31	1.72E+13
8/10/1994	6.8	42	73.43	6.98E+09
8/7/1996	3.2	14	84.05	1.09E+09
8/16/1995	40.8	410	42.95	4.09E+11
9/30/1998	58.9	320	37.04	4.61E+11
9/11/1997	8.4	76	70.89	1.56E+10
9/20/1994	0.0	30	98.22	3.33E+07
9/4/1996	3.2	62	84.05	4.81E+09
9/21/1995	0.5	30	95.59	3.33E+08
10/9/1997	0.4	26	96.44	2.59E+08
10/9/1996	5.7	40	76.21	5.54E+09
5/16/2001	20.2	18	56.26	8.88E+09
5/25/2000	40.8	100	42.95	9.98E+10
5/22/2002	226.5	24	19.58	1.33E+11
5/25/2004	446.2	460	14.35	5.02E+12
6/28/2000	8879.1	132	1.08	2.87E+13
6/22/2004	210.7	240	20.36	1.24E+12
7/5/2001	142.7	323	24.64	1.13E+12
8/13/2001	3.9	187	81.75	1.76E+10
8/1/2000	804.1	4800	10.61	9.44E+13
8/14/2002	2.7	9	85.65	5.99E+08
8/3/2004	29.4	140	48.63	1.01E+11
9/12/2001	4.1	122	81.04	1.22E+10
9/18/2000	15.2	74	61.15	2.75E+10
9/26/2002	2.5	510	86.87	3.11E+10
9/14/2004	38.5	10	44.13	9.42E+09
10/30/2000	21.5	32	54.96	1.68E+10
10/24/2001	156.3	2000	23.57	7.65E+12

Data for fecal coliform load duration curve

Skillet Fork Flow (cfs)	% of Time Exceeded	Fecal load (cfu/day)
9.06	69.95	4.43E+10
9.29	69.33	4.54E+10
9.74	68.71	4.77E+10
10.19	68.08	4.99E+10
10.65	67.46	5.21E+10
10.87	66.83	5.32E+10
11.33	66.21	5.54E+10
11.78	65.58	5.76E+10
12.23	64.96	5.99E+10
12.68	64.33	6.21E+10
12.91	63.71	6.32E+10
13.59	63.08	6.65E+10
14.04	62.46	6.87E+10
14.72	61.83	7.21E+10
15.18	61.21	7.43E+10
15.86	60.58	7.76E+10
16.08	59.96	7.87E+10
16.76	59.34	8.20E+10
17.21	58.71	8.42E+10
18.12	58.09	8.87E+10
18.57	57.46	9.09E+10
19.48	56.84	9.53E+10
20.39	56.21	9.98E+10
21.07	55.59	1.03E+11
21.52	54.96	1.05E+11
22.65	54.34	1.11E+11
22.65	53.71	1.11E+11
24.92	53.09	1.22E+11
24.92	52.46	1.22E+11
24.92	51.84	1.22E+11
27.18	51.21	1.33E+11
27.18	50.59	1.33E+11
29.45	49.97	1.44E+11
29.45	49.34	1.44E+11
29.45	48.72	1.44E+11
31.71	48.09	1.55E+11
31.71	47.47	1.55E+11
33.98	46.84	1.66E+11
33.98	46.22	1.66E+11
36.24	45.59	1.77E+11
36.24	44.97	1.77E+11
38.51	44.34	1.88E+11
40.77	43.72	2.00E+11
40.77	43.09	2.00E+11
43.04	42.47	2.11E+11
45.30	41.85	2.22E+11
45.30	41.22	2.22E+11

Data for fecal coliform load duration curve

Skillet Fork Flow (cfs)	% of Time Exceeded	Fecal load (cfu/day)
47.57	40.60	2.33E+11
49.83	39.97	2.44E+11
52.10	39.35	2.55E+11
54.36	38.72	2.66E+11
56.63	38.10	2.77E+11
58.89	37.47	2.88E+11
61.16	36.85	2.99E+11
63.42	36.22	3.10E+11
65.69	35.60	3.21E+11
67.95	34.97	3.33E+11
72.48	34.35	3.55E+11
74.75	33.72	3.66E+11
77.01	33.10	3.77E+11
79.28	32.48	3.88E+11
83.81	31.85	4.10E+11
88.34	31.23	4.32E+11
90.60	30.60	4.43E+11
95.13	29.98	4.66E+11
99.66	29.35	4.88E+11
104.19	28.73	5.10E+11
108.72	28.10	5.32E+11
113.25	27.48	5.54E+11
117.78	26.85	5.76E+11
124.58	26.23	6.10E+11
131.38	25.60	6.43E+11
140.44	24.98	6.87E+11
147.23	24.36	7.21E+11
156.29	23.73	7.65E+11
165.35	23.11	8.09E+11
174.41	22.48	8.54E+11
185.74	21.86	9.09E+11
199.33	21.23	9.75E+11
208.39	20.61	1.02E+12
219.71	19.98	1.08E+12
233.30	19.36	1.14E+12
251.42	18.73	1.23E+12
269.55	18.11	1.32E+12
289.93	17.48	1.42E+12
317.11	16.86	1.55E+12
339.76	16.23	1.66E+12
373.74	15.61	1.83E+12
407.72	14.99	2.00E+12
446.22	14.36	2.18E+12
482.46	13.74	2.36E+12
536.83	13.11	2.63E+12
588.92	12.49	2.88E+12
654.61	11.86	3.20E+12

Data for fecal coliform load duration curve

Skillet Fork Flow (cfs)	% of Time Exceeded	Fecal load (cfu/day)
720.30	11.24	3.52E+12
804.11	10.61	3.94E+12
910.56	9.99	4.46E+12
1044.20	9.36	5.11E+12
1189.17	8.74	5.82E+12
1368.11	8.11	6.70E+12
1544.79	7.49	7.56E+12
1814.33	6.86	8.88E+12
2108.80	6.24	1.03E+13
2468.94	5.62	1.21E+13
2831.36	4.99	1.39E+13
3329.68	4.37	1.63E+13
3963.90	3.74	1.94E+13
4756.68	3.12	2.33E+13
5640.06	2.49	2.76E+13
6727.31	1.87	3.29E+13
8244.91	1.24	4.03E+13
11302.78	0.62	5.53E+13

Attachment 5

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Skillet Fork Responsiveness Summary

1. The report documents that nonpoint sources are the major contributor of the pollutants of concern (total phosphorus by itself or as a contributor to elevated manganese levels and fecal coliform) for all four watersheds. This report does not address relative contributions of nonpoint sources, nor does it address potential strategies to attain needed load reductions.

   I appreciate that IEPA is following steps recommended by the Science Advisory Committee (SAC) to accelerate TMDL implementation in nonpoint source-dominated watersheds. However, it seems that the plan outlined here is to leave all analysis of the significance of nonpoint sources to local experts to be convened at an unspecified time on a voluntary basis. A much more effective approach would be for IEPA, who has just devoted considerable resources to collecting data and performing analyses on these and other similar watersheds, to assess nonpoint sources and at least include a few sample load reduction plans showing different ways load reductions could be achieved in the watershed as a starting point for the stakeholder process.

Response: Point source and nonpoint sources are very different when it comes to implementation. The Illinois EPA regulates point sources by issuing permits. Illinois EPA can revise the NPDES permits if the TMDL shows that is needed. For nonpoint sources, there are no permits required. We have no regulatory authority for nonpoint sources and therefore actions are voluntary. Our implementation plan gives general guidelines on ways the local community can clean up impaired waters. We hope that there are people in the community, whether it be a local watershed group or an individual farmer, who will come forward and be willing to take the appropriate steps. Illinois EPA has staff who can help a community start and maintain a watershed group. We also have 319 Nonpoint Source Program funds available for projects. The implementation plan will identify ways to monitor and address nonpoint sources using an adaptive management approach. We think this will be more useful than assigning nonpoint source loads with models based on limited data and assumptions about loading and runoff.

2. I appreciate the summary of modeling inputs, approaches, and calibration provided in the report. I also appreciate the conservative assumptions used in the assessment of phosphorus point source loads to Stephen A. Forbes. The conservative approach supports the argument that point sources are not a major contributor of phosphorus; similar conservative assumptions should be made to assess the importance of point sources to the Skillet Fork.

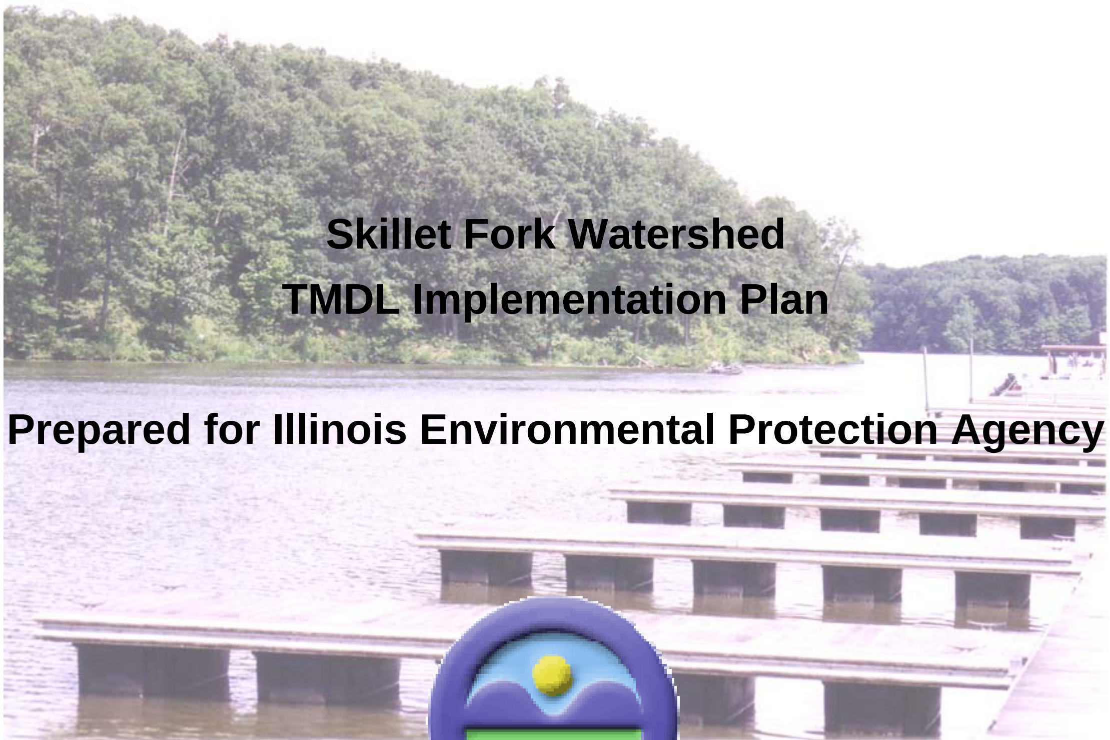
   Response: The Skillet Fork (Segment CA-03) TMDL was done for fecal coliform and all the known facilities that discharge fecal coliform are listed in the report. Two facilities in the watershed have permit limits of 400 cfu/100ml. They are required to submit data that shows compliance with this standard. The loads for these facilities were based on their design flows and the maximum amount they are allowed to discharge, which is 400 cfu/100m. The other facilities in the watershed have disinfection exemptions. An exemption is granted when the facility provides data from their effluent that is used in bacteria die-off equations to show it is meeting 200 cfu/100ml at the end of the exempted segment. The design flow for these facilities and the 200 cfu/100ml were used for load estimates at the end of the exempted segments.

3. The analysis of loading capacity is flawed in that it assumes 24-hour die-off of fecal coliform bacteria (and associated bacteria). This is neither a defensible nor a conservative assumption. The analysis should be redone assuming a longer period of bacteria viability.

Response: Load duration curves do not have any type of die-off or regrowth in their analysis. We use the data samples and flow data that were collected from the waters.

4. The analysis of point source loads of fecal coliform bacteria is flawed. Data from the Lower Sangamon fecal coliform TMDL showed that of 14 facilities with fecal coliform monitoring data, 12 exceed fecal coliform effluent limits on average 54% of the time, with an average concentration of 5500cfu/100ml in samples exceeding the limit. Calculating waste loads assuming that sewage treatment plants are meeting effluent limits of 400cfu/100ml all of the time is neither defensible nor conservative.

Response: Neither of the facilities that are required to monitor monthly have had any exceedences of the standard. For Stephen Forbes State Park Shower Building, data from 2004 through 2005 showed only one month that the facility discharged, with a fecal count of 1 cfu/100ml. The rest of the data showed there were no discharges at this facility. For Stephen Forbes State Park Concession Building, there were no discharges of effluent from 2004-2005. These are small state park facilities.



Skillet Fork Watershed
TMDL Implementation Plan

Prepared for Illinois Environmental Protection Agency

December 2006

Skillet Fork (IL_CA-03): Fecal Coliform

Sam Dale Lake (IL_RBF): Phosphorus

Stephen A. Forbes Lake (IL_RCD): Phosphorus

Wayne City Side Channel Reservoir (IL_RCT): Manganese

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SUMMARY

Total Maximum Daily Loads (TMDLs) were developed and approved by the U.S. EPA for several waterbodies in Southeastern Illinois, to address water quality impairments. These include TMDLs for Skillet Fork (IL_CA-03), to address water quality impairment due to fecal coliform bacteria; for Stephen A. Forbes Lake (IL_RCD) and Sam Dale Lake (IL_RBF), to address impairments due to phosphorus; and for Wayne City Side Channel Reservoir (IL_RCT) to address impairment due to manganese. These TMDLs determined that significant reductions in existing pollutant loadings were needed to meet water quality objectives. The next step in the TMDL process is to develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. This document identifies a number of alternative actions to be considered by local stakeholders for TMDL implementation, and presents recommendations for implementation actions and additional monitoring.

INTRODUCTION

Section 303(d) of the 1972 Clean Water Act requires States to define waters that are not meeting designated uses under technology-based controls and identify them on a list of impaired waters, which is referred to as the 303(d) list. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to develop Total Maximum Daily Loads (TMDLs) for these impaired water bodies. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and conditions in the water body. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (U.S. EPA, 1991).

Skillet Fork (IL_CA-03), Stephen A. Forbes Lake (IL_RCD), Sam Dale Lake (IL_RBF), and Wayne City Side Channel Reservoir (IL_RCT) are listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as waterbodies that are not meeting their designated uses. As such, they have been targeted as high priority waterbodies for TMDL development. TMDLs for these waterbodies have been developed (LTI, 2006) and approved by the U.S. EPA. The next step in the TMDL process is to develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. Adaptive management recognizes that proceeding with some initial improvement efforts is better than waiting to find a “perfect” solution. In an adaptive management approach, the TMDL and the watershed to which it applies are revisited over time to assess progress and make adjustments that continue to move toward achieving the TMDL’s goals. Adaptive management may be conducted through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This document presents the implementation plan for the Skillet Fork, Stephen A. Forbes Lake, Sam Dale Lake, and Wayne City Side Channel Reservoir TMDLs. It is divided into sections describing the watershed, summarizing the TMDLs, describing existing controls within the watershed for the pollutants of interest, outlining the implementation approach, presenting a variety of implementation alternatives, recommending particular control alternatives, describing areas for targeting controls, presenting reasonable assurances that the measures will be implemented, and outlining future monitoring and adaptive management.

WATERSHED DESCRIPTION

The impaired waterbodies addressed in this report are all located within the Skillet Fork watershed. This watershed is located in Southeastern Illinois, approximately 10 miles east of the city of Mount Vernon and the intersection of Interstates 57 and 64. Skillet Fork is a tributary to the Little Wabash River, with its confluence located three miles northeast of Carmi, Illinois, near river mile 39. Portions of the Skillet Fork watershed lie in Clay, Marion, Wayne, Jefferson, White and Hamilton counties. The watershed is approximately 672,425 acres (1,051 square miles) in size, and there are about 1,720 miles of streams in the watershed. The main stem of the Skillet Fork River is approximately 97 miles long (54 miles are listed as being impaired). The waterbodies of concern are Skillet Fork (IL_CA-03), Stephen A. Forbes Lake (IL_RCD), Sam Dale Lake (IL_RBF), and Wayne City Side Channel Reservoir (IL_RCT). A detailed characterization of the impaired waterways and their watersheds is presented in the First Quarterly Status Report (LTI, 2004)..

Figure 1 shows a map of the watershed, and includes some key features such as waterways, impaired waterbodies, public water intakes and other key features. The map also shows the locations of point source discharges that have a permit to discharge under the National Pollutant Discharge Elimination System (NPDES).

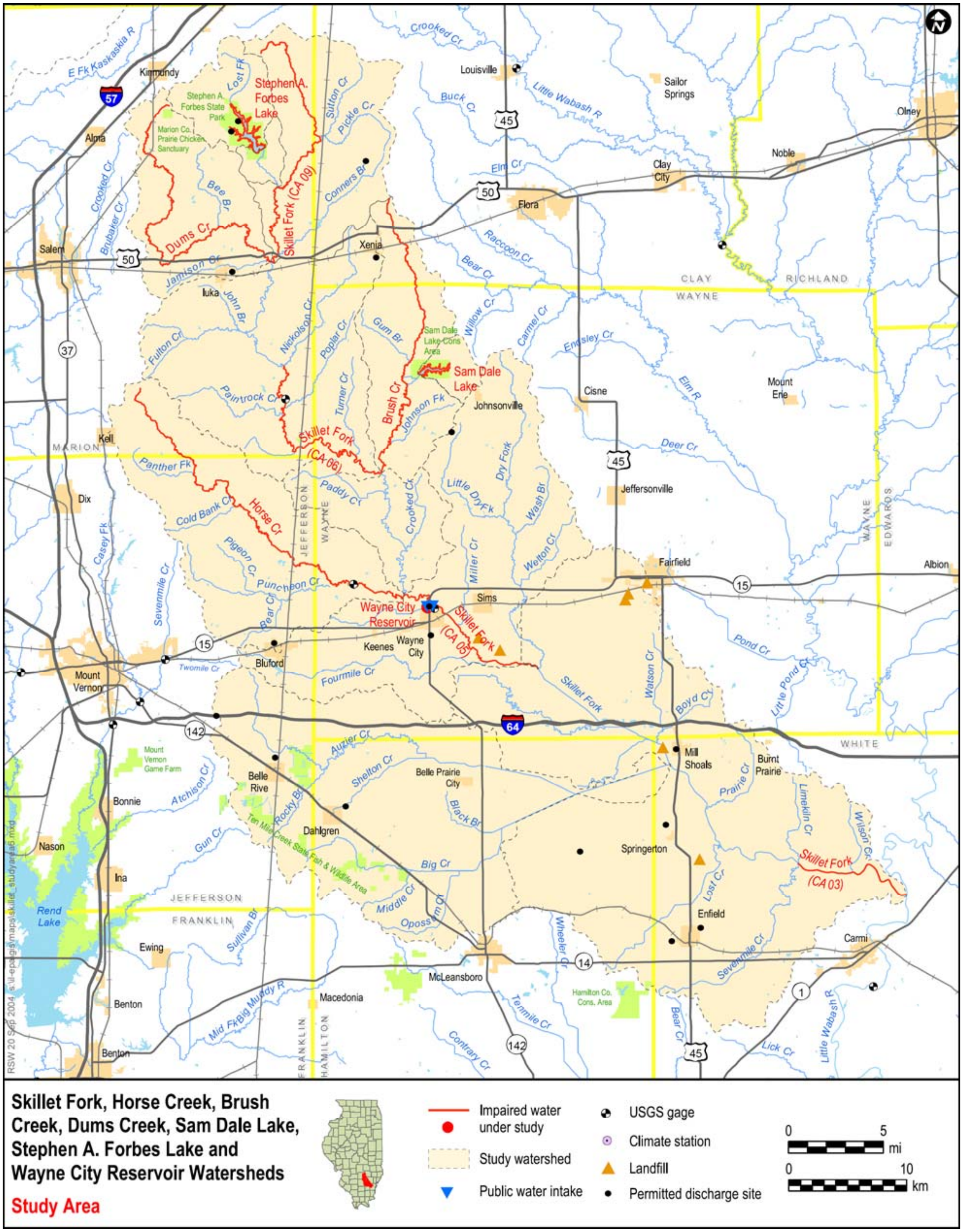

Figure 1. Skillet Fork Watershed

TMDL SUMMARY

The impairments in waters of the Skillet Fork Watershed addressed in this report are summarized in Table 1, with the parameters (causes) that they are listed for, and the impairment status of each designated use, as identified in the 303(d) list (IEPA, 2006). TMDL Implementation Plans for Sam Dale Lake, Stephen A. Forbes Lake, Wayne City Side Channel Reservoir, and Skillet Fork fecal coliform are included in this report. Other TMDLs and implementation plans for Skillet Fork, Horse Creek, Brush Creek, and Dums Creek will be conducted separately. While TMDLs are currently only being developed for pollutants that have numerical water quality standards (indicated in Table 1 with bold font), many controls that are implemented to address TMDLs for these pollutants will reduce other pollutants as well. For example, any controls to reduce phosphorus loads from watershed sources (stream bank erosion, runoff, etc.) would also serve to reduce sediment loads to a lake, as phosphorus Best Management Practices (BMPs) are often the same or similar to sediment BMPs. Furthermore, any reduction of phosphorus loads, either through implementation of watershed controls or dredging of in-lake sediments, is expected to work towards reducing algae concentrations, as phosphorus is the nutrient most responsible for limiting algal growth.

Table 1. Summary of Impairments

Skillet Fork	
Assessment Unit ID	IL_CA-03
Size (miles)	7.2
Listed For	**Fecal Coliform,** manganese, pH, dissolved oxygen, total suspended solids, habitat assessment (streams), sedimentation/siltation, total phosphorus, PCBs
Use Support[1]	Aquatic life (N), fish consumption (N), primary contact (N), secondary contact (X), aesthetic quality (X)

[1]F=full support, P=partial support, N=nonsupport, X=not assessed

Sam Dale Lake	
Assessment Unit ID	IL_RBF
Size (Acres)	194
Listed For	**Phosphorus**, total suspended solids, aquatic algae
Use Support[1]	Aquatic life (F), fish consumption (X), primary contact (X), secondary contact (X), aesthetic quality (N)

[1]F=full support, P=partial support, N=nonsupport, X=not assessed

Stephen A. Forbes Lake	
Assessment Unit ID	IL_RCD
Size (Acres)	525
Listed For	**Phosphorus**, total suspended solids, aquatic algae
Use Support[1]	Aquatic life (F), fish consumption (F), primary contact (X), secondary contact (X), aesthetic quality (N)

[1]F=full support, P=partial support, N=nonsupport, X=not assessed

Wayne City Side Channel Reservoir	
Assessment Unit ID	IL_RCT
Size (Acres)	8
Listed For	**Manganese**, total suspended solids, aquatic algae
Use Support[1]	Aquatic life (F), fish consumption (X), public and food processing water supplies (N), primary contact (X), secondary contact (X), aesthetic quality (N)

[1]F=full support, P=partial support, N=nonsupport, X=not assessed

Potential sources contributing to the listing of these waterbodies on the 303(d) list are summarized in Table 2.

Table 2. Waterbody Impairment Causes and Sources

Waterbody	Cause of impairments	Potential Sources
Skillet Fork (IL_CA 03)		
	Fecal coliform	Municipal point sources, agricultural runoff, failing septic systems, intensive animal feeding operations
Sam Dale Lake (IL_RBF)		
	Phosphorus	Agricultural runoff, sediment phosphorus release during seasonal hypolimnetic anoxia, failing septic systems
Lake Stephen A. Forbes (IL_RCD)		
	Phosphorus	Agricultural runoff, sediment phosphorus release during seasonal hypolimnetic anoxia, failing septic systems
Wayne City SCR (IL_RCT)		
	Manganese	Natural background sources, sediment manganese release during seasonal hypolimnetic anoxia

EXISTING CONTROLS

The local Natural Resource Conservation Service (NRCS), Farm Service Agency (FSA), and Soil and Water Conservation District (SWCD) offices have information on existing best management practices within the watershed, and can be contacted to understand what efforts have been made or are planned to control nonpoint sources.

The Clean Lakes Study for Stephen A. Forbes Lake indicated that the Marion County SWCD has been involved in the implementation of several management practices within the Stephen A. Forbes lake watershed, including conservation tillage, vegetative filter strips, grassed waterways, grade control structures, and land use changes (IDOC, ca. 1993). Shoreline stabilization has also been implemented at four lakeside locations (IDOC, ca. 1993)

Prior to TMDL development, information on land uses and agricultural practices was obtained as part of the Watershed Characterization (LTI. 2005). Information on participation in the Conservation Reserve Program (CRP) was obtained through calls to county agencies. It was estimated that there are:

- 20,000-30,000 acres in Jefferson County in the CRP (Jefferson County NRCS);
- 13,000 acres in White County (White County FSA);
- 33,000 acres in Hamilton County in the CRP (Hamilton County FSA), with most of these located in the northwest part of the county;
- 50,000 acres in Wayne County in the CRP (Wayne Co. NRCS); and
- many CRP acres in Marion County, especially in the Skillet Fork watershed due to the poorer soils in the county (Marion County SWCD).

Note that these area estimates are for the entire county rather than the portion of the county that was in the Skillet Fork watershed. Watershed-specific estimates were not available.

IMPLEMENTATION APPROACH

The approach to be taken for TMDL development and implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps, with the first three steps corresponding to TMDL development and the latter two steps corresponding to implementation:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply relatively simple models (e.g. BATHTUB) to define the load-response relationship and define the maximum allowable pollutant load that the lakes can assimilate and still attain water quality standards.
3. Compare the maximum allowable load to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards.
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.

5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. The Association of Illinois Soil and Water Conservation Districts (SWCDs), using Section 319 grant funding, have made available a Watershed Liaison to provide educational, informational, and technical assistance to local agencies and communities. The liaison can assist in establishing local watershed planning groups, as well as acting as an overall facilitator for coordination between local, state, and Federal agencies.

The adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps One through Three described above have been completed, as described in the TMDL report (LTI, 2006). This plan represents Step Four of the process. Step Five is briefly described in the last section of this document, and will be conducted as implementation proceeds.

IMPLEMENTATION ALTERNATIVES

Based on the objectives for the TMDL, information obtained at the public meetings, and experience in other watersheds, a number of alternatives have been identified for the implementation phase of these TMDLs. These alternatives are focused on those sources suspected of contributing phosphorus loads to the lakes (agricultural sources, release from existing lake bottom sediments, and failing private sewage disposal systems) and fecal coliform loads to Skillet Fork (runoff from livestock operations, municipal point sources, and failing private sewage disposal systems).

For manganese, the primary source appears to be release from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. The lack of dissolved oxygen in lake bottom waters is presumed to be due primarily to sediment oxygen demand resulting from the effects of nutrient enrichment, as there are no significant point source discharges to the lake, nor were other significant sources of oxygen demanding materials identified in the watershed characterization prepared during the TMDL process (LTI, 2004). For this reason, release from in-place sediments is considered a controllable source, and the best management practices (BMPs) described to reduce phosphorus loads are expected to reduce manganese loadings from the sediments. BMPs designed to reduce erosion are expected to provide secondary benefits in reducing manganese, given that manganese concentrations in local soils are often elevated (LTI, 2005).

The implementation alternatives identified for this watershed include:

- Nutrient Management Plans
- Conservation Tillage
- Conservation Buffers
- Sediment Control Structures
- Streambank and Shoreline Enhancement and Protection
- Grassed Waterways
- Private Sewage Disposal System Inspection and Maintenance Program
- Aeration
- Dredging
- Phosphorus Inactivation
- Point Source Controls
- Restrict Livestock Access to Waterbodies

Each of these alternatives is described briefly in this section, including information about their costs and effectiveness in reducing loadings of the constituents of concern. Costs have been updated from their original sources, based on literature citations, to 2006 costs using the Engineering News Record Construction Cost Index, as provided by the Natural Resource Conservation Service (NRCS) (http://www.economics.nrcs.usda.gov/cost/priceindexes/index.html). Some of the measures described below are most applicable to a single pollutant, while others will have broader applicability. Table 3 summarizes the implementation alternatives and the pollutants which each is expected to reduce.

It should be noted that there is usually a wide range in the effectiveness of the various practices; this is largely due to variations in climate, soils, crops, topography, design, construction, and maintenance of the practices (NRCS, 2006). Establishing the effectiveness of alternatives for phosphorus reduction is complicated by the different forms in which phosphorus can be transported. Some practices are effective at reducing particulate phosphorus, but may exacerbate the transport of dissolved phosphorus, the more bioavailable form (NRCS, 2006).

Table 3. Applicability of Implementation Alternatives

Alternative	Fecal Coliform	Phosphorus	Manganese
Nutrient Management Plans	◆	◆	◆
Conservation Tillage		◆	◆
Conservation Buffers	◆	◆	◆
Sediment Control Structures		◆	◆
Streambank and Shoreline Enhancement and Protection	◆	◆	◆
Grassed Waterways		◆	◆
Aeration		◆	◆
Dredging		◆	◆
Phosphorus Inactivation		◆	◆
Private Sewage Disposal System Inspection and Maintenance Program	◆	◆	◆
Point Source Controls	◆		
Restrict Livestock Access to Waterbodies	◆	◆	

Nutrient Management

Nutrient management plans are designed to minimize nutrient losses from agricultural lands, and therefore minimize the amount of phosphorus transported to the lakes. Because agriculture is the most common land use in the watershed, controls focused on reducing phosphorus loads from these areas are expected to help reduce phosphorus loads delivered to the lake. The focus of a nutrient management plan is to increase the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface and ground waters (EPA, 2003). The majority of phosphorus lost from agricultural land is transported via surface runoff, mostly in particulate form attached to eroded soil particles, while nitrogen generally leaches through the soil. A nutrient management plan identifies the amount, source, time of application, and placement of each nutrient needed to produce each crop grown on each field each year, to optimize efficient use of all sources of nutrients (including soil reserves, commercial fertilizer, legume crops, and organic sources) and minimize the potential for losses that lead to degradation of soil and water quality (UIUC, 2005).

Steps in developing a nutrient management plan include (UIUC, 2005):

- Assess the natural nutrient sources (soil reserves and legume contributions).
- Identify fields or areas within fields that require special nutrient management precautions.
- Assess nutrient needs for each field by crop.
- Determine quantity of nutrients that will be available from organic sources, such as manure or industrial or municipal wastes.
- Allocate nutrients available from organic sources.
- Calculate the amount of commercial fertilizer needed for each field.

- Determine the ideal time and method of application.
- Select nutrient sources that will be most effective and convenient for the operation.

A Pennsylvania State University study on the relative effectiveness of nutrient management in controlling phosphorus indicated that total phosphorus loads can be reduced by 35% with nutrient management (EPA, 2003). Nutrient management is generally effective, but for phosphorus, most fertilizer is applied to the surface of the soil and is subject to transport (NRCS, 2006). In an extensively cropped watershed, the loss of even a small fraction of the fertilizer-applied phosphorus can have a significant impact on water quality. In addition to reducing nutrient loads, appropriate application of manure can reduce fecal coliform loads. This may be important in the Skillet Fork watershed, since livestock are present throughout the watershed and it is common practice to spread manure on the fields (LTI, 2004).

Costs of developing nutrient management plans have been estimated at $6 to $20/acre (EPA, 2003). These costs are often offset by the savings associated with using less fertilizer. For example, a study in Iowa showed that improved nutrient management on cornfields led to a savings of about $3.60/acre (EPA, 2003).

Conservation Tillage

The objective of conservation tillage is to provide profitable crop production while minimizing soil erosion (UIUC, 2005). This reduction in erosion also reduces the amount of nutrients, particularly phosphorus, lost from the land and delivered to the lake. The Natural Resources Conservation Service (NRCS) has replaced the term conservation tillage with the term crop residue management, or the year-round management of residue to maintain the level of cover needed for adequate control of erosion. This often requires more than 30% residue cover after planting (UIUC, 2005). Conservation tillage/crop residue management systems are recognized as cost-effective means of significantly reducing soil erosion and maintaining productivity. The most recent Illinois Soil Transect Survey (IDOA, 2004) suggests that approximately 77% of land under soybean production and 71% of the land in small grain production in the Skillet Fork watershed is farmed using reduced till, mulch till, or no-till, while approximately 52% of corn fields are farmed with conventional methods. Additional conservation tillage measures could be considered as part of this implementation plan, particularly for cornfields.

Conservation tillage practices have been reported to reduce total phosphorus loads by 45% (EPA, 2003). In general, conservation tillage and no-till practices are moderate to highly effective at reducing particulate phosphorus, but exhibit low or even negative effectiveness in reducing dissolved phosphorus (NRCS, 2006). A wide range of costs has been reported for conservation tillage practices, ranging from $12/acre to $83/acre in capital costs (EPA, 2003). For no-till, costs per acre provided in the Illinois Agronomy Handbook for machinery and labor range from $36 to $66 per acre, depending on the farm size and planting methods used (UIUC, 2005). In general, the total cost per acre for machinery and labor decreases as the amount of tillage decreases and farm size increases (UIUC, 2005).

Conservation Buffers

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants (NRCS, 1999), generally by slowing the rate of runoff, while filtering sediment and nutrients. Additional benefits may include the creation of wildlife habitat, improved aesthetics, and potential economic benefits from marketing specialty forest crops (Trees Forever, 2005). This category of controls includes buffer strips, field borders, filter strips, vegetative barriers, riparian buffers, etc. (NRCS, 1999).

Filter strips and similar vegetative control methods can be very effective in reducing nutrient transport. The relative gross effectiveness of filter strips in reducing total phosphorus has been reported as 75% (EPA, 2003). Reduction of particulate phosphorus is moderate to high, while effectiveness for dissolved phosphorus is low to negative (NRCS, 2006). Vegetated filter strips and riparian buffers can also be used to reduce bacteria; riparian buffer zones have bacteria removal efficiencies of 43-57% (Commonwealth of Virginia, 2003).

Costs of conservation buffers vary from about $200/acre for filter strips of introduced grasses or direct seeding of riparian buffers, to approximately $360/acre for filter strips of native grasses or planting bare root riparian buffers, to more than $1,030/acre for riparian buffers using bare root stock shrubs (NRCS, 2005).

The Conservation Practices Cost-Share Program (CPP), part of the Illinois Conservation 2000 Program, provides cost sharing for conservation practices including field borders and filter strips (http://www.agr.state.il.us/Environment/conserv/index.html). The Department of Agriculture distributes funding for the cost-share program to Illinois' soil and water conservation districts (SWCDs), which prioritize and select projects. The Illinois Buffer Partnership offers cost sharing for installation of streamside buffer plantings at selected sites. An additional program that may be of interest is the Visual Investments to Enhance Watersheds (VIEW), which involves a landscape design consultant in the assessment and design of targeted BMPs within a watershed. Sponsored by Trees Forever (www.treesforever.org), VIEW guides a committee of local stakeholders through a watershed landscape planning process (Trees Forever, 2005). Additional funding for conservation buffers may be available through other sources such as the Conservation Reserve Program.

Sediment Control Basins

Sediment control basins trap sediments (and nutrients bound to that sediment) before they reach surface waters (EPA, 2003). Basins could be installed throughout the watershed, in areas selected to minimize disruption to existing croplands. In addition to controlling sediment, these basins would reduce phosphorus loads to the lakes. Costs for these basins can vary widely depending on location and size; estimates prepared for another Illinois watershed range from $1,200 to more than $200,000 per basin (Zahniser Institute, undated). This same study estimated a trapping efficiency for sediment of 75%. The Clean Lake Study for Stephen A. Forbes Lake (IDOC, ca. 1993) discussed installation of an in-lake sedimentation basin in the upper end of the main tributary, Lost Fork, but this alternative was discarded due to concerns about upstream flooding problems and road access issues, as well as the cost.

Implementation of storm water wetlands at various locations in the watershed may be feasible where hydric soils exist, but where wetland, forest or development does not currently exist. This is discussed in more detail in the section "Identifying Priority Areas for Control." These wetlands would trap sediments and nutrients; a study prepared for another Illinois watershed provides an estimated phosphorus removal rate of 45% (Zahniser Institute, undated). Wetlands generally have low to moderate effectiveness at reducing particulate phosphorus, and low to negative effectiveness at reducing dissolved phosphorus (NRCS, 2006).

Streambank and Shoreline Enhancement and Protection

Erosion of the banks and beds of tributary streams is a potentially significant source of sediment to the waterbodies in the Skillet Fork Watershed. This sediment load not only leads to sedimentation in the lakes, but also contributes to phosphorus loading. It can also increase fecal coliform loadings. Streambank stabilization (including grade stabilization to reduce erosive velocities and shear stresses) is a key measure in reducing loads.

A recent aerial assessment report of Skillet Fork noted extensive channelization, severely incised channels, and geotechnical problems throughout Skillet Fork (IDOA, 2005). This study recommends additional study in the downstream areas (approximately 5 miles in length), and grade control structures and bank stabilization practices, including rock riffle grade controls and stone toe protection, in the remainder of the stream. Using costs presented in the report, the estimated cost to stabilize the segments described is approximately $14 million

Because of the potential cost of stabilizing streambanks throughout the watershed, additional study is recommended to prioritize sites for streambank stabilization. Such study should include direct observations of bank conditions, as well as an assessment of stream hydraulics and geomorphology to support identification and design of effective stabilization measures.

For the lakes, shoreline enhancement efforts, such as planting deep-rooted vegetation or installing rip-rap in unprotected shoreline areas, can provide protection against erosion and the associated increased pollutant loads. Streambank protection and stabilization can reduce both nutrient and bacteria loads by 40% (Commonwealth of Virginia, 2003). Estimates for rip-rapping are approximately $67-$73/ton (NRCS, 2005), while estimates for plantings at another Illinois lake suggest a cost of approximately $5/linear foot (CMT, 2004). Costs for shoreline stabilization in Stephen A. Forbes Lake have been estimated at $642,700 (IDOC, ca. 1993).

Grassed Waterways

Grassed waterways are another alternative to consider for this watershed. A grassed waterway is a natural or constructed channel that is planted with suitable vegetation to reduce erosion (NRCS, 2000). Grassed waterways are used to convey runoff without causing erosion or flooding, to reduce gully erosion, and to improve water quality. They may be used in combination with filter strips, and are effective at reducing soil loss, with typical reductions between 60 and 80 percent (Lin et al, 1999). Grassed waterways cost approximately $1,800/acre, not including costs for tile or seeding (MCSWCD, 2006).

Aeration

As noted in the TMDL report (LTI, 2006), the existing sediments are a significant source of both phosphorus (Sam Dale Lake and Stephen A. Forbes Lake) and manganese (Wayne City SCR). When dissolved oxygen is absent in the hypolimnion (deep layer) of the lakes, phosphorus and manganese are released from the sediments. Control of this internal load requires either removal of phosphorus (and manganese) from the lake bottom (such as through dredging), or preventing oxygen-deficient conditions from occurring. Aeration of portions of the lakes might be considered as an alternative to increase mixing and improve oxygen levels. Destratifiers have also been installed in other Illinois lakes to prevent thermal stratification, and thus increase oxygen concentrations in the deeper lake waters. Studies have indicated that such systems can significantly improve water quality (Raman et. al, 1998). A destratification system installed in Lake Evergreen in McLean County, a lake larger (754 acres) than either Sam Dale Lake (194 acres) or Stephen A. Forbes Lake (525 acres), was effective in improving dissolved oxygen levels throughout the lake, up to the depth of its operation (Raman et al, 1998). The destratifier used on Lake Evergreen cost approximately $72,000 (Raman et al, 1998). It should, however, be noted that artificial circulation/aeration for Stephen A. Forbes Lake was discarded as an alternative in a prior study, because the size and shape of the lake make artificial circulation difficult and expensive to successfully implement (IDOC, ca. 1993).

With regard to manganese in the Wayne City SCR, aeration in either the reservoir or its tributaries may reduce manganese concentrations. In the tributaries, instream energy dissipation via rock weirs or rock riffles could be used. An aerator could also be installed in the reservoir. In either case, manganese in the water column would be oxidized and precipitate from the water column. However, given that the manganese impairment is for the public water supply use, it would likely be more cost efficient to consider treatment of the public water supply, rather than the entire lake. It is important to note that the water quality standard is designed to prevent offensive tastes and appearances in drinking water, as well as staining laundry and fixtures. Manganese in water does not present a human health hazard.

Dredging

As noted in the TMDL report (LTI, 2006), in-place sediments are a significant source of phosphorus in Sam Dale and Stephen A. Forbes Lakes, and of manganese in the Wayne City SCR. Control of these internal loads requires removal of phosphorus and manganese from the lake bottoms, such as through dredging. Dredging of the existing sediments is, however, an expensive alternative, and would be only a temporary solution; if phosphorus (and manganese) loads are not reduced in the watershed, it is likely that the flux of these elements from the sediments will continue to be a problem in the future. Hydraulic dredging of 250,000 cubic yards of sediment from Stephen A. Forbes Lake has been estimated at $1.4 million (IDOC, ca. 1993).

Phosphorus Inactivation

Phosphorus inactivation involves application of aluminum salts or calcium compounds to the lake to reduce phosphorus in the water column and slow its release from sediments

(McComas, 1993). This can be an effective means of mitigating excess phosphorus in lakes and reservoirs (NALMS, 2004). Addition of aluminum sulfate (alum) is most common, but compounds such as calcium carbonate and calcium hydroxide (lime) can also be used (McComas, 1993). When alum is added to lake water, a series of chemical hydrolysis steps leads to the formation of a solid precipitate that has a high capacity to absorb phosphates. This flocculent material settles to the lake bottom, removing the phosphorus from the water column and providing a barrier that retards release of phosphorus from the sediments (NALMS, 2004). Aluminum concentrations in lake water are usually at acceptable levels for drinking water shortly after alum application (NALMS, 2004).

This alternative is best used in combination with a reduction in phosphorus inputs from watershed sources. If the external phosphorus load is being addressed, and most of the phosphorus comes from in-place sediments, a single dose treatment will likely be sufficient (Sweetwater, 2006). If watershed sources are not controlled, repeated treatments will be needed. Often, it is possible to do repeat dosing over several years, giving a partial dose every three to five years (Sweetwater, 2006). Phosphorus inactivation has been used in lakes of similar size to Sam Dale and Stephen A. Forbes, with an average reduction in total phosphorus on the order of 30 to 60%, lasting for approximately five to eight years (Cooke et al, 2005). Costs for phosphorus inactivation are approximately $1,000 to $1,300 per acre (Sweetwater, 2006). This translates to a cost of $194,000 to $252,200 for Sam Dale Lake, and $525,000 to $682,500 for Stephen A. Forbes Lake. This alternative is recommended only in concert with watershed load reductions.

Private Sewage Disposal System Inspection and Maintenance Program

All county health departments serving the Skillet Fork watershed were contacted during the early stages of the TMDL project (LTI, 2005). Based on calls made to the county health departments, it was determined that most of the urbanized areas are served by public sewer, with areas outside municipal boundaries served primarily by private septic systems. None of the county health officials contacted were able to estimate the percent of septic systems that are failing, and many noted that they only inspect a system if a complaint is made about it. Very few complaints (1-2 per year at most) have been received by the health departments. Several county health departments (Marion, Jefferson/Wayne, and Egyptian (White)) mentioned that there might be straight pipes in the watershed; however, none had an estimate of how many were in existence.

IEPA is developing a permitting program for individual private sewage disposal systems. The proposed general permit is intended to minimize discharges to the ground surface and receiving waters, and includes requirements designed to protect surface waters (IEPA, 2006).

A more proactive program to maintain functioning systems and address nonfunctioning systems could be developed to minimize the potential for releases from private sewage disposal systems. The U.S. EPA has developed guidance for managing private sewage disposal systems (EPA, 2005). This guidance includes procedures for assessing existing conditions, assessing public health and environmental risks, selecting a management approach, and implementing a management program (including funding information).

This alternative would require the commitment of staff time for County Health Department personnel; cost depends on whether the additional inspection activities could be accomplished by existing staff or would require additional personnel.

Point Source Controls

There are fourteen sewage treatment operations (STPs) expected to discharge fecal coliform in the watershed upstream of the Segment CA 03 sampling stations (LTI, 2006). Only two of these STPs have a permit limit specified for fecal coliform but all are potential sources. The twelve facilities without fecal coliform limitations currently have disinfection exemptions, and are not required to remove fecal coliform from their effluent.. IEPA will examine disinfection exemptions as part of TMDL implementation. IEPA intends to remove disinfection exemptions for point sources discharging directly to impaired waterbodies, and will require point sources discharging upstream of impaired segments to demonstrate that their discharge has no reasonable potential to exceed water quality standards in applicable stream reaches. IEPA will evaluate the need for additional point source controls through the NPDES permitting program; permits might need to be modified to ensure consistency with the WLA.

Restrict Livestock Access to Lake and Tributaries

Livestock are a source of bacteria, and are present within the Skillet Fork watershed (LTI, 2004). The 2002 Census of Agriculture (USDA, 2002) indicates there are several thousand livestock head in the counties comprising the Skillet Fork watershed, including in the vicinity of this segment of Skillet Fork and upstream in the watershed. Several hog confined animal feeding operations (CAFOs) are located in White County (LTI, 2004). Telephone calls to local agencies suggested that most cattle within the watershed might be free range, with perhaps one-third or fewer fenced away from local waterbodies.

One recommended component of TMDL implementation would be to restrict livestock access to the creek. This could be accomplished by fencing and installation of alternative systems for livestock watering. Livestock exclusion and other grazing management measures have been shown to reduce phosphorus loads on the order of 49%, and fecal coliform counts by 29-46% (EPA, 2003). The principal direct costs of providing grazing practices vary from relatively low variable costs of dispersed salt blocks to higher capital and maintenance costs of supplementary water supply improvements. Improving the distribution of grazing pressure by developing a planned grazing system or strategically locating water troughs, salt, or feeding areas to draw cattle away from riparian zones can result in improved utilization of existing forage, better water quality, and improved riparian habitat. Fencing costs are estimated as $3,500 to $4,000 per mile (USEPA, 2003). Capital costs for pipeline watering range from $0.32 to $2.60 per foot, while watering tanks and troughs range from $291 to $1,625 each (EPA, 2003).

IDENTIFYING PRIORITY AREAS FOR CONTROLS

Priority areas for locating controls were identified through a review of available information. Information reviewed included: tributary water quality data; an aerial assessment report; and GIS-based information. Based on this review, it is recommended that streambank stabilization be initiated in the Skillet Fork watershed to reduce bank erosion, and that this work occur concurrently with watershed controls in priority areas. Additional data collection is also recommended, to help focus control efforts.

Tributary Monitoring

Available water quality data obtained as part of the Stage 1 Watershed Characterization work were reviewed and little tributary monitoring data was identified. Additional data collection is therefore recommended to help understand where loads are being generated in the watershed and focus control efforts. Specific data collection recommendations are provided in the Monitoring and Adaptive Management section later in this Implementation Plan.

Aerial Assessment Report

A recent aerial assessment report of Skillet Fork noted extensive channelization, severely incised channels, and geotechnical problems throughout Skillet Fork (IDOA, 2005). This study recommends additional study in the downstream areas (approximately 5 miles in length), and grade control structures and bank stabilization practices, including rock riffle grade controls and stone toe protection, in the remainder of the stream. Using costs presented in the report, the estimated cost to stabilize the segments described is approximately $14 million

Because of the potential cost of stabilizing streambanks throughout the watershed, additional study is recommended to prioritize sites for streambank stabilization. Such study should include direct observations of bank conditions, as well as an assessment of stream hydraulics and geomorphology to support identification and design of effective stabilization measures.

GIS Analysis

GIS soils, land use and topography data were analyzed to identify areas that are expected to generate the highest sediment and associated pollutant loads. This analysis is most applicable to the watershed of the three lakes; it is less applicable for the control of fecal coliform to Skillet Fork.

Within the GIS, maps were generated to show areas with steep slopes (Figure 2), highly erodible soils (Figure 3), and finally, priority areas for best management practices (BMPs). Priority areas are defined as agricultural areas that have both steep slopes and highly erodible soils (Figure 4). These maps serve as a good starting point for selecting areas to target for implementing control projects, to maximize the benefit of the controls. Other locations that should be investigated for control projects are those that have either erodible soils or steep slopes, because both of these characteristics make soil more prone to erosion.

GIS analysis was also used to investigate the presence of hydric soils in each lake's watershed to determine whether wetland restoration or creation is a viable option within this watershed. To support this analysis, areas having hydric soils, which are not already developed, forested, or covered by water or wetlands were identified. A significant proportion (37%) of the Stephen A. Forbes Lake watershed and the Sam Dale Lake watershed (18%) was identified as being potentially suitable for wetland restoration or creation. Although data on hydric soils were not available for all counties, using available data it was determined that at least 15% of the soils in the Skillet Fork/Wayne City Side Channel Reservoir watershed are potentially suitable for wetland restoration or creation. These areas are shown in Figure 5.

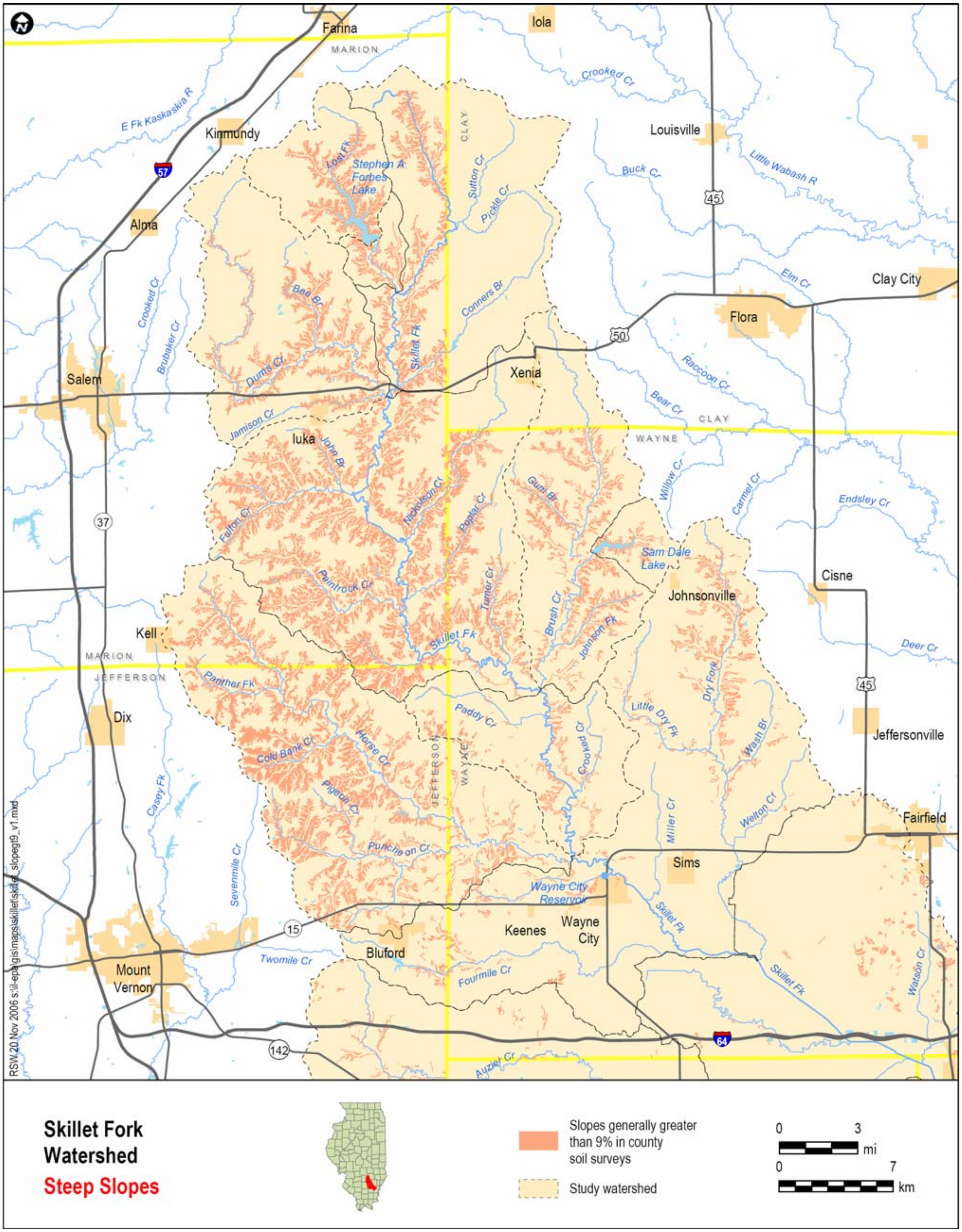

Figure 2. Areas with Steep Slopes

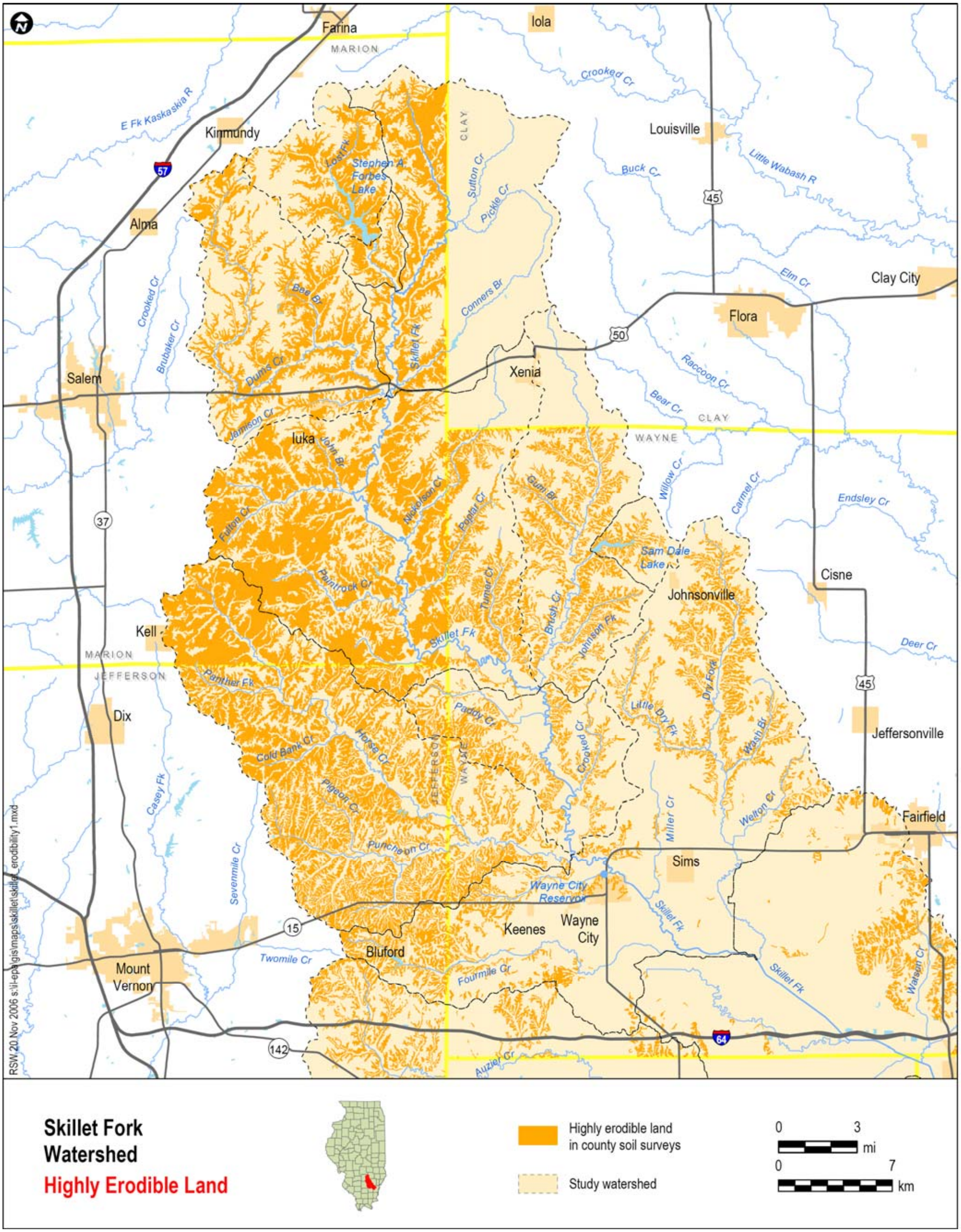

Figure 3. Areas of Highly Erodible Land

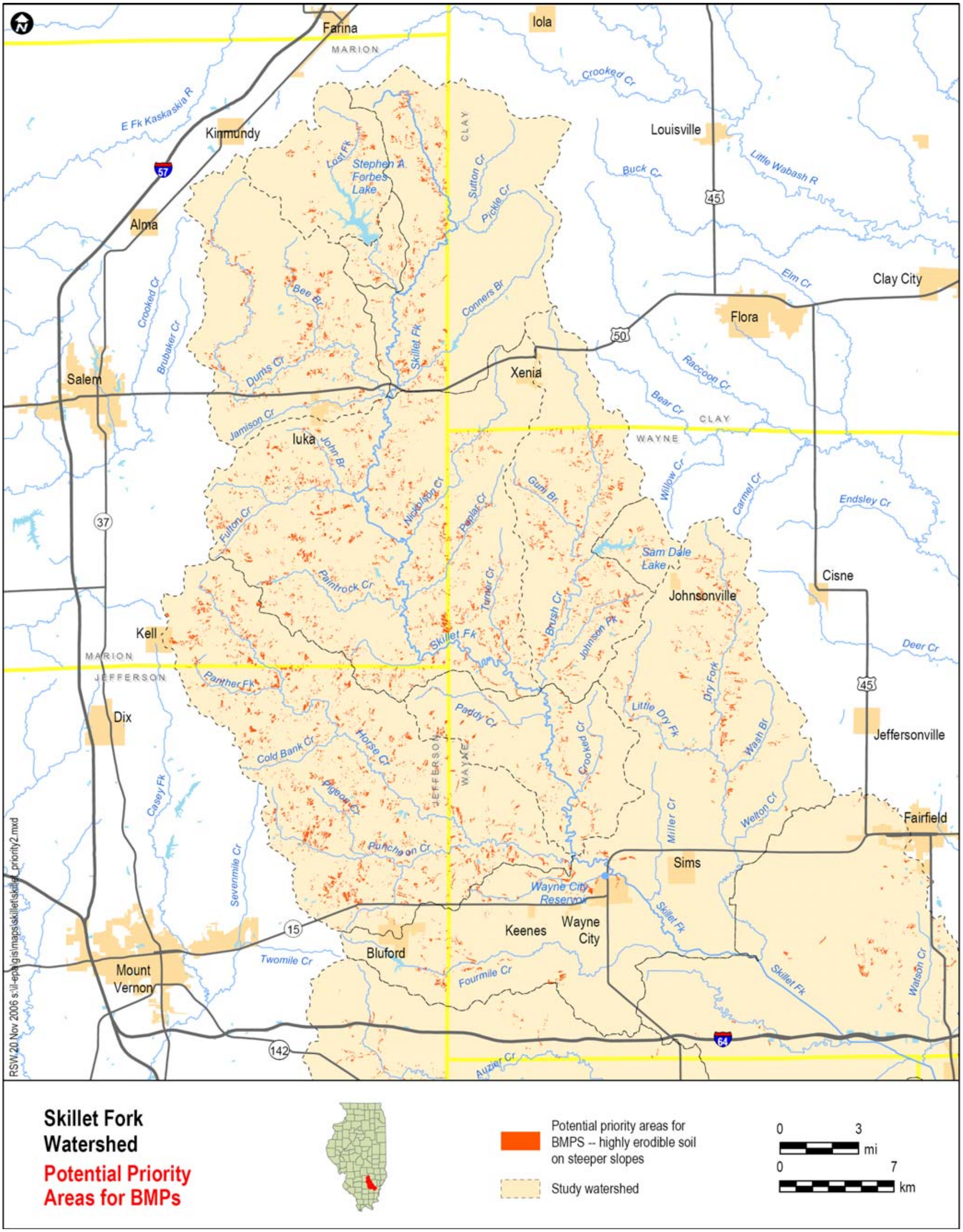

Figure 4. Potential Priority Areas for BMPs

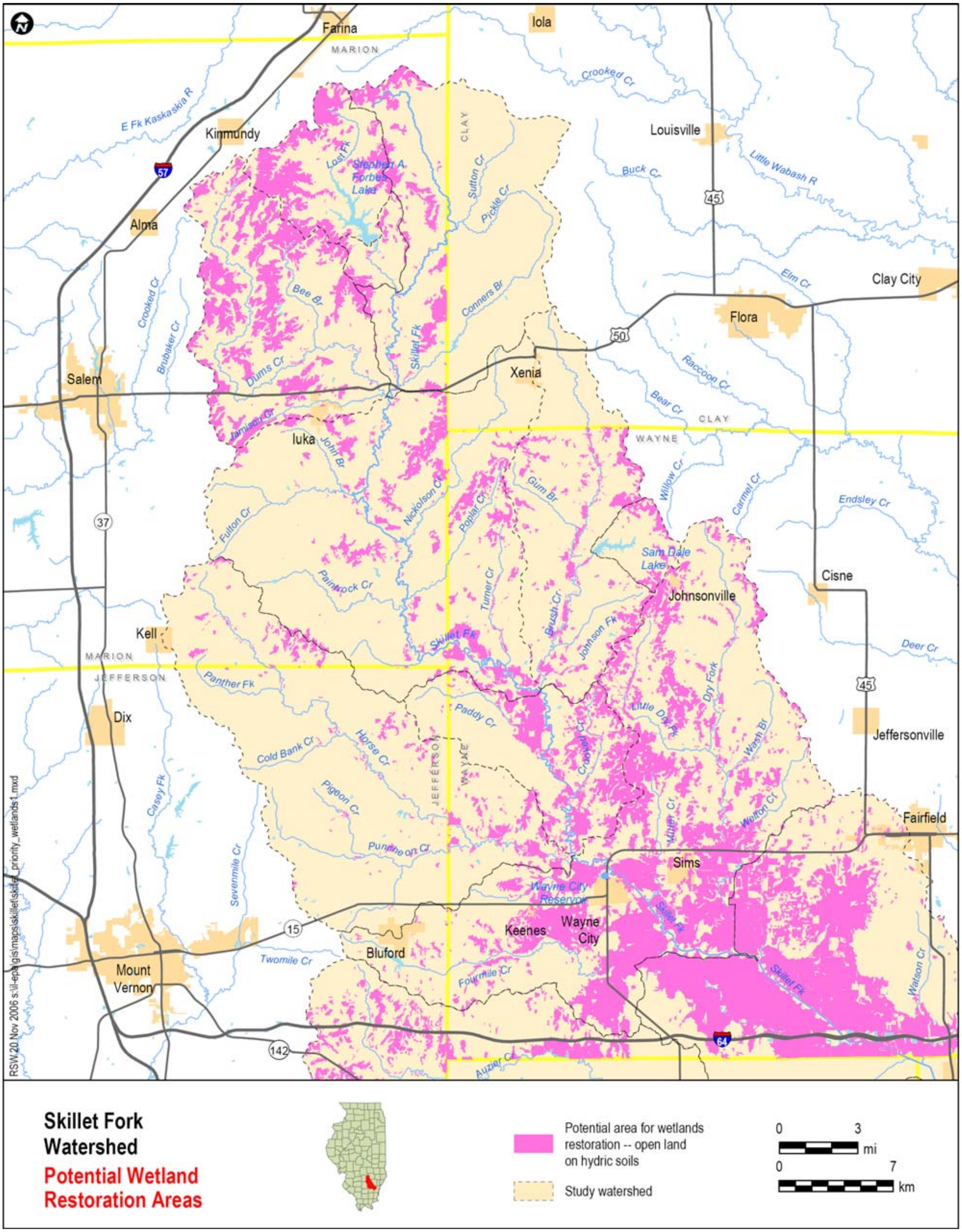

Figure 5. Potential Wetland Restoration Areas

REASONABLE ASSURANCE

The U.S. EPA requires states to provide reasonable assurance that the load reductions identified in the TMDL will be met. Reasonable assurance for point sources means that NPDES permits will be consistent with any applicable wasteload allocation contained in the TMDL. In terms of reasonable assurance for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permits for the point source dischargers in the watershed will be modified if necessary to ensure they are consistent with the applicable wasteload allocations presented in the TMDL. Permit information for these facilities is summarized in Table 4.

Table 4. Permitted Dischargers

NPDES ID	Facility Name	Disinfection exemption?	Average design flow (MGD)	Permit expiration date
IL0024643	Beaver Creek School STP	Year-round since 1994	0.0125	9-30-10
IL0046957	Bluford STP	Year-round since 1989	0.06	12-31-10
IL0054496	Springerton STP	Year-round since 2002	0.02	11-30-07
IL0068977	IL DNR-Stephen Forbes State Park Shower Bldg STP	No	0.004	7-31-10
IL0073903	IL DNR Stephen Forbes State Park Concession Bldg.	No	0.006	8-31-10
ILG580029	Xenia STP	Year-round since 1990	0.055	12-31-07
ILG580080	Dahlgren STP	Year-round since 1991	0.05	12-31-07
ILG580105	Enfield West STP	Year-round since 1990	0.025	12-31-07
ILG580108	Enfield East STP	Year-round since 1990	0.05	12-31-07
ILG580129	Belle Rive STP	Year-round since 1989	0.048	12-31-07
ILG580146	Iuka STP	Year-round since 1993	0.043	12-31-07
ILG580195	Mill Shoals STP	Year-round since 1989	0.0382	12-31-07
ILG580220	Wayne City South STP	Year-round since 1994	0.19	12-31-07
IL0068829	IL DOT-I64 Jefferson Co West STD (Goshen Rd West Rest Area)	Year-round since 2001	0.006	2-28-09

For nonpoint sources, reasonable assurance means that nonpoint source controls are specific to the pollutant of concern, implemented according to an expeditious schedule and supported by reliable delivery mechanisms and adequate funding (U.S. EPA, 1999).

One of the most important aspects of implementing nonpoint source controls is obtaining adequate funding to implement voluntary or incentive-based programs. Funding is available from a variety of sources, including the following:

- *Illinois Nutrient Management Planning Program*, cosponsored by the Illinois Department of Agriculture (IDOA) and IEPA (http://www.agr.state.il.us/Environment/LandWater/tmdl.html). This program targets funding to Soil and Water Conservation Districts (SWCDs) for use in impaired waters. The nutrient management plan practice cost share is only available to landowners/operators with land in TMDL watersheds. The dollar amount allocated to each eligible SWCD is based on their portion of the total number of cropland acres in eligible watersheds.
- *Clean Water Act Section 319 grants* to address nonpoint source pollution (http://www.epa.state.il.us/water/financial-assistance/non-point.html). Section 319 of the Clean Water Act provides Federal funding for states for the implementation of approved nonpoint source (NPS) management programs. Funding under these grants has been used in Illinois to finance projects that demonstrate cost-effective solutions to NPS problems. Projects must address water quality issues relating directly to NPS pollution. Funds can be used for the implementation of watershed management plans, including the development of information/education programs, and for the installation of best management practices.
- *Conservation 2000* (http://www.epa.state.il.us/water/conservation-2000/), which funds nine programs across three state natural resource agencies (IEPA, IDOA, and the Department of Natural Resources). Conservation 2000 is a six-year, $100 million initiative designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water resources while providing additional high-quality opportunities for outdoor recreation. This program includes the Priority Lake and Watershed Implementation Program and the Clean Lakes Program.
- *Conservation Practices Cost-Share Program*. Another component of Conservation 2000, the Conservation Practices Program (CPP) focuses on conservation practices, such as terraces, filter strips and grass waterways, that are aimed at reducing soil loss on Illinois cropland to tolerable levels. IDOA distributes funding for the cost-share program to Illinois' SWCDs, which prioritize and select projects. Construction costs are divided between the state and landowners.
- *Conservation Reserve Program* administered by the Farm Service Agency (http://www.nrcs.usda.gov/programs/crp/). The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on

their lands in an environmentally beneficial and cost-effective manner. CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation.

- *Wetlands Reserve Program* (http://www.nrcs.usda.gov/programs/wrp/). NRCS's Wetlands Reserve Program (WRP) is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The NRCS provides technical and financial support to help landowners with their wetland restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection. Figure 5 shows potential wetland restoration areas. These are areas with hydric soils that are not currently developed, covered by water, or forested.
- *Environmental Quality Incentive Program* sponsored by NRCS (general information at http://www.nrcs.usda.gov/PROGRAMS/EQIP/; Illinois information and materials at http://www.il.nrcs.usda.gov/programs/eqip/). The Environmental Quality Incentives Program (EQIP) provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical assistance to eligible participants to install or implement structural and management practices on eligible agricultural land. EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive.
- *Wildlife Habitat Incentives Program* (WHIP) (http://www.il.nrcs.usda.gov/programs/whip/index.html). WHIP is a NRCS program for developing and improving wildlife habitat, primarily on private lands. It provides both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat.
- *Funding for Private Sewage Systems.* EPA guidance (2005) indicates that funding might be available through programs such as the USDA Rural Utilities Service. (http://www.epa.gov/owm/septic/pubs/onsite_handbook.pdf)

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability
- Use the results of future monitoring to conduct adaptive management.

MONITORING AND ADAPTIVE MANAGEMENT

Future monitoring is needed to assess the effectiveness of the various restoration alternatives and to conduct adaptive management. The Illinois EPA conducts a variety of lake and stream monitoring programs (IEPA, 2002). Ongoing stream monitoring programs include: a statewide 213-station Ambient Water Quality Monitoring Network (AWQMN); an Intensive Basin Survey Program that covers all major watersheds on a five-year rotation basis; and a Facility-Related Stream Survey Program that conducts approximately 20-30 stream surveys each year. Skillet Fork is monitored at three locations (near Carmi, Wayne City, and Iuka) as part of the AWQMN, and is on the Intensive Basin Survey list for 2006 monitoring. The ongoing Illinois EPA Lake Monitoring Program includes: an Ambient Lake Monitoring Program that samples approximately 50 lakes annually; an Illinois Clean Lakes Program that typically monitors three to five projects each year; and a Volunteer Lake Monitoring Program that encompasses over 170 lakes each year. Sam Dale Lake is considered a "core" lake and is monitored approximately every three years. Beyond this IEPA monitoring, local agencies and watershed organizations are encouraged to conduct additional monitoring to assess sources of pollutants and evaluate changes in water quality in the lake.

In particular, the following monitoring is recommended:

- Monitoring for phosphorus in major tributaries upstream of Sam Dale Lake and Stephen A. Forbes Lake, to better understand where loads are being generated in the watershed, and monitor improvements in water quality as controls are implemented. This monitoring should be conducted during both wet and dry weather.
- Monitoring for manganese and phosphorus in Skillet Fork near the point where water is diverted to Wayne City Side Channel Reservoir (Skillet Fork at Illinois Route 15), to assess water quality entering the reservoir. Monitoring for manganese within Wayne City Side Channel Reservoir can be used to assess water quality over time and evaluate the effectiveness of watershed controls.
- Fecal coliform monitoring in Skillet Fork and major tributaries. This monitoring should be conducted primarily during wet weather because that is when elevated fecal coliform concentrations have been observed. Sites should be selected to include locations downstream of potential fecal coliform loads, such as livestock operations or areas that have higher concentrations of septic systems. Suggested locations for initial monitoring include three tributaries that drain directly to segment CA 03:
    - Sevenmile Creek at Co. Rd. 750E (N. of Co. Road 1800N)
    - Limekiln Creek at Co. Rd. 2000N
    - Wilson Creek near confluence with Skillet Fork
- Monitoring is also recommended at two locations within the listed segment:
    - Skillet Fork at Co. Rd. 800E – to assess Skillet Fork water quality from upstream portions of the watershed

- o Skillet Fork at Co. Hwy 1/Co. Rd. 1125E/1150E – to assess spatial trends in fecal concentrations in Skillet Fork.

The results of this monitoring will help guide future monitoring and implementation efforts. For example, if elevated fecal coliform concentrations are found in the tributaries, and not at the upstream end of segment CA 03, then implementation efforts should be focused in the tributary watersheds. If elevated fecal coliform concentrations are observed at the upstream end of the listed Skillet Fork segment (Skillet Fork at Co. Rd. 800E), then additional monitoring and implementation efforts should be focused on upstream areas of the watershed.

If elevated fecal coliform concentrations are observed during dry weather, then dry weather monitoring at additional upstream Skillet Fork locations is recommended. Sampling at bridge crossings progressively moving upstream from segment CA 03 will provide insight on spatial trends in fecal concentrations and will help identify stream reaches that are receiving significant fecal loads.

Dry weather fecal coliform monitoring is also recommended in Skillet Fork and tributaries upstream and downstream of the STP outfalls listed in Table 4, especially those located closer to segment CA 03. This monitoring will help assess the contributions of these sources to the fecal coliform impairment.

These activities will provide additional information to identify or confirm potential sources of the pollutants of concern, and assist in targeting implementation efforts.

Continued monitoring efforts will provide the basis for assessment of the effectiveness of the TMDLs, as well as future adaptive management decisions. As various alternatives are implemented, the monitoring will determine their effectiveness and identify which alternatives should be expanded, and which require adjustments to meet the TMDL goals.

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FINAL Approved TMDL
Skillet Fork Watershed

Prepared for: **Illinois Environmental Protection Agency**

August 2007

Brush Creek (IL_CAR-01): Manganese, Dissolved oxygen

Dums Creek (IL_CAW-04): Dissolved oxygen

Horse Creek (IL_CAN-01): Manganese, Dissolved oxygen

Skillet Fork (IL_CA-03): Manganese, Dissolved oxygen, pH

Skillet Fork (IL_CA-05): Fecal coliform, Manganese, Dissolved oxygen, pH

Skillet Fork (IL_CA-06): Fecal coliform, Manganese, Dissolved oxygen, pH

Skillet Fork (IL_CA-09): Dissolved oxygen

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INTRODUCTION

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the 2006 303(d) list, which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

Skillet Fork (IL_CA-03, IL_CA-05, IL_CA-06, IL_CA-09), Brush Creek (IL_CAR-01), Dums Creek (IL_CAW-04) and Horse Creek (IL_CAN-01) are listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as waterbodies that are not meeting their designated uses. As such, they have been targeted as high priority waterbodies for TMDL development. This document presents the TMDLs designed to allow these waterbodies to fully support their designated uses. The report covers each step of the TMDL process and is organized as follows:

- Problem Identification
- Required TMDL Elements
- Watershed Characterization
- Description of Applicable Standards and Numeric Targets
- Development of Water Quality Model
- TMDL Development
- Public Participation and Involvement
- Implementation Plan

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1. PROBLEM IDENTIFICATION

The impairments in waters of the Skillet Fork Watershed addressed in this report are summarized below, with the parameters (causes) that they are listed for, and the impairment status of each designated use, as identified in the 303(d) list (IEPA, 2006). This report includes fecal coliform, manganese and pH TMDLs for segments of Skillet Fork; and manganese TMDLs for Brush Creek and Horse Creek. Dissolved oxygen assessments were conducted for Skillet Fork, Brush Creek, Dums Creek and Horse Creek and it was determined that the low dissolved was due to low flow. The pollutants addressed in this TMDL are indicated in the table below. Pollutants with numeric water quality standards are in bold. A fecal coliform TMDL for Skillet Fork segment IL_CA-03 has been previously approved by US EPA Region 5 in a separate report. While TMDLs are currently only being developed for pollutants that have numerical water quality standards, many controls that are implemented to address TMDLs for manganese will reduce other pollutants as well. As discussed in the Stage 1 Report, the source of manganese is due to sediment running off the fields and entering the river. These sediments are also the cause of sedimentation/siltation, TSS, and phosphorus impairments in Skillet Fork, Brush Creek, and Horse Creek and the phosphorus impairment in Skillet Fork. Therefore, as discussed in the implementation plan, the sediment reductions needed to achieve the manganese allocations will also result in eliminating the impairments due to total phosphorus, total suspended solids, and sedimentation/siltation in Skillet Fork, Brush Creek, and Horse Creek.

Skillet Fork	
Assessment Unit ID	IL_CA-03
Length (miles)	7.2
Listed For	Fecal coliform, **manganese, pH, dissolved oxygen**, total suspended solids, sedimentation/siltation, total phosphorus, PCBs, alteration in stream-side or littoral vegetative covers
Use Support[1]	Aquatic life (N), fish consumption (N), primary contact (N), secondary contact (X), aesthetic quality (X)

[1]F=full support, N=nonsupport, X=not assessed

Skillet Fork	
Assessment Unit ID	IL_CA-05
Length (miles)	10.96
Listed For	**Fecal coliform, manganese, pH, dissolved oxygen**, total suspended solids, sedimentation/siltation, PCBs, alteration in stream-side or littoral vegetative covers
Use Support[1]	Aquatic life (N), fish consumption (N), public and food processing water supply (N), primary contact (N), secondary contact (X), aesthetic quality (X)

[1]F=full support, N=nonsupport, X=not assessed

Skillet Fork	
Assessment Unit ID	IL_CA-06
Length (miles)	16.63
Listed For	**Fecal coliform, manganese, pH, dissolved oxygen**, total suspended solids, sedimentation/siltation, PCBs
Use Support[1]	Aquatic life (N), fish consumption (N), primary contact (N), secondary contact (X), aesthetic quality (X)

[1]F=full support, N=nonsupport, X=not assessed

Skillet Fork	
Assessment Unit ID	IL_CA-09
Length (miles)	19.78
Listed For	**Dissolved oxygen**, PCBs
Use Support[1]	Aquatic life (N), fish consumption (N), primary contact (X), secondary contact (X), aesthetic quality (X)

[1]F=full support, N=nonsupport, X=not assessed

Brush Creek	
Assessment Unit ID	IL_CAR-01
Length (miles)	21.27
Listed For	**Manganese, dissolved oxygen**
Use Support[1]	Aquatic life (N), fish consumption (X), primary contact (X), secondary contact (X), aesthetic quality (X)

[1]F=full support, P=partial support, N=nonsupport, X=not assessed

Dums Creek	
Assessment Unit ID	IL_CAW-04
Length (miles)	25.39
Listed For	**Dissolved oxygen**
Use Support[1]	Aquatic life (N), fish consumption (X), primary contact (X), secondary contact (X), aesthetic quality (X)

[1]F=full support, N=nonsupport, X=not assessed

Horse Creek	
Assessment Unit ID	IL_CAN-01
Length (miles)	28.22
Listed For	**Manganese, dissolved oxygen**
Use Support[1]	Aquatic life (N), fish consumption (F), primary contact (X), secondary contact (X), aesthetic quality (X)

[1]F=full support, N=nonsupport, X=not assessed

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2. REQUIRED TMDL ELEMENTS

USEPA Region 5 guidance for TMDL development requires TMDLs to contain eleven specific components. Each of those components is summarized below, by waterbody.

Skillet Fork (IL_CA-03)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Skillet Fork, HUC 0512011506. The pollutants of concern addressed in this TMDL are **manganese, pH and dissolved oxygen**. Potential sources contributing to the manganese impairment include soils naturally enriched in manganese. Naturally acidic soils and permitted dischargers are potential sources contributing to the pH impairment. Low flow has been identified as the source of low instream dissolved oxygen. Skillet Fork is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Illinois EPA has prioritized listed waterbodies on a watershed basis. This segment has a high priority rating because it is located within a watershed that contains one or more waterbodies that are less than full support for *public and food processing water supply* use.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:**

   The IEPA guidelines (IEPA, 2006) for identifying **manganese** as a cause of impairment in streams state that manganese is a potential cause of impairment of the aquatic life use if greater than 10% of the total manganese samples exceed 1000 ug/l. The IEPA guidelines (IEPA, 2006) for identifying manganese as a cause of impairment in streams state that manganese is a potential cause of impairment of the public and food processing water supply use if greater than 10% of the total manganese samples collected in 2001 or later exceed 150 ug/l. Because there are no water intakes in this segment, the TMDL target for manganese is based on the manganese standard to protect the aquatic life use. The TMDL target is a total manganese concentration of 1,000 ug/l.

   The IEPA guidelines (IEPA, 2006) for identifying **pH** as a cause of impairment in streams state that pH is a potential cause of impairment of the aquatic life use if greater than 10% of the samples are less than 6.5 SU or greater than 9.0 SU. The TMDL target for pH is the range between 6.5 and 9.0.

   The IEPA guidelines (IEPA, 2006) for identifying **dissolved oxygen** as a cause of impairment in streams state that dissolved oxygen is a potential cause of impairment of the aquatic life use if greater than 10% of the samples are less than 5 mg/l. The TMDL target for dissolved oxygen is 5.0 mg/l. For QUAL2E model runs, segment-specific modeling targets (5.0 mg/l plus half of the observed segment-specific diurnal) were used to consider diurnal variation and ensure that the 5.0 mg/l water quality standard is met.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** Loading capacity was determined for each impairment cause in segment IL_CA-03, as presented below.

Manganese

A load capacity calculation was completed to determine the maximum manganese loads that will maintain compliance with the manganese target under a range of flow conditions:

Flow (cfs)	IL_CA-03 Allowable Load (lbs/day)
11	61
23	122
113	611
226	1,221
453	2,443
906	4,885
1,359	7,328
1,811	9,771
2,264	12,213

pH

Because pH is not a load, but rather a measure of acidity and/or alkalinity of a given solution, this TMDL uses an *other appropriate measure* (40 CFR section 130.2(i) rather than an actual mass-per-unit time measure. For this TMDL, the State's numeric pH criterion (6.5 – 9.0 SU) is used as the TMDL target (*other appropriate measure*) for segment IL_CA-03.

Dissolved Oxygen

Based on a review of all available data, dissolved oxygen violations of the water quality standard were observed to occur only during low flow conditions. QUAL2E water quality model simulations for low flow conditions showed that, even with external BOD and ammonia loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results indicated that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit and that DO standards could only be attained via reduction of SOD. Although SOD is the overwhelming oxygen sink, the true cause of low DO is a lack of base flow (which greatly exacerbates the effect of SOD). Due to the expected presence of dissolved oxygen standard violations at zero external loading, TMDLs are not being conducted for dissolved oxygen.

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDLs are as follows:

Manganese

Flow (cfs)	Load Allocation (LA) (lbs/day)
11	55
23	110
113	550
226	1,099
453	2,198
906	4,397
1,359	6,595
1,811	8,794
2,264	10,992

pH

The pH TMDL target for nonpoint sources in the Skillet Fork segment IL_CA-03 watershed is between 6.5 and 9.0 standard units.

5. **Wasteload Allocations (WLA):** Wasteload allocations are presented below, by impairment.

Manganese

The manganese wasteload allocation for segment IL-CA-03 does not need to be calculated because there are no manganese permit limits for the dischargers in this watershed and these facilities are not expected to discharge manganese.

pH

There are fifteen point source dischargers in the segment IL_CA-03 watershed: Trunkline Gas Co. – Johnsonville; Beaver Creek School STP; Bluford STP; Springerton STP; ILDNR S.A. Forbes State Park Shower Bldg STP; ILDNR Stephen Forbes State Park Concession Bldg.; Xenia STP; Dahlgren STP; Enfield West STP; Enfield East STP; Belle Riv STP; Iuka STP; Mill Shoals STP; Wayne City South STP; IL DOT-I64 Jefferson Co. West STP. Effluent pH levels for these point sources shall be between 6.5 and 9.0 standard units at the point of discharge.

Because point sources are identified as being located in a segment's watershed and because segment IL_CA-03 is the most downstream segment in the Skillet Fork watershed, some of the dischargers that are identified above, are also located within the watershed for upstream segments. As such, they appear in this TMDL report for multiple segments.

6. **Margin of Safety:**

Both explicit and implicit margins of safety were incorporated into this TMDL, as described below.

Manganese

The manganese TMDL contains an implicit and explicit Margin of Safety. An implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no loss of manganese that enters the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDL also contains an explicit Margin of Safety of 10%. This 10% MOS was included in addition to the implicit MOS to address potential uncertainty in the effectiveness of load reduction alternatives. This Margin of Safety can be reviewed in the future as new data are developed.

Skillet Fork (IL_CA-03) Flow (cfs)	Manganese Margin of Safety (lbs/day)
11	6
23	12
113	61
226	122
453	244
906	489
1,359	733
1,811	977
2,264	1,221

pH

The pH TMDL for segment IL_CA-03 incorporates an implicit margin of safety. The targets used for this TMDL ensure that loads from the point and nonpoint sources must individually meet the pH target of 6.5 – 9.0 standard units. As long as pH from both point and nonpoint sources are consistent with the TMDL target, water quality standards in this segment will be met.

7. **Seasonal Variation:** Seasonal variation is considered within the TMDL as described below:

Manganese

The TMDL was conducted with an explicit consideration of seasonal variation. The manganese standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the river.

pH

The TMDL was conducted with an explicit consideration of seasonal variation. The pH standard will be met regardless of season because the TMDL requirements apply year-round.

8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permits for the point source dischargers in the watershed will be modified if necessary as part of the permit review process (typically every 5 years) to ensure that they are consistent with the applicable wasteload allocations.
   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

   Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan is included as part of the implementation plan.
10. **Transmittal Letter:** A transmittal letter accompanies the final TMDL report.
11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (summarized in Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. In March 2005, a public meeting was conducted in Wayne City, Illinois to present the Stage 1 findings. A second public meeting was held on July 19, 2007 to present the results of this TMDL and Implementation Plan.

Skillet Fork (IL_CA-05)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Skillet Fork, HUC 0512011506. The pollutants of concern addressed in this TMDL are **fecal coliform, manganese, pH and dissolved oxygen**. Potential sources contributing to the **fecal coliform** impairment include municipal point sources, agricultural runoff, failing septic systems and intensive animal feeding operations. Potential sources contributing to the **manganese** impairment include soils naturally enriched in manganese. Naturally acidic soils and permitted dischargers are potential sources contributing to the **pH** impairment. Low flow has been identified as the source of low instream **dissolved oxygen**. Skillet Fork is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Illinois EPA has prioritized listed waterbodies on a watershed basis. This segment has a high priority rating because it is located within a watershed that contains one or more waterbodies that are less than full support for *public and food processing water supply* use.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:**

   The IEPA guidelines (IEPA, 2006) for identifying **fecal coliform** as a cause of impairment in streams state that fecal coliform is a potential cause of impairment of the primary contact use if the geometric mean of all samples collected during May through October (minimum five samples) is greater than 200 colony forming units (cfu)/100 ml, or if greater than 10% of all samples exceed 400 cfu/100 ml. For the Skillet Fork TMDL for fecal coliform, the target is set at 200 cfu/100 ml across the entire flow regime during May-October.

   The IEPA guidelines (IEPA, 2006) for identifying **manganese** as a cause of impairment in streams state that manganese is a potential cause of impairment of the aquatic life use if greater than 10% of the total manganese samples exceed 1000 ug/l. The IEPA guidelines (IEPA, 2006) for identifying manganese as a cause of impairment in streams state that manganese is a potential cause of impairment of the public and food processing water supply use if greater than 10% of the total manganese samples collected in 2001 or later exceed 150 ug/l. Because there is a water intake in this segment, the TMDL target for manganese is based on the manganese standard to protect the public and food processing supply use. The TMDL target is a total manganese concentration of 150 ug/l.

   The IEPA guidelines (IEPA, 2006) for identifying **pH** as a cause of impairment in streams state that pH is a potential cause of impairment of the aquatic life use if greater than 10% of the samples are less than 6.5 SU or greater than 9.0 SU. The TMDL target for pH is the range between 6.5 and 9.0.

The IEPA guidelines (IEPA, 2006) for identifying **dissolved oxygen** as a cause of impairment in streams state that dissolved oxygen is a potential cause of impairment of the aquatic life use if greater than 10% of the samples are less than 5 mg/l. The TMDL target for dissolved oxygen is 5.0 mg/l. For QUAL2E model runs, segment-specific modeling targets (5.0 mg/l plus half of the observed segment-specific diurnal) were used to consider diurnal variation and ensure that the 5.0 mg/l water quality standard is met.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** Loading capacity was determined for each impairment cause in segment IL_CA-05, as presented below.

Fecal coliform

A load capacity calculation was completed to determine the maximum fecal coliform loads that will maintain compliance with the target under a range of flow conditions:

Flow (cfs)	IL_CA-05 Allowable Load (cfu/day)
5	2.45E+10
10	4.89E+10
50	2.45E+11
100	4.89E+11
200	9.79E+11
400	1.96E+12
600	2.94E+12
800	3.91E+12
1000	4.89E+12

Manganese

A load capacity calculation was completed to determine the maximum manganese loads that will maintain compliance with the manganese target under a range of flow conditions:

Flow (cfs)	IL_CA-05 Allowable Load (lbs/day)
5	4.0
10	8.1
50	40.5
100	80.9
200	161.8
400	323.6
600	485.4
800	647.3
1000	809.1

pH

Because pH is not a load, but rather a measure of acidity and/or alkalinity of a given solution, this TMDL uses an *other appropriate measure* (40 CFR section 130.2(i) rather than an actual mass-per-unit time measure. For this TMDL, the State's numeric pH criterion (6.5 – 9.0 SU) is used as the TMDL target (*other appropriate measure*) for segment IL_CA-05.

Dissolved Oxygen

Based on a review of all available data, dissolved oxygen violations of the water quality standard were observed to occur only during low flow conditions. QUAL2E water quality model simulations for low flow conditions showed that, even with external BOD and ammonia loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results indicated that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit and that DO standards could only be attained via reduction of SOD. Although SOD is the overwhelming oxygen sink, the true cause of low DO is a lack of base flow (which greatly exacerbates the effect of SOD). Due to the expected presence of dissolved oxygen standard violations at zero external loading, TMDLs are not being conducted for dissolved oxygen.

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDLs are as follows:

Fecal coliform

Flow (cfs)	IL_CA-05 Load Allocation (cfu/day)
5	2.18E+10
10	4.62E+10
50	2.42E+11
100	4.87E+11
200	9.76E+11
400	1.95E+12
600	2.93E+12
800	3.91E+12
1000	4.89E+12

Manganese

Flow (cfs)	IL_CA-05 Load Allocation (lbs/day)
5	3.64
10	7.28
50	36.41
100	72.82
200	145.63
400	291.26
600	436.90
800	582.53
1000	728.16

pH

The pH TMDL target for nonpoint sources in the Skillet Fork segment IL_CA-05 watershed is between 6.5 and 9.0 standard units.

5. **Wasteload Allocations (WLA):** Wasteload allocations are presented below, by impairment.

Fecal coliform

There are six sewage treatment plants in the Skillet Fork (IL_CA-05) watershed. These are the Bluford STP; ILDNR S.A. Forbes State Park Shower Bldg STP; ILDNR Stephen Forbes State Park Concession Bldg.; Xenia STP; Iuka STP and Wayne City South STP. Four of these facilities have a disinfection exemption and two have permit limits for fecal coliform. For the four facilities with disinfection exemptions, the WLA was calculated from the current permitted flow and a fecal coliform concentration consistent with meeting water quality standards (200 cfu/100 ml) at the end of each dischargers' exempted reach. The WLA for the other two facilities (the ILDNR facilities) was calculated from current permitted flow and a fecal coliform concentration consistent with meeting the water quality standard (200 cfu/100 ml) at the end of the effluent pipe. The WLA for these facilities equals 2,710 million cfu/day.

Manganese

The manganese wasteload allocation for segment IL-CA-05 does not need to be calculated because there are no manganese permit limits for the dischargers in this watershed and these facilities are not expected to discharge manganese.

pH

There are seven point source dischargers in the segment IL_CA-05 watershed: Trunkline Gas Co. – Johnsonville; Bluford STP; ILDNR S.A.

Forbes State Park Shower Bldg STP; ILDNR Stephen Forbes State Park Concession Bldg.; Xenia STP; Iuka STP and Wayne City South STP. Effluent pH levels for these point sources shall be between 6.5 and 9.0 standard units at the point of discharge.

6. **Margin of Safety:** Both explicit and implicit margins of safety were incorporated into this TMDL, as described below.

Fecal coliform

The TMDL contains an implicit margin of safety for fecal coliform, through the use of multiple conservative assumptions. The TMDL target (no more than 200 cfu/100 ml at any time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 ml for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load.

Manganese

The manganese TMDL contains an implicit and explicit Margin of Safety. An implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no loss of manganese that enters the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDL also contains an explicit Margin of Safety of 10%. This 10% MOS was included in addition to the implicit MOS to address potential uncertainty in the effectiveness of load reduction alternatives. This Margin of Safety can be reviewed in the future as new data are developed.

Skillet Fork (IL_CA-05) Flow (cfs)	Manganese Margin of Safety (lbs/day)
5	0.40
10	0.81
50	4.05
100	8.09
200	16.18
400	32.36
600	48.54
800	64.73
1000	80.91

pH

The pH TMDL for segment IL_CA-05 incorporates an implicit margin of safety. The targets used for this TMDL ensure that loads from the point and nonpoint sources must individually meet the pH target of 6.5 – 9.0 standard units. As long as pH from both point and nonpoint sources are consistent with the TMDL target, water quality standards in this segment will be met.

7. **Seasonal Variation:**

Fecal coliform

This TMDL was conducted with an explicit consideration of seasonal variation. The load duration curve approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur at any given point in the season in which the standard applies.

Manganese

The TMDL was conducted with an explicit consideration of seasonal variation. The manganese standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the river.

pH

The TMDL was conducted with an explicit consideration of seasonal variation. The pH standard will be met regardless of season because the TMDL requirements apply year-round.

8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permits for the point source dischargers in the watershed will be modified if necessary as part of the permit review process (typically every 5 years) to ensure that they are consistent with the applicable wasteload allocations.
In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan is included as part of the implementation plan.
10. **Transmittal Letter:** A transmittal letter accompanies the final TMDL report.
11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (summarized in Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. In March 2005, a public meeting was conducted in Wayne City, Illinois to present the Stage 1 findings. A second public meeting was held on July 19, 2007 to present the results of this TMDL and Implementation Plan.

Skillet Fork (IL_CA-06)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Skillet Fork, HUC 0512011502. The pollutants of concern addressed in this TMDL are **fecal coliform, manganese, pH and dissolved oxygen**. Potential sources contributing to the **fecal coliform** impairment include municipal point sources, agricultural runoff, failing septic systems and intensive animal feeding operations. Potential sources contributing to the **manganese** impairment include soils naturally enriched in manganese. Naturally acidic soils and permitted dischargers are potential sources contributing to the **pH** impairment. Low flow has been identified as the source of low instream **dissolved oxygen**. Skillet Fork is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Illinois EPA has prioritized listed waterbodies on a watershed basis. This segment has a high priority rating because it is located within a watershed that contains one or more waterbodies that are less than full support for *public and food processing water supply* use.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:**

   The IEPA guidelines (IEPA, 2006) for identifying **fecal coliform** as a cause of impairment in streams state that fecal coliform is a potential cause of impairment of the primary contact use if the geometric mean of all samples collected during May through October (minimum five samples) is greater than 200 colony forming units (cfu)/100 ml, or if greater than 10% of all samples exceed 400 cfu/100 ml. For the Skillet Fork TMDL for fecal coliform, the target is set at 200 cfu/100 ml across the entire flow regime during May-October.

   The IEPA guidelines (IEPA, 2006) for identifying **manganese** as a cause of impairment in streams state that manganese is a potential cause of impairment of the aquatic life use if greater than 10% of the total manganese samples exceed 1000 ug/l. The IEPA guidelines (IEPA, 2006) for identifying manganese as a cause of impairment in streams state that manganese is a potential cause of impairment of the public and food processing water supply use if greater than 10% of the total manganese samples collected in 2001 or later exceed 150 ug/l. Because there are no water intakes in this segment, the TMDL target for manganese is based on the manganese standard to protect aquatic life. The TMDL target is a total manganese concentration of 1000 ug/l.

   The IEPA guidelines (IEPA, 2006) for identifying **pH** as a cause of impairment in streams state that pH is a potential cause of impairment of the aquatic life use if greater than 10% of the samples are less than 6.5 SU or greater than 9.0 SU. The TMDL target for pH is the range between 6.5 and 9.0.

The IEPA guidelines (IEPA, 2006) for identifying **dissolved oxygen** as a cause of impairment in streams state that dissolved oxygen is a potential cause of impairment of the aquatic life use if greater than 10% of the samples are less than 5 mg/l. The TMDL target for dissolved oxygen is 5.0 mg/l. For QUAL2E model runs, segment-specific modeling targets (5.0 mg/l plus half of the observed segment-specific diurnal) were used to consider diurnal variation and ensure that the 5.0 mg/l water quality standard is met.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** Loading capacity was determined for each impairment cause in segment IL_CA-06, as presented below.

Fecal coliform

A load capacity calculation was completed to determine the maximum fecal coliform loads that will maintain compliance with the target under a range of flow conditions:

Flow (cfs)	IL_CA-06 Allowable Load (cfu/day)
2	1.10E+10
4	2.19E+10
22	1.10E+11
45	2.19E+11
90	4.39E+11
179	8.77E+11
269	1.32E+12
359	1.75E+12
448	2.19E+12

Manganese

A load capacity calculation was completed to determine the maximum manganese loads that will maintain compliance with the manganese target under a range of flow conditions:

Flow (cfs)	IL_CA-06 Allowable Load (lbs/day)
2	10.8
4	21.6
22	118.7
45	242.7
90	485.4
179	965.5
269	1,450.9
359	1,936.4
448	2,416.4

pH

Because pH is not a load, but rather a measure of acidity and/or alkalinity of a given solution, this TMDL uses an *other appropriate measure* (40 CFR section 130.2(i) rather than an actual mass-per-unit time measure. For this TMDL, the State's numeric pH criterion (6.5 – 9.0 SU) is used as the TMDL target (*other appropriate measure*) for segment IL_CA-06.

Dissolved Oxygen

Based on a review of all available data, dissolved oxygen violations of the water quality standard were observed to occur only during low flow conditions. QUAL2E water quality model simulations for low flow conditions showed that, even with external BOD and ammonia loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results indicated that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit and that DO standards could only be attained via reduction of SOD. Although SOD is the overwhelming oxygen sink, the true cause of low DO is a lack of base flow (which greatly exacerbates the effect of SOD). Due to the expected presence of dissolved oxygen standard violations at zero external loading, TMDLs are not being conducted for dissolved oxygen.

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDLs are as follows:

Fecal coliform

Flow (cfs)	IL_CA-06 Load Allocation (cfu/day)
2	1.02E+10
4	2.11E+10
22	1.09E+11
45	2.19E+11
90	4.38E+11
179	8.77E+11
269	1.32E+12
359	1.75E+12
448	2.19E+12

Manganese

Flow (cfs)	IL_CA-06 Load Allocation (lbs/day)
2	10
4	19
22	107
45	218
90	437
179	869
269	1,306
359	1,743
448	2,175

pH

The pH TMDL target for nonpoint sources in this segment's watershed is between 6.5 and 9.0 standard units.

5. **Wasteload Allocations (WLA):** Wasteload allocations are presented below, by impairment.

Fecal coliform

There are four sewage treatment plants in the Skillet Fork (IL_CA-06) watershed. These are the ILDNR S.A. Forbes State Park Shower Bldg STP; ILDNR Stephen Forbes State Park Concession Bldg.; Xenia STP; and Iuka STP. Two of these facilities have a disinfection exemption and two have permit limits for fecal coliform. For the two facilities with disinfection exemptions, the WLA was calculated from the current permitted flow and a fecal coliform concentration consistent with meeting water quality standards (200 cfu/100 ml) at the end of each dischargers' exempted reach. The WLA for the other two facilities (the ILDNR facilities) was calculated from current permitted flow and a fecal coliform concentration consistent with meeting the water quality standard (200 cfu/100 ml) at the end of the effluent pipe. The WLA for these facilities equals 818 million cfu/day.

Manganese

The manganese wasteload allocation for segment IL-CA-06 does not need to be calculated because there are no manganese permit limits for the dischargers in this watershed and these dischargers are not expected to discharge manganese.

pH

There are four point source dischargers in this segment's watershed: ILDNR S.A. Forbes State Park Shower Bldg STP; ILDNR Stephen Forbes State Park Concession Bldg.; Xenia STP; and Iuka STP. Effluent pH levels for these point sources shall be between 6.5 and 9.0 standard units at the point of discharge.

6. **Margin of Safety:** Both explicit and implicit margins of safety were incorporated into this TMDL, as described below.

Fecal coliform

The TMDL contains an implicit margin of safety for fecal coliform, through the use of multiple conservative assumptions. The TMDL target (no more than 200 cfu/100 ml at any time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 ml for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load.

Manganese

The manganese TMDL contains an implicit and explicit Margin of Safety. An implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no loss of manganese that enters the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDL also contains an explicit Margin of Safety of 10%. This 10% MOS was included in addition to the implicit MOS to address potential uncertainty in the effectiveness of load reduction alternatives. This Margin of Safety can be reviewed in the future as new data are developed.

Skillet Fork (IL_CA-06) Flow (cfs)	Manganese Margin of Safety (lbs/day)
2	1.1
4	2.2
22	11.9
45	24.3
90	48.5
179	96.5
269	145.1
359	193.6
448	241.6

pH

The pH TMDL for segment IL_CA-06 incorporates an implicit margin of safety. The targets used for this TMDL ensure that loads from the point and nonpoint sources must individually meet the pH target of 6.5 – 9.0 standard units. As long as pH from both point and nonpoint sources are consistent with the TMDL target, water quality standards in this segment will be met.

7. **Seasonal Variation:**

Fecal coliform

This TMDL was conducted with an explicit consideration of seasonal variation. The load duration curve approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur at any given point in the season where the standard applies.

Manganese

The TMDL was conducted with an explicit consideration of seasonal variation. The manganese standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the river.

pH

The TMDL was conducted with an explicit consideration of seasonal variation. The pH standard will be met regardless of season because the TMDL requirements apply year-round.

8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permits for the point source dischargers in the watershed will be modified if necessary as part of the permit review process (typically every 5 years) to ensure that they are consistent with the applicable wasteload allocations.

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan is included as part of the implementation plan.

10. **Transmittal Letter:** A transmittal letter accompanies the final TMDL report.

11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (summarized in Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. In March 2005, a public meeting was conducted in Wayne City, Illinois to present the Stage 1 findings. A second public meeting was held on July 19, 2007 to present the results of this TMDL and Implementation Plan.

Skillet Fork (IL_CA-09)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Skillet Fork, HUC 0512011502. The pollutant of concern addressed in this TMDL is **dissolved oxygen**. Low flow has been identified as the source of low instream **dissolved oxygen**. Skillet Fork is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Illinois EPA has prioritized listed waterbodies on a watershed basis. This segment has a high priority rating because it is located within a watershed that contains one or more waterbodies that are less than full support for *public and food processing water supply* use.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:**
   The IEPA guidelines (IEPA, 2006) for identifying **dissolved oxygen** as a cause of impairment in streams state that dissolved oxygen is a potential cause of impairment of the aquatic life use if greater than 10% of the samples are less than 5 mg/l. The TMDL target for dissolved oxygen is 5.0 mg/l. For QUAL2E model runs, segment-specific modeling targets (5.0 mg/l plus half of the observed segment-specific diurnal) were used to consider diurnal variation and ensure that the 5.0 mg/l water quality standard is met.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** Based on a review of all available data, dissolved oxygen violations of the water quality standard were observed to occur only during low flow conditions. QUAL2E water quality model simulations for low flow conditions showed that, even with external BOD and ammonia loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results indicated that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit and that DO standards could only be attained via reduction of SOD. Although SOD is the overwhelming oxygen sink, the true cause of low DO is a lack of base flow (which greatly exacerbates the effect of SOD). Due to the expected presence of dissolved oxygen standard violations at zero external loading, TMDLs are not being conducted for dissolved oxygen.

Brush Creek (IL_CAR-01)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Brush Creek, HUC 0512011502. The pollutants of concern addressed in this TMDL are **manganese and dissolved oxygen**. Potential sources contributing to the **manganese** impairment include soils naturally enriched in manganese. Low flow has been identified as the source of low instream **dissolved oxygen**. Brush Creek is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Illinois EPA has prioritized listed waterbodies on a watershed basis. This segment has a high priority rating because it is located within a watershed that contains one or more waterbodies that are less than full support for *public and food processing water supply* use.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:**

   The IEPA guidelines (IEPA, 2006) for identifying **manganese** as a cause of impairment in streams state that manganese is a potential cause of impairment of the aquatic life use if greater than 10% of the total manganese samples exceed 1000 ug/l. The IEPA guidelines (IEPA, 2006) for identifying manganese as a cause of impairment in streams state that manganese is a potential cause of impairment of the public and food processing water supply use if greater than 10% of the total manganese samples collected in 2001 or later exceed 150 ug/l. Because there are no water intakes in this segment, the TMDL target for manganese is based on the manganese standard to protect aquatic life. The TMDL target is a total manganese concentration of 1000 ug/l.

   The IEPA guidelines (IEPA, 2006) for identifying **dissolved oxygen** as a cause of impairment in streams state that dissolved oxygen is a potential cause of impairment of the aquatic life use if greater than 10% of the samples are less than 5 mg/l. The TMDL target for dissolved oxygen is 5.0 mg/l. For QUAL2E model runs, segment-specific modeling targets (5.0 mg/l plus half of the observed segment-specific diurnal) were used to consider diurnal variation and ensure that the 5.0 mg/l water quality standard is met.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** Loading capacity was determined for each impairment cause in this segment, as presented below.

   Manganese

   A load capacity calculation was completed to determine the maximum manganese loads that will maintain compliance with the manganese target under a range of flow conditions:

Flow (cfs)	IL_CAR-01 Allowable Load (lbs/day)
0.2	1.1
0.6	3.2
3	16.2
10	53.9
40	215.8
140	755.1
5000	26,968.9

Dissolved oxygen

Based on a review of all available data, dissolved oxygen violations of the water quality standard were observed to occur only during low flow conditions. QUAL2E water quality model simulations for low flow conditions showed that, even with external BOD and ammonia loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results indicated that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit and that DO standards could only be attained via reduction of SOD. Although SOD is the overwhelming oxygen sink, the true cause of low DO is a lack of base flow (which greatly exacerbates the effect of SOD). Due to the expected presence of dissolved oxygen standard violations at zero external loading, TMDLs are not being conducted for dissolved oxygen.

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDLs are as follows:

Manganese

Flow (cfs)	IL_CAR-01 Load Allocation (lbs/day)
0.2	0.97
0.6	2.91
3	14.56
10	48.54
40	194.18
140	679.62
5000	24271.99

5. **Wasteload Allocations (WLA):** There are no permitted dischargers within this watershed and so wasteload allocations do not need to be calculated.

6. **Margin of Safety:** Both explicit and implicit margins of safety were incorporated into this TMDL, as described below.

Manganese

The manganese TMDL contains an implicit and explicit Margin of Safety. An implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no loss of manganese that enters the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDL also contains an explicit Margin of Safety of 10%. This 10% MOS was included in addition to the implicit MOS to address potential uncertainty in the effectiveness of load reduction alternatives. This Margin of Safety can be reviewed in the future as new data are developed.

Brush Creek (IL_CAR-01) Flow (cfs)	Manganese Margin of Safety (lbs/day)
0.2	0.11
0.6	0.32
3	1.62
10	5.39
40	21.58
140	75.51
5000	2696.89

7. **Seasonal Variation:** Seasonal variation is considered within the TMDL as described below:

   Manganese

   The TMDL was conducted with an explicit consideration of seasonal variation. The manganese standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the river.

8. **Reasonable Assurances:** There are no permitted point sources in this watershed and so reasonable assurances for point sources are not discussed. In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

   Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan is included as part of the implementation plan.

10. **Transmittal Letter:** A transmittal letter accompanies the final TMDL report.

11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (summarized in Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. In March 2005, a public meeting was conducted in Wayne City, Illinois to present the Stage 1 findings. A second public meeting was held on July 19, 2007 to present the results of this TMDL and Implementation Plan.

Horse Creek (IL_CAN-01)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Horse Creek, HUC 0512011503. The pollutants of concern addressed in this TMDL are **manganese and dissolved oxygen**. Potential sources contributing to the **manganese** impairment include soils naturally enriched in manganese. Low flow has been identified as the source of low instream **dissolved oxygen**. Horse Creek is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Illinois EPA has prioritized listed waterbodies on a watershed basis. This segment has a high priority rating because it is located within a watershed that contains one or more waterbodies that are less than full support for *public and food processing water supply* use.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:**

   The IEPA guidelines (IEPA, 2006) for identifying **manganese** as a cause of impairment in streams state that manganese is a potential cause of impairment of the aquatic life use if greater than 10% of the total manganese samples exceed 1000 ug/l. The IEPA guidelines (IEPA, 2006) for identifying manganese as a cause of impairment in streams state that manganese is a potential cause of impairment of the public and food processing water supply use if greater than 10% of the total manganese samples collected in 2001 or later exceed 150 ug/l. Because there are no water intakes in this segment, the TMDL target for manganese is based on the manganese standard to protect aquatic life. The TMDL target is a total manganese concentration of 1000 ug/l.

   The IEPA guidelines (IEPA, 2006) for identifying **dissolved oxygen** as a cause of impairment in streams state that dissolved oxygen is a potential cause of impairment of the aquatic life use if greater than 10% of the samples are less than 5 mg/l. The TMDL target for dissolved oxygen is 5.0 mg/l. For QUAL2E model runs, segment-specific modeling targets (5.0 mg/l plus half of the observed segment-specific diurnal) were used to consider diurnal variation and ensure that the 5.0 mg/l water quality standard is met.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** Loading capacity was determined for each impairment cause in this segment, as presented below.

   Manganese

   A load capacity calculation was completed to determine the maximum manganese loads that will maintain compliance with the manganese target under a range of flow conditions:

Flow (cfs)	IL_CAN-01 Allowable Load (lbs/day)
0.3	1.6
1	5.4
5	27.0
20	107.9
70	377.6
250	1348.4
9500	51240.9

Dissolved oxygen

Based on a review of all available data, dissolved oxygen violations of the water quality standard were observed to occur only during low flow conditions. QUAL2E water quality model simulations for low flow conditions showed that, even with external BOD and ammonia loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results indicated that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit and that DO standards could only be attained via reduction of SOD. Although SOD is the overwhelming oxygen sink, the true cause of low DO is a lack of base flow (which greatly exacerbates the effect of SOD). Due to the expected presence of dissolved oxygen standard violations at zero external loading, TMDLs are not being conducted for dissolved oxygen.

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDLs are as follows:

Manganese

Flow (cfs)	IL_CAN-01 Load Allocation (lbs/day)
0.3	1.46
1	4.85
5	24.27
20	97.09
70	339.81
250	1213.60
9500	46116.78

5. **Wasteload Allocations (WLA):** Wasteload allocations are presented below, by impairment.

Manganese

The manganese wasteload allocation for segment IL-CAN-01 does not need to be calculated because there are no manganese permit limits for the dischargers in this watershed and they are not expected to discharge manganese.

6. **Margin of Safety:** Both explicit and implicit margins of safety were incorporated into this TMDL, as described below.

   Manganese

   The manganese TMDL contains an implicit and explicit Margin of Safety. An implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no loss of manganese that enters the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDL also contains an explicit Margin of Safety of 10%. This 10% MOS was included in addition to the implicit MOS to address potential uncertainty in the effectiveness of load reduction alternatives. This Margin of Safety can be reviewed in the future as new data are developed.

Horse Creek (IL_CAN-01) Flow (cfs)	Manganese Margin of Safety (lbs/day)
0.3	0.16
1	0.54
5	2.70
20	10.79
70	37.76
250	134.84
9500	5124.09

7. **Seasonal Variation:** Seasonal variation is considered within the TMDL as described below:

   Manganese

   The TMDL was conducted with an explicit consideration of seasonal variation. The manganese standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the river.

8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permits for the point source dischargers in the watershed will be modified if necessary as part of the permit review process (typically every 5 years) to ensure that they are consistent with the applicable wasteload allocations.

   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan is included as part of the implementation plan.

10. **Transmittal Letter:** A transmittal letter accompanies the final TMDL report.

11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (summarized in Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. In March 2005, a public meeting was conducted in Wayne City, Illinois to present the Stage 1 findings. A second public meeting was held on July 19, 2007 to present the results of this TMDL and Implementation Plan.

Dums Creek (IL_CW-04)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Skillet Fork, HUC 0512011502. The pollutant of concern addressed in this TMDL is **dissolved oxygen**. Low flow has been identified as the source of low instream **dissolved oxygen**. Dums Creek is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Illinois EPA has prioritized listed waterbodies on a watershed basis. This segment has a high priority rating because it is located within a watershed that contains one or more waterbodies that are less than full support for *public and food processing water supply* use.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:**
   The IEPA guidelines (IEPA, 2006) for identifying **dissolved oxygen** as a cause of impairment in streams state that dissolved oxygen is a potential cause of impairment of the aquatic life use if greater than 10% of the samples are less than 5 mg/l. The TMDL target for dissolved oxygen is 5.0 mg/l. For QUAL2E model runs, segment-specific modeling targets (5.0 mg/l plus half of the observed segment-specific diurnal) were used to consider diurnal variation and ensure that the 5.0 mg/l water quality standard is met.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:**
   Based on a review of all available data, dissolved oxygen violations of the water quality standard were observed to occur only during low flow conditions. QUAL2E water quality model simulations for low flow conditions showed that, even with external BOD and ammonia loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results indicated that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit and that DO standards could only be attained via reduction of SOD. Although SOD is the overwhelming oxygen sink, the true cause of low DO is a lack of base flow (which greatly exacerbates the effect of SOD). Due to the expected presence of dissolved oxygen standard violations at zero external loading, TMDLs are not being conducted for dissolved oxygen.

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3. WATERSHED CHARACTERIZATION

The Stage 1 Report presents and discusses information describing the Skillet Fork watershed to support the identification of sources contributing to the listed impairments as applicable. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including geology and soils, climate, land cover, hydrology, urbanization and population growth, point source discharges and watershed activities.

The impaired waterbodies addressed in this report are all located within the Skillet Fork watershed. This watershed is located in Southeastern Illinois, approximately 10 miles east of the city of Mount Vernon and the intersection of Interstates 57 and 64. Skillet Fork is a tributary to the Little Wabash River, with its confluence located three miles northeast of Carmi, Illinois, near river mile 39. Portions of the Skillet Fork watershed lie in Clay, Marion, Wayne, Jefferson, White and Hamilton counties. The watershed is approximately 672,425 acres (1,051 square miles) in size, and there are about 1,720 miles of streams in the watershed. The main stem of the Skillet Fork River is approximately 97 miles long (54 miles are listed as being impaired). The waterbodies of concern are Skillet Fork (IL_CA-03, IL_CA-05, IL_CA-06 and IL_CA-09), Brush Creek (IL_CAR-01), Dums Creek (IL_CAW-04) and Horse Creek (IL_CAN-01).

Figure 1 shows a map of the watershed, and includes some key features such as waterways, impaired waterbodies, public water intakes and other key features. The map also shows the locations of point source discharges that have a permit to discharge under the National Pollutant Discharge Elimination System (NPDES).

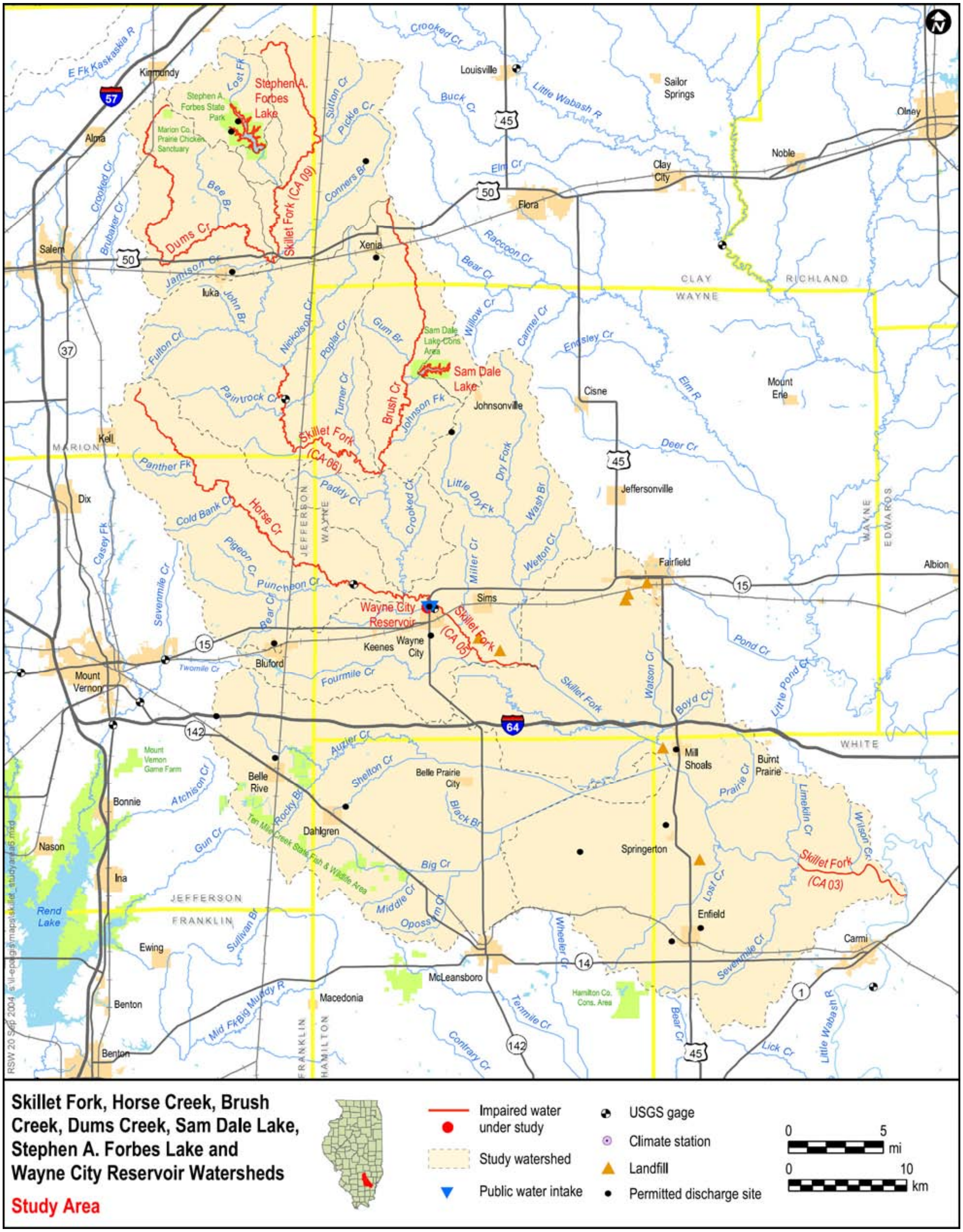

Figure 1. Base Map of Skillet Fork Watershed

4. DESCRIPTION OF APPLICABLE STANDARDS AND NUMERIC TARGETS

A water quality standard includes the designated uses of the waterbody, water quality criteria to protect designated uses, and an antidegradation policy to maintain and protect existing uses and high quality waters. Water quality criteria are sometimes in a form that are not directly amenable for use in TMDL development and may need to be translated into a target value for TMDLs. This section discusses the applicable designated uses, use support, criteria and TMDL targets for waterbodies in the Skillet Fork watershed that are addressed in this report.

4.1 DESIGNATED USES AND USE SUPPORT

Water quality assessments in Illinois are based on a combination of chemical (water, sediment and fish tissue), physical (habitat and flow discharge), and biological (macroinvertebrate and fish) data. Illinois EPA conducts its assessment of water bodies using a set of seven designated uses: aquatic life, aesthetic quality, indigenous aquatic life (for specific Chicago-area waterbodies), primary contact (swimming), secondary contact, public and food processing water supply, and fish consumption (IEPA, 2006). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of two possible "use-support" levels:

- Fully Supporting (the water body attains the designated use); or
- Not Supporting (the water body does not attain the designated use).

Water bodies assessed as "Not Supporting" for any designated use are identified as impaired. Waters identified as impaired based on biological (macroinvertebrate, macrophyte, algal and fish), chemical (water, sediment and fish tissue), and/or physical (habitat and flow discharge) monitoring data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters (IEPA, 2006).

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized on a watershed basis. Illinois EPA watershed boundaries are based on the USGS ten-digit hydrologic units to provide the state with the ability to address watershed issues at a manageable level and document improvements to a watershed's health (IEPA, 2006).

4.2 WATER QUALITY CRITERIA

Illinois has established water quality criteria and guidelines for allowable concentrations of fecal coliform, manganese, dissolved oxygen and pH under its CWA Section 305(b) program, as summarized below. A comparison of available water quality data to these criteria is provided in the Stage 1 Report.

4.2.1 Fecal Coliform

The general use water quality standard (35 IAC 302.209) for fecal coliform in Illinois waters is as follows:

> During the months May through October, based on a minimum of five samples taken over not more that an 30 day period, fecal coliform (STORET

number 31616) shall not exceed a geometric mean of 200 per 100ml, nor shall more than 10% of the samples during any 30 day period exceed 400 per 100 ml in protected waters. Protected waters are defined as waters which, due to natural characteristics, aesthetic value or environmental significance are deserving of protection from pathogenic organisms. Protected waters will meet one or both of the following conditions:

1. Presently support or have the physical characteristics to support primary contact;
2. Flow through or adjacent to parks or residential areas.

The IEPA guidelines (IEPA, 2006) for identifying fecal coliform as a cause of impairment in streams state that fecal coliform is a potential cause of impairment of the primary contact use if the geometric mean of all samples collected during May through October (minimum five samples) is greater than 200 cfu/100 mL, or if greater than 10% of all samples exceed 400 cfu/100 mL. The available data support the listing of fecal coliform as a cause of impairment in Skillet Fork (IL_CA-05, IL_CA-06).

4.2.2 Manganese

The water quality standard for total manganese in Illinois waters designated as public and food processing water supplies (35 IAC 302.304) states that manganese (total) shall not exceed 0.15 mg/L. The public and food processing water supply guideline for streams indicates impairment if more than 10% of the observations measured since 2001 exceed 0.15 mg/L.

The water quality standard for total manganese in Illinois waters designated for aquatic life (35 IAC 302.208) states that concentrations of manganese (total) shall not exceed 1.0 mg/l except in waters for which mixing is allowed pursuant to Section 302.102. The aquatic life guideline for streams indicates impairment if more than 10% of the observations measured in the last five years exceed 1.0 mg/L. The available data confirm the listing of Skillet Fork (IL_CA-03, IL_CA-06), Brush Creek (IL_CAR-01) and Horse Creek (IL_CAN-01) for total manganese is appropriate based on IEPA's guidelines for the aquatic life use. The data also confirm the listing of Skillet Fork (IL_CA-05) based on the public and food processing water supply use.

4.2.3 Dissolved oxygen

The water quality standard for dissolved oxygen in Illinois waters designated for aquatic life (35 IAC 302.206) is that dissolved oxygen shall not be less than 6.0 mg/L during at least 16 hours of any 24 hour period, nor less than 5.0 mg/L at any time.

The aquatic life guideline for streams indicates impairment if more than 10% of the observations measured in the last five years are below 5 mg/L. The available data confirm the listing of Skillet Fork (IL_CA-03, IL_CA-05, IL_CA-06, IL_CA-09), Brush Creek (IL_CAR-01), Dums Creek (IL_CAW-04) and Horse Creek (IL_CAN-01) for dissolved oxygen is appropriate based on IEPA's guidelines.

4.2.4 pH

The water quality standard for pH in Illinois waters designated for aquatic life (35 IAC 302.204) states that pH (STORET number 00400) shall be within the range of 6.5 to 9.0 except for natural causes. The aquatic life guideline for streams indicates impairment if more than 10% of the observations measured in the last five years are greater than 9.0 SU or less than 6.5 SU. The available data confirm the listing of Skillet Fork (IL_CA-03, IL_CA-05 and IL_CA-06) for pH is appropriate based on IEPA's guidelines.

4.3 DEVELOPMENT OF TMDL TARGETS

The TMDL target is a numeric endpoint specified to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint. When appropriate numeric standards do not exist, surrogate parameters must be selected to represent the designated use.

4.3.1 Fecal Coliform

For the Skillet Fork fecal coliform TMDLs, the target was set at 200 cfu/100 mL.

4.3.2 Manganese

For the Skillet Fork (IL_CA-03, IL_CA-06), Brush Creek (IL_CAR-01) and Horse Creek (IL_CAN-01) manganese TMDLs, the target was set to the water quality criterion for total manganese of 1000 µg/L. For the Skillet Fork (IL_CA-05) manganese TMDL, the target was set to the water quality criterion for total manganese of 150 µg/L because this segment is used for water supply.

4.3.3 Dissolved oxygen

The water quality standard for dissolved oxygen in Illinois waters designated for aquatic life is that dissolved oxygen shall not be less than 6.0 mg/L during at least 16 hours of any 24 hour period, nor less than 5.0 mg/L at any time. For Skillet Fork, Brush Creek, Dums Creek and Horse Creek, the target was based upon the water quality criterion for dissolved oxygen of 5 mg/L. The QUAL2E model used to calculate the TMDL predicts a daily average dissolved oxygen concentration and does not directly predict daily minimum values. QUAL2E results can be translated into a form comparable to a daily minimum, by subtracting the observed difference between daily average and daily minimum dissolved oxygen from the model output. For QUAL2E model runs, segment-specific modeling targets (5.0 mg/l plus half of the observed segment-specific diurnal) were used to consider diurnal variation and ensure that the 5.0 mg/l water quality standard is met. The observed segment-specific diurnal variations were:

Segment	Diurnal
Skillet Fork (IL_CA-09)	0.14 mg/l
Dums Cr (IL_CAW-04)	0.72 mg/l
Skillet Fork (IL_CA-06)	0.65 mg/l
Brush Cr (IL_CAR-01)	0.62 mg/l
Horse Cr (IL_CAN-01)	0.71 mg/l
Skillet Fork (IL_CA-05)	1.03 mg/l
Skillet Fork (IL_CA-03)	6.56 mg/l

4.3.4 pH

For Skillet Fork (IL_CA-03, IL_CA-05 and IL_CA-06), the target was set to the water quality criterion of $6.5 \leq pH \leq 9.0$.

5. DEVELOPMENT OF WATER QUALITY MODELS

Water quality models are used to define the relationship between pollutant loading and the resulting water quality. The dissolved oxygen assessment is based on the QUAL2E model. A model was not applied for the pH TMDL. The TMDLs for manganese and fecal coliform apply the Load Duration Curve approach in conjunction with a load capacity calculation. The development of these approaches is described in the following sections, including information on:

- Model selection
- Modeling approach
- Model inputs
- Model calibration (QUAL2E)/analysis (Load duration)

5.1 QUAL2E MODEL

The QUAL2E water quality model was used to define the relationship between external oxygen-demanding loads and the resulting concentrations of dissolved oxygen in Skillet Fork, Dums Creek, Brush Creek and Horse Creek. QUAL2E is a one-dimensional stream water quality model applicable to dendritic, well-mixed streams. It assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the main direction of flow. The model allows for multiple waste discharges, water withdrawals, tributary flows, and incremental inflows and outflows.

5.1.1 Model Selection

A detailed discussion of the model selection process for the Skillet Fork watershed is provided in the Stage 1 Report.

Of the models discussed, the QUAL2E model (Brown and Barnwell, 1987) was selected to address dissolved oxygen impairments. QUAL2E is the most commonly used water quality model for addressing low flow conditions. Because problems are restricted to low flow conditions, watershed loads during these periods are not expected to be significant contributors to the impairment. For this reason, an empirical approach was selected for determining watershed loads.

5.1.2 Modeling Approach

The approach selected for the dissolved oxygen assessment is based upon discussions with IEPA and their Scientific Advisory Committee. The approach consists of using data collected during 2005 dry weather surveys to define current loads to the river, and using the QUAL2E model to define the extent to which loads must be reduced to meet water quality standards. This is the recommended approach presented in the detailed discussion of the model selection process provided in the Stage 1 report. The dominant land use in the watershed is agriculture. Implementation plans for nonpoint sources will consist of voluntary controls, applied on an incremental basis. The approach taken for these TMDLs, will expedite these implementation efforts.

Determination of existing loading sources and prioritization of restoration alternatives may be conducted by local experts as part of the implementation process (see Section 8). Based upon their recommendations, a voluntary implementation plan could be developed that includes both accountability and the potential for adaptive management.

5.1.3 Model Inputs

This section provides an overview of the model inputs required for QUAL2E application, and how they were derived. The following categories of inputs are required for QUAL2E:

- Model options (title data)
- Model segmentation
- Hydraulic characteristics
- Reach kinetic coefficients
- Initial conditions
- Incremental inflow conditions
- Headwater characteristics
- Point source flows and loads

5.1.3.a *Model Options*

This portion of the input file defines the specific water quality parameters to be simulated. QUAL2E was set up to simulate biochemical oxygen demand, the nitrogen series and dissolved oxygen.

5.1.3.b *Model Segmentation*

The QUAL2E model divides the river being simulated into discrete segments (called "reaches") that are considered to have constant channel geometry and hydraulic characteristics. Reaches are further divided into "computational elements", which define the interval at which results are provided. The Skillet Fork QUAL2E model consists of 26 reaches (some of which are non-impacted connecting reaches), which are comprised of a varying number of computational elements. Computational elements have a fixed length of 0.75 miles. Reaches are defined with respect to branches (mainstem, Dums Creek, Brush Creek and Horse Creek), impacted and non-impacted section boundaries, and water quality monitoring stations. Model segmentation is presented below in Table 1.

Table 1. QUAL2E Segmentation

Reach	River miles	Number of computational elements	Branch or Mainstem Section
1	90.4 – 97.1	9	IL_CA-09
2	86.9 – 90.4	4	IL_CA-09
3	83.2 – 86.9	5	IL_CA-09
4	77.3 – 83.2	8	IL_CA-09
5	16.0 – 25.4	12	Dums Cr.
6	4.2 -- 16.0	16	Dums Cr.
7	0.0 -- 4.2	6	Dums Cr.
8	66.7 – 77.3	14	Non-impacted
9	63.4 – 66.7	4	IL_CA-06
10	52.8 – 63.4	14	IL_CA-06
11	50.1 – 52.8	4	IL_CA-06
12	12.7 – 21.3	11	Brush Cr.
13	1.3 – 12.7	15	Brush Cr.
14	0.0 -- 1.3	2	Brush Cr.
15	38.1 – 50.1	16	Non-impacted
16	20.0 – 28.2	11	Horse Cr.
17	13.6 – 20.0	9	Horse Cr.
18	4.0 – 13.6	13	Horse Cr.
19	0.0 -- 4.0	5	Horse Cr.
20	35.8 – 38.1	3	IL_CA-05
21	31.9 – 35.8	5	IL_CA-05
22	27.2 – 31.9	7	IL_CA-05
23	19.5 – 27.2	10	Non-impacted
24	7.2 – 19.5	17	Non-impacted
25	3.1 -- 7.2	5	IL_CA-03
26	0.0 -- 3.1	4	IL_CA-03

5.1.3.c *Hydraulic Characteristics*

A functional representation was used to describe the hydraulic characteristics of the system. For each reach, velocity and depth were specified, based on measurements taken during the two field surveys.

5.1.3.d *Reach Kinetic Coefficients*

Kinetic coefficients were set at typical values in the absence of specific data. Sediment oxygen demand (SOD) was based on measurements taken during the field survey (Horse Creek SOD was set at average values because its measurements were abnormally low and inconsistent with the observed instream dissolved oxygen data). The model reaeration rate was adjusted to match minimum observed dissolved oxygen concentrations. Decay rates for BOD and ammonia were not calibrated because concentrations were generally low; uncertainty in these rates will have little affect on model predictions.

5.1.3.e *Initial Conditions*

Initial model conditions were based on field observations taken during 2005. Specifically, site-specific information on creek flow, velocity, morphometry, and concentrations of BOD and ammonia were used to specify initial conditions.

5.1.3.f *Incremental Inflow Conditions*

Incremental inflows were not used in the model representation of the system.

5.1.3.g *Headwater Characteristics*

Headwater characteristics were based on watershed-typical values, branch upstream field measurements, and drainage area-based flows.

5.1.3.h *Point Source Flows and Loads*

The model considers 44 point sources, including 35 tributaries, which do not have permitted discharges and 9 tributaries which are affected by the 15 permitted dischargers in the entire watershed. Of these 15 permitted dischargers 12 contribute loads. The other three are the Mill Shoals STP, which was not reported to have discharge flow, and the Forbes State Park Concession Building and the Forbes State Park Shower Building STP, which discharge to a lake.

The non-impacted point source tributaries were considered to have concentrations at typical background levels. The impacted point source tributaries were considered to have concentrations at the average of the permitted discharger, less a delivery factor of 50% for BOD.

Drainage flows were based on incremental drainage areas and the recorded daily average flow of 7 cfs at the USGS Skillet Fork – Wayne City gage (03380500) for the date of the September field survey (9/1/2005). Flow increments were distributed equally among headwaters and non-impacted point source tributaries. Permitted discharge flows were considered to be the monthly average flows from the Discharge Monitoring Reports.

5.1.4 QUAL2E Calibration

QUAL2E model calibration consisted of:

1. Applying the model with all inputs specified as above
2. Comparing model results to dissolved oxygen, BOD and ammonia data
3. Adjusting model coefficients to provide the best comparison between model predictions and observed dissolved oxygen data.

The QUAL2E dissolved oxygen calibration for all modeled sections is discussed below. The model was initially applied with the model inputs as specified above. Observed data for the survey conducted September 1, 2005 were used for calibration purposes.

QUAL2E was calibrated to match the observed dissolved oxygen concentrations measured along the mainstem of the river (both impacted and non-impacted sections) and impacted tributaries Dums Creek, Brush Creek and Horse Creek. Model results initially contained both overpredictions and underpredictions relative to the observed dissolved oxygen data. The dissolved oxygen mass balance component analysis showed that the most important source of dissolved oxygen was reaeration and the most important sink was sediment oxygen demand. The mismatch between model and data was minimized during the calibration process by primarily adjusting the reaeration rates. The resulting dissolved oxygen predictions compared well to the measured concentrations, as shown in Figure 2a, 2b, 2c and 2d. The QUAL2E model output files from the calibration run are included in Attachment 1.

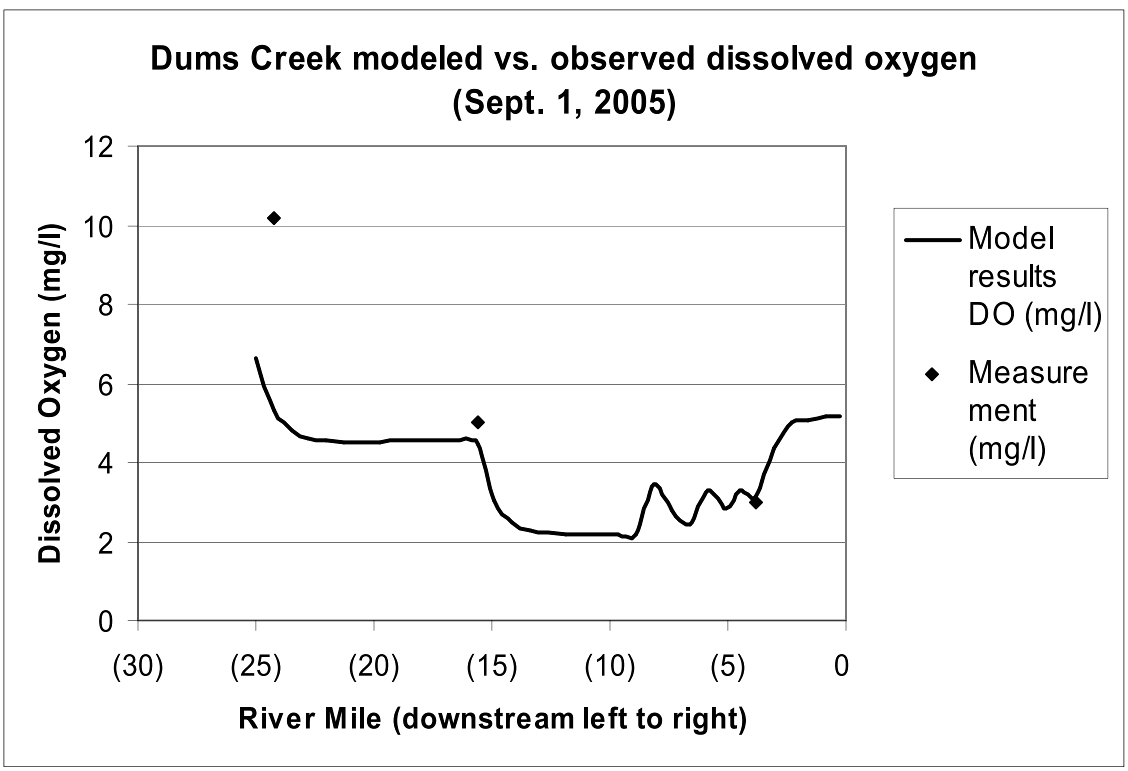

Figure 2a. QUAL2E Calibration Dums Creek

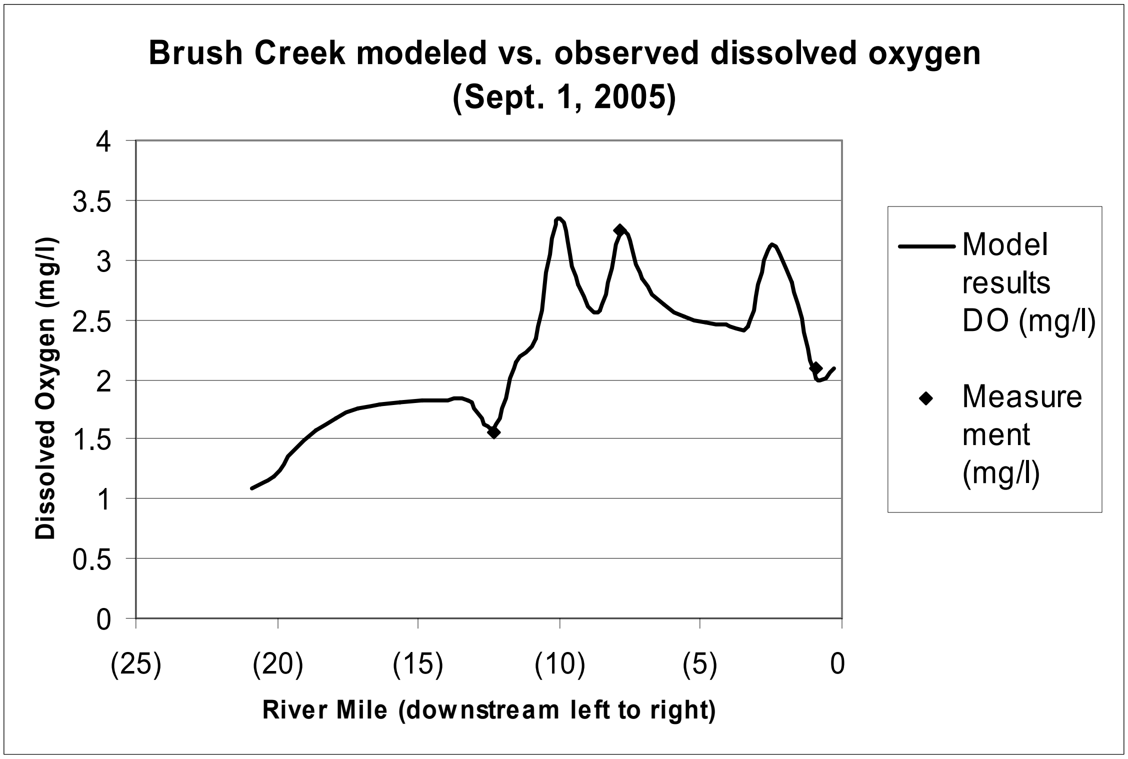

Figure 2b. QUAL2E Calibration Brush Creek

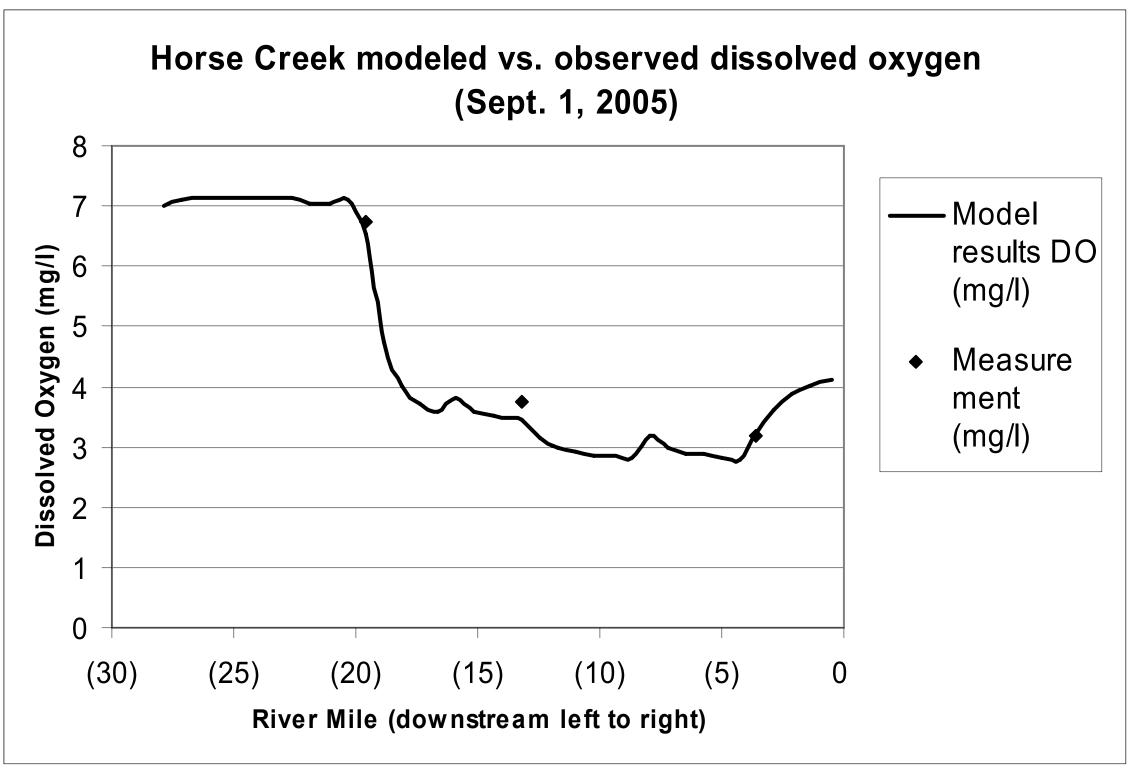

Figure 2c. QUAL2E Calibration Horse Creek

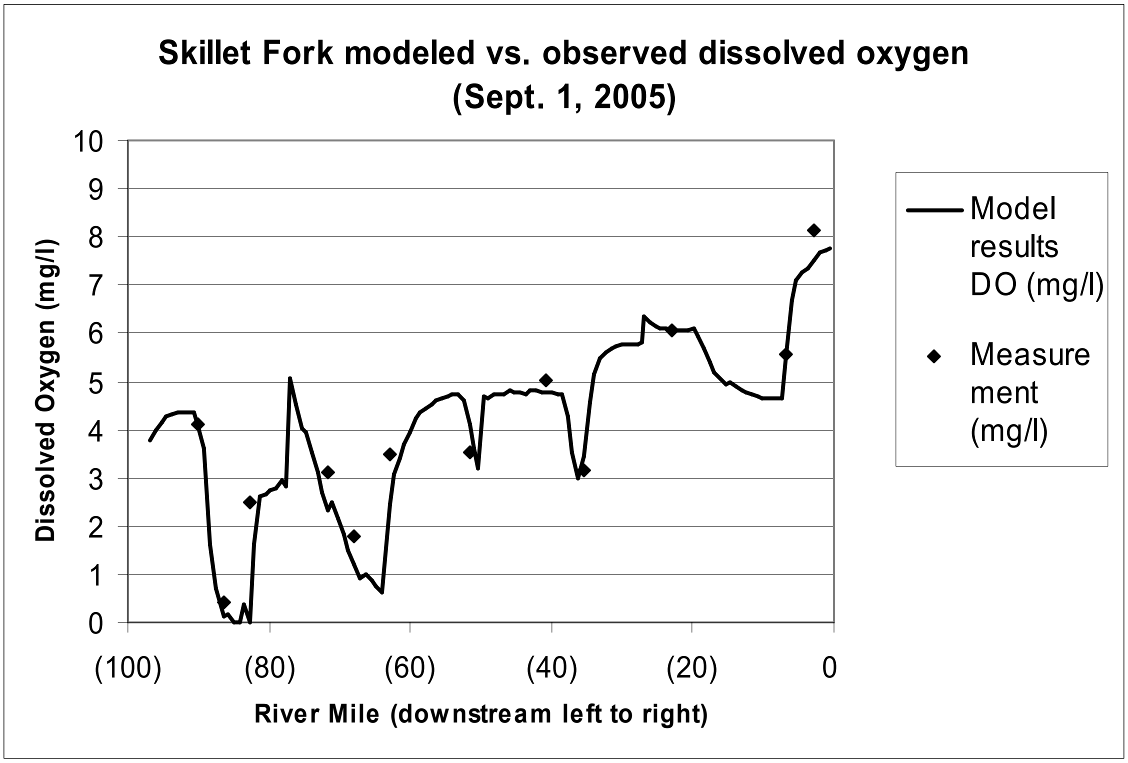

Figure 2d. QUAL2E Calibration Skillet Fork Mainstem

5.2 LOAD DURATION CURVE ANALYSIS

A load duration curve approach was used in the fecal coliform and manganese analysis for Skillet Fork. A load-duration curve is a graphical representation of observed pollutant load compared to maximum allowable load over the entire range of flow conditions. The load duration curve provides information to:

- Help identify the issues surrounding the problem and differentiate between point and nonpoint source problems, as discussed immediately below;
- Address frequency of deviations (how many samples lie above the curve vs. those that plot below); and
- Aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards for different flow conditions.

5.2.1 Model Selection

A detailed discussion of the model selection process for Skillet Fork is provided in the Stage 1 Report. The load-duration curve approach was selected because it is a simpler approach that can be supported with the available data and still support the selected level of TMDL implementation for this TMDL. The load-duration curve approach identifies broad categories of manganese and fecal coliform sources and the extent of control required from these source categories to attain water quality standards.

5.2.2 Approach

The load duration curve approach uses stream flows for the period of record to gain insight into the flow conditions under which exceedances of the water quality standard occur. A load-duration curve is developed by: 1) ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results; 2) translating the flow duration curve (produced in step 1) into a load duration curve by multiplying the flows by the water quality standard; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph. Observed loads that fall above the load duration curve exceed the maximum allowable load, while those that fall on or below the line do not exceed the maximum allowable load. An analysis of the observed loads relative to the load duration curve provides information on whether the pollutant source is point or nonpoint in nature. A more complete description of the load duration curve approach is provided in the Stage 1 Report.

5.2.3 Data inputs

This section describes the flow and water quality data used to support development of the load duration curve for total manganese and fecal coliform bacteria.

5.2.3.a *Flow*

Daily flow measurements are available for the USGS gage on Skillet Fork (USGS gage number 03380500 at Wayne City, IL) for the period from 1908 through 2004. To estimate flows for the listed segments, the gaged flows were adjusted for the size of the drainage area. The adjustment ratio for each segment is as follows:

- Skillet Fork (IL_CA-03) - multiplied by 2.26 because the watershed for IL_CA-03 is 2.26 times the size of the watershed at the Skillet Fork gage.
- Skillet Fork (IL_CA-05) – Not adjusted because this sampling site is the same as the USGS gage station.
- Skillet Fork (IL_CA-06) – multiplied by 0.448 because the watershed for IL_CA-05 is 0.448 times the size of the watershed at the Skillet Fork gage.
- Brush Creek (IL_CAR-01) – multiplied by 0.121 because the watershed for IL_CAR-01 is 0.121 times the size of the watershed at the Skillet Fork gage.
- Horse Creek (IL_CAN-01) – multiplied by 0.216 because the watershed for IL_CAN-01 is 0.216 times the size of the watershed at the Skillet Fork gage.

5.2.3.b *Manganese*

Total manganese data collected by IEPA as part of their ambient water quality monitoring program between 1994 and 2003 were used in the analysis. Total manganese data collected by LimnoTech during the 2005 dry weather surveys were also used in the analysis.

5.2.3.c *Fecal coliform*

Fecal coliform data collected by IEPA between 1994 and 2005 were used in the analysis. The data were collected as part of IEPA's ambient water quality monitoring program. Only data for the months of May-October were used because the water quality standard applies only during this period.

5.2.4 Analysis

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. Load duration curves for manganese and fecal coliform were generated by multiplying the flows in the duration curve by the water quality standard of 1000 µg/L for total manganese (150 µg/L for Skillet Fork IL_CA-05), and 200 cfu/100 mL for fecal coliform bacteria. The load duration curves are shown with a solid line in Figures 3 through 9; Figures 3 through 7 are for manganese, and Figures 8 and 9 are for fecal coliform. Observed pollutant loads of manganese were calculated using available concentration data paired with corresponding flows, and were plotted on the same graphs. For fecal coliform, observed pollutant loads were calculated in the same manner, using only measurements collected between May and October. The worksheets for these analyses are provided in Attachments 2 and 3.

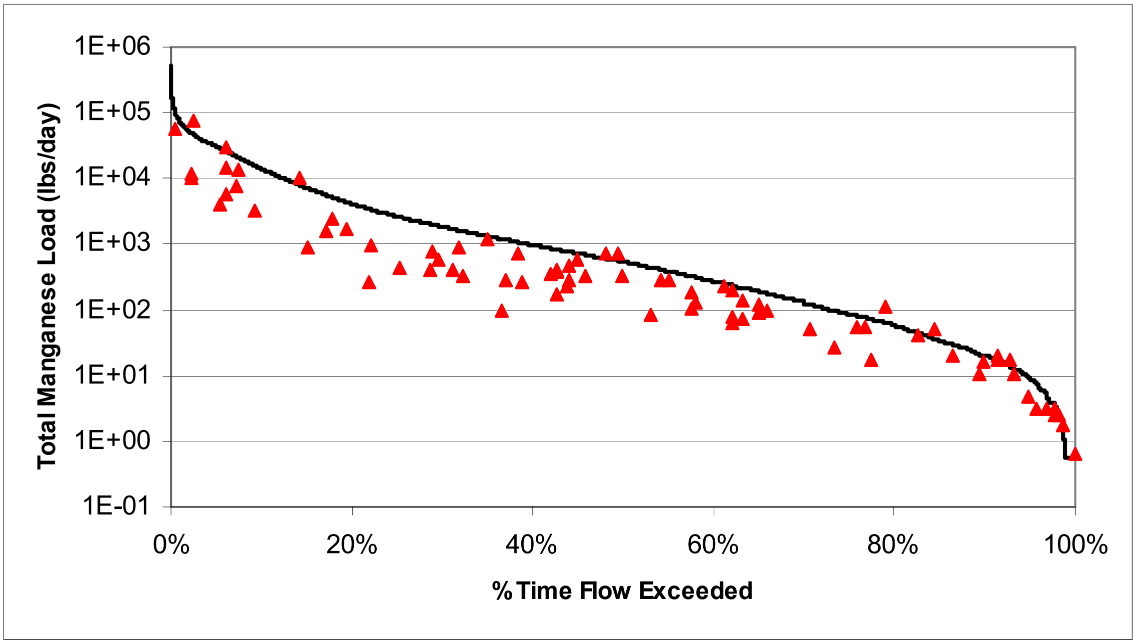

Figure 3. Manganese Load Duration Curve for Skillet Fork (IL_CA-03) with Observed Loads (triangles)

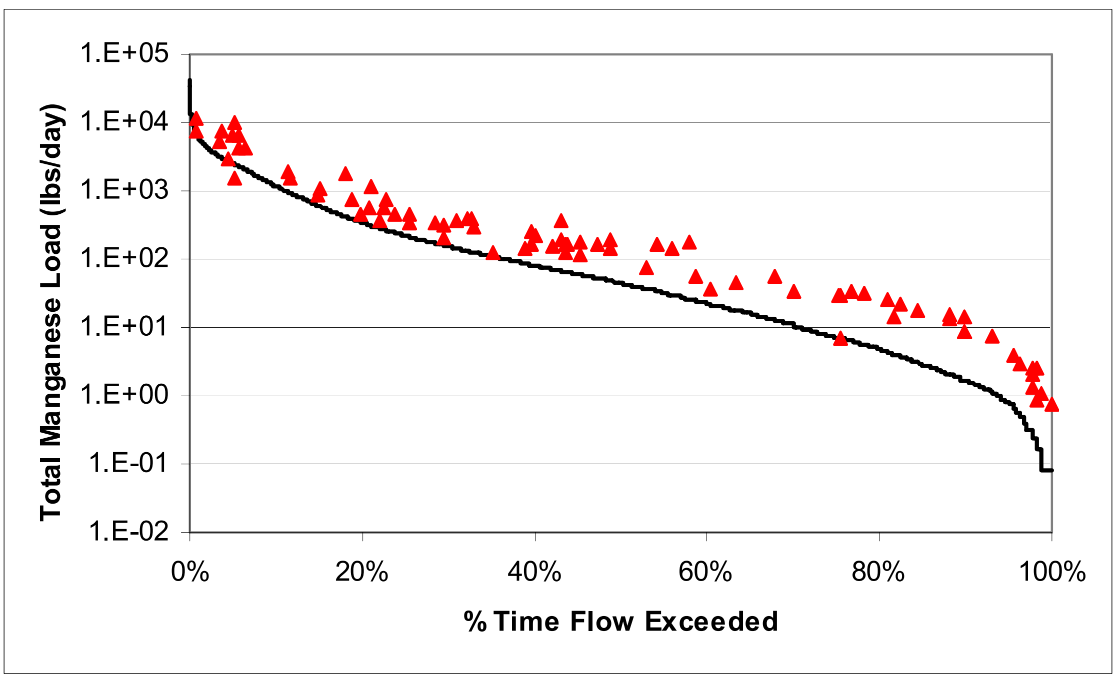

Figure 4. Manganese Load Duration Curve for Skillet Fork (IL_CA-05) with Observed Loads (triangles)

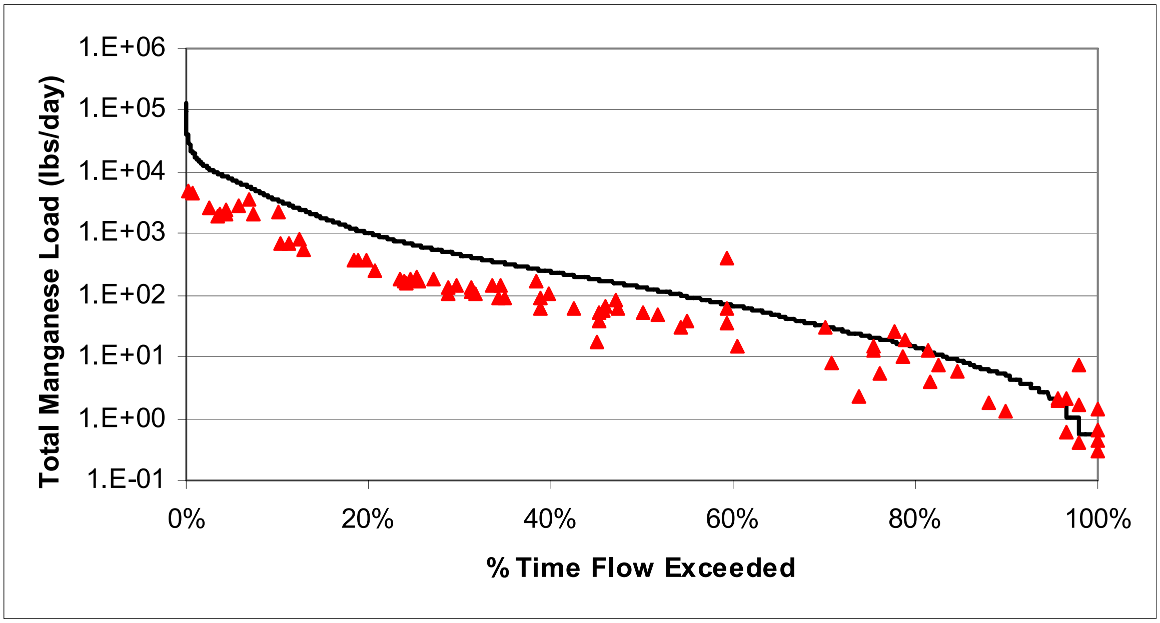

Figure 5. Manganese Load Duration Curve for Skillet Fork (IL_CA-06) with Observed Loads (triangles)

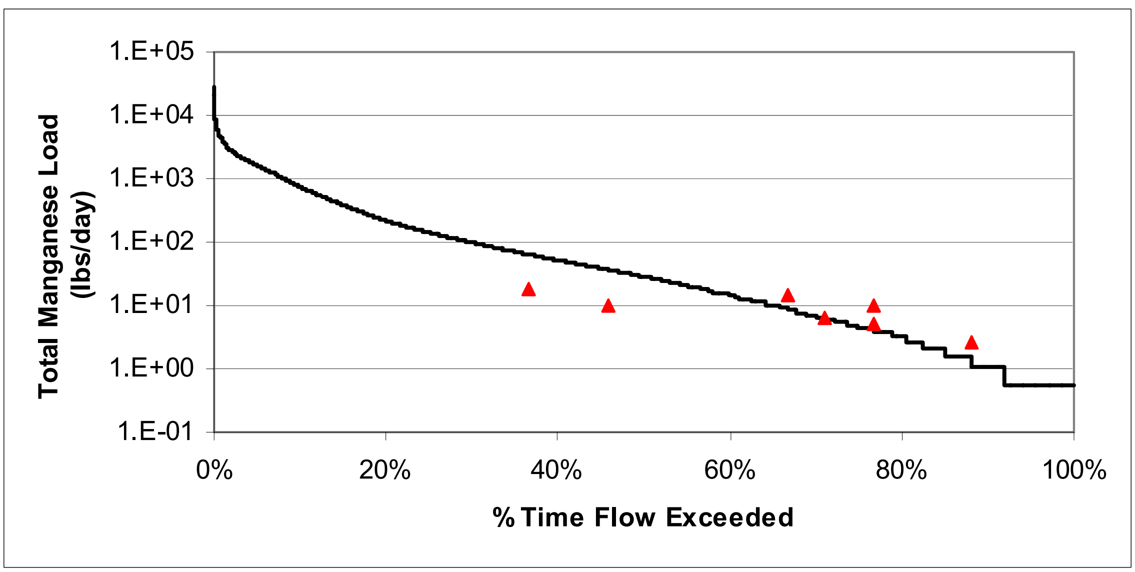

Figure 6. Manganese Load Duration Curve for Brush Creek (IL_CAR-01) with Observed Loads (triangles)

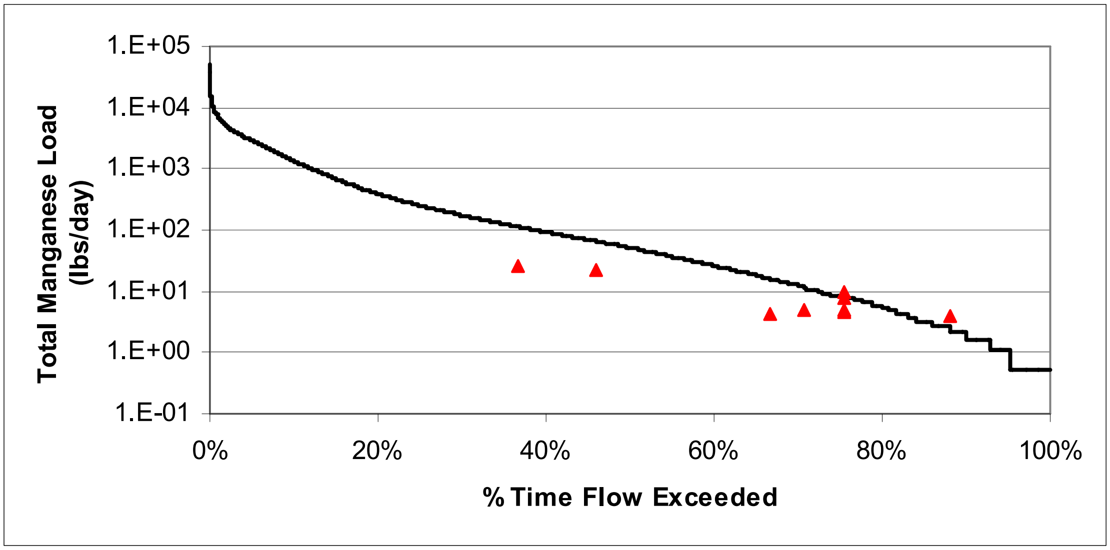

Figure 7. Manganese Load Duration Curve for Horse Creek (IL_CAN-01) with Observed Loads (triangles)

In Figures 3 and 4, the data show that exceedances of the manganese targets occur over the range of observed flows in Skillet Fork segments IL_CA-03 and IL_CA-05. This indicates that both dry and wet weather sources contribute to observed violations of the water quality standard. In Figures 5 through 7, the data show exceedances of the manganese targets occurring in the lower range of flows. This indicates that dry weather sources, such as groundwater contribute to observed violations of the water quality standard.

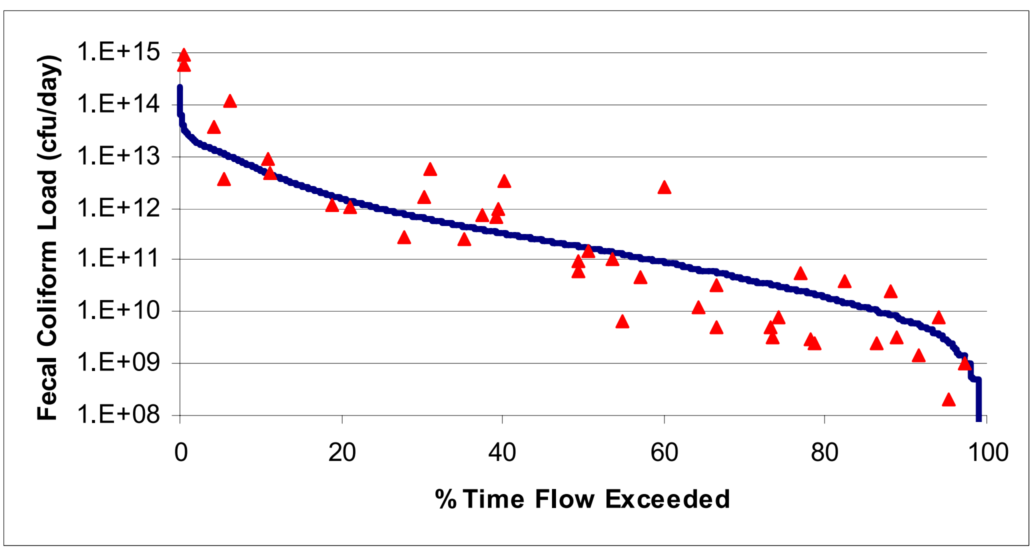

Figure 8. Fecal Coliform Load Duration Curve for Skillet Fork (IL_CA-05) with Observed Loads (triangles)

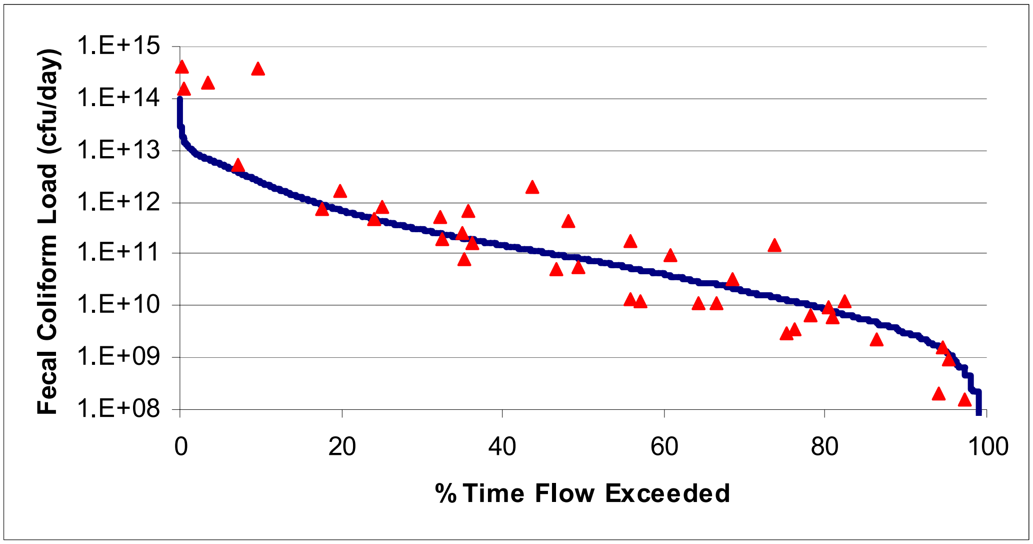

Figure 9. Fecal Coliform Load Duration Curve for Skillet Fork (IL_CA-06) with Observed Loads (triangles)

Figures 8 and 9 indicate that observed loads exceed the target over the range of flows, with the exception being at very low flows, where the target is met. These results indicate both wet and dry weather sources are contributing to violations of the fecal coliform target.

5.3 pH APPROACH

The pH TMDL did not require application of a model.

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6. TMDL DEVELOPMENT

This section presents the development of the total maximum daily load for the impaired waterbodies in Skillet Fork watershed. It begins with a description of how the total loading capacity was calculated, and then describes how the loading capacity is allocated among point sources, non-point sources, and the margin of safety. A discussion of critical conditions and seasonality considerations is also provided.

6.1 DISSOLVED OXYGEN

A dissolved oxygen assessment was conducted for four segments of Skillet Fork (IL_CA-03, IL_CA-05, IL_CA-06, IL_CA-09), Brush Creek (IL_CAR-01), Dums Creek (IL_CAW-04) and Horse Creek (IL-CAN-01). Results of these assessments indicate that low stream flows and existing sediment oxygen demand preclude attainment of dissolved oxygen standards, even in the complete absence of external pollutant loads. For this reasons, no TMDLs are being developed for dissolved oxygen. Details of the assessments are discussed below

6.1.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

The first step in determining the loading capacity was to reduce external sources of oxygen-demanding substances (BOD and ammonia) to determine whether these reductions would result in the river attaining the dissolved oxygen target.[1].

QUAL2E simulations showed that, even with permitted loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results showed that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit, and that DO standards could only be attained during critical periods via reduction of SOD[2].

6.2 FECAL COLIFORM TMDL

A load capacity calculation approach was applied to support development of a fecal coliform TMDL for two Skillet Fork segments (IL_CA-05 and IL_CA-06)

6.2.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

[1] This modeling target considers observed diurnal variation and ensures that the 5.0 mg/L water quality standard is met.

[2] Although SOD is the dominant source of the oxygen deficit, the true cause of low dissolved oxygen is a lack of base flow (which greatly exacerbates the effect of SOD). Because TMDLs cannot be written to control flow, the focus of this TMDL was instead on SOD, as its effect on dissolved oxygen is dominant under low flow conditions.

6.2.1.a *Skillet Fork (IL_CA-05)*

The loading capacity for Skillet Fork segment IL_CA-05 was defined over a range of specified flows based on expected Skillet Fork flows. The allowable loading capacity was computed by multiplying flow by the TMDL target (200 cfu/100 mL). The fecal coliform loading capacity for IL_CA-05 is presented in Table 2.

Table 2. Fecal Coliform Load Capacity (IL_CA-05)

Skillet Fork Flow (cfs)	Allowable Load (cfu/day)
5	2.45E+10
10	4.89E+10
50	2.45E+11
100	4.89E+11
200	9.79E+11
400	1.96E+12
600	2.94E+12
800	3.91E+12
1000	4.89E+12

The maximum fecal coliform concentrations recorded between May and October were examined for each flow duration interval, as shown in Table 3, in order to estimate the percent reduction in existing loads required to meet the 200 cfu/100 mL target. As shown in Table 3, a greater reduction is needed at higher river flows to meet the target. During these higher flow periods, fecal coliform measurements were observed to exceed 200 cfu/100 mL more frequently.

Table 3. Required Reductions in Existing Loads under Different Flow Conditions (IL_CA-05)

Flow Percentile Interval	Skillet Fork Flow (cfs)	# samples > 200/ # samples (May-Oct)	Maximum fecal coliform concentration (cfu/100 ml)	Percent Reduction to Meet Target
0-30	132 - 45,000	6/10	5700	96%
30-60	18 - 132	7/14	5900	97%
60-100	0 - 18	5/19	580	66%

6.2.1.b *Skillet Fork (IL_CA-06)*

The loading capacity for Skillet Fork segment IL_CA-06 was defined over a range of specified flows based on expected Skillet Fork flows. The allowable loading capacity was computed by multiplying flow by the TMDL target (200 cfu/100 ml). The fecal coliform loading capacity for IL_CA-06 is presented in Table 4.

Table 4. Fecal Coliform Load Capacity (IL_CA-06)

Skillet Fork Flow (cfs)	Allowable Load (cfu/day)
2	1.10E+10
4	2.19E+10
22	1.10E+11
45	2.19E+11
90	4.39E+11
179	8.77E+11
269	1.32E+12
359	1.75E+12
448	2.19E+12

The maximum fecal coliform concentrations recorded between May and October were examined for each flow duration interval, as shown in Table 5, in order to estimate the percent reduction in existing loads required to meet the 200 cfu/100 ml target. As shown below, a greater reduction is needed at higher river flows to meet the target. During these higher flow periods, fecal coliform measurements were observed to exceed 200 cfu/100 ml more frequently.

Table 5. Required Reductions in Existing Loads under Different Flow Conditions (IL_CA-06)

Flow Percentile Interval	Skillet Fork Flow (cfs)	# samples > 200/ # samples	Maximum fecal coliform concentration (cfu/100 ml)	Percent Reduction to Meet Target
0-30	59 - 20,200	7/9	30,800	99%
30-60	8 - 59	6/13	3,300	94%
60-100	0 - 8	6/19	2,100	90%

6.2.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

6.2.2.a *Skillet Fork (IL_CA-05)*

The WLA for the six point source discharges in the Skillet Fork segment IL_CA-05 watershed was calculated based on the permitted design average flow for these dischargers and a fecal coliform concentration that is consistent with meeting the TMDL target (200 cfu/100mL). For those facilities with disinfection exemptions, the WLA is based on the dischargers meeting 200 cfu/100 mL at the downstream end of their exempted reach. WLAs are presented in Table 6.

Table 6. Segment IL_CA-05 Permitted Dischargers and WLAs

NPDES ID	Facility Name	Disinfection exemption?	Design average flow (MGD)	Permit expiration date	WLA (cfu/day)
IL0046957	Bluford STP	Year-round since 1989	0.06	12-31-10	4.55E+08
IL0068977	IL DNR-Stephen Forbes State Park Shower Bldg STP	No	0.004	7-31-10	3.03E+07
IL0073903	IL DNR Stephen Forbes State Park Concession Bldg.	No	0.006	8-31-10	4.55E+07
ILG580029	Xenia STP	Year-round since 1990	0.055	12-31-07	4.17E+08
ILG580146	Iuka STP	Year-round since 1993	0.043	12-31-07	3.26E+08
ILG580220	Wayne City South STP	Year-round since 1994	0.19	12-31-07	1.44E+09

The total WLA for the six (6) point source dischargers in the IL_CA-05 watershed is 2.71E+09 cfu/day.

The remainder of the loading capacity is given to the load allocation for nonpoint sources as an implicit MOS was used in this TMDL (Table 7). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall fecal coliform load.

Table 7. Fecal Coliform TMDL for Segment IL_CA-05 Skillet Fork[1]

Flow (cfs)	Allowable Load (cfu/day)	Wasteload Allocation (WLA) (cfu/day)*	Load Allocation (LA) (cfu/day)
5	2.45E+10	2.71E+09	2.18E+10
10	4.89E+10	2.71E+09	4.62E+10
50	2.45E+11	2.71E+09	2.42E+11
100	4.89E+11	2.71E+09	4.87E+11
200	9.79E+11	2.71E+09	9.76E+11
400	1.96E+12	2.71E+09	1.95E+12
600	2.94E+12	2.71E+09	2.93E+12
800	3.91E+12	2.71E+09	3.91E+12
1000	4.89E+12	2.71E+09	4.89E+12

[1]This TMDL has an implicit Margin of Safety, so MOS is not included in this table.

6.2.2.b *Skillet Fork (IL_CA-06)*

The WLA for the four point source discharges in the Skillet Fork segment IL_CA-06 watershed was calculated based on the permitted design flow for these dischargers and a fecal coliform concentration that is consistent with meeting the TMDL target (200 cfu/100mL). For those facilities with disinfection exemptions, the WLA is based on the dischargers meeting 200 cfu/100 mL at the downstream end of their exempted reach. WLAs are presented in Table 8.

Table 8. Segment IL_CA-06 Permitted Dischargers and WLAs

NPDES ID	Facility Name	Disinfection exemption?	Design average flow (MGD)	Permit expiration date	WLA (cfu/day)
IL0068977	IL DNR-Stephen Forbes State Park Shower Bldg STP	No	0.004	7-31-10	3.03E+07
IL0073903	IL DNR Stephen Forbes State Park Concession Bldg.	No	0.006	8-31-10	4.55E+07
ILG580029	Xenia STP	Year-round since 1990	0.055	12-31-07	4.17E+08
ILG580146	Iuka STP	Year-round since 1993	0.043	12-31-07	3.26E+08

The total WLA for the four (4) point source dischargers in the IL_CA-06 watershed is 8.18E+08 cfu/day.

The remainder of the loading capacity is given to the load allocation for nonpoint sources as an implicit MOS was used in this TMDL (Table 9). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall fecal coliform load.

Table 9. Fecal Coliform TMDL for Segment IL_CA-06 Skillet Fork[1]

Flow (cfs)	Allowable Load (cfu/day)	Wasteload Allocation (WLA) (cfu/day)*	Load Allocation (LA) (cfu/day)
2	1.10E+10	8.18E+08	1.02E+10
4	2.19E+10	8.18E+08	2.11E+10
22	1.10E+11	8.18E+08	1.09E+11
45	2.19E+11	8.18E+08	2.19E+11
90	4.39E+11	8.18E+08	4.38E+11
179	8.77E+11	8.18E+08	8.77E+11
269	1.32E+12	8.18E+08	1.32E+12
359	1.75E+12	8.18E+08	1.75E+12
448	2.19E+12	8.18E+08	2.19E+12

[1]This TMDL has an implicit Margin of Safety, so MOS is not included in this table.

6.2.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Figure 8 and 9 provide a graphical depiction of the data compared to the load capacity, showing that exceedances of the TMDL target occur over the full range of flow conditions. TMDL development utilizing the load-duration approach applies to the full range of flow conditions; therefore critical conditions were addressed during TMDL development.

6.2.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The load capacity calculation approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in any given point in the season where the standard applies.

6.2.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The fecal coliform TMDL contains an implicit margin of safety, through the use of multiple conservative assumptions. First, the TMDL target (no more than 200 cfu/100 mL at any point in time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 mL for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. This margin of safety can be reviewed in the future as new data are developed.

6.3 MANGANESE TMDL

A load capacity calculation approach was applied to support development of manganese TMDLs for Skillet Fork (IL_CA-03, IL_CA-05 and IL_CA-06), Brush Creek (IL_CAR-01), and Horse Creek (IL_CAN-01).

6.3.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. The loading capacity was defined over a range of specified flows based on expected flows. The allowable loading capacity was computed by multiplying flow by the TMDL target concentration. The manganese loading capacities for three segments of Skillet Fork (IL_CA-03, IL_CA-05 and IL_CA-06), Brush Creek (IL_CAR-01) and Horse Creek (IL_CAN-01) are presented below.

6.3.1.a *Skillet Fork (IL_CA-03)*

The manganese loading capacity for Skillet Fork (IL_CA-03) was calculated based on Skillet Fork flows and the TMDL target for manganese of 1,000 µg/L (Table 10).

Table 10. Manganese Load Capacity (IL_CA-03)

Skillet Fork Flow (cfs)	Allowable Load (lbs/day)
11	61
23	122
113	611
226	1,221
453	2,443
906	4,885
1,359	7,328
1,811	9,771
2,264	12,213

The maximum manganese concentrations were examined for each flow duration interval, as shown in Table 11, in order to estimate the percent reduction in existing loads required to meet the 1,000 µg/L target. Reductions of up to 41% in current loads are needed at both lower and higher river flows to meet the target.

Table 11. Required Reductions in Existing Loads under Different Flow Conditions (IL_CA-03)

Flow Percentile Interval	Skillet Fork Flow (cfs)	# samples > 1,000/# samples	Maximum manganese concentration (µg/L)	Percent Reduction to Meet Target
0-20	760 – 97000	3 / 16	1700	41%
20-40	180 – 760	0 / 14	870	0%
40-60	50 – 180	2 / 18	1300	23%
60-80	11 – 50	1 / 19	1700	41%
80-100	0.1 – 11	4 / 18	1400	29%

6.3.1.b *Skillet Fork (IL_CA-05)*

The manganese loading capacity for Skillet Fork (IL_CA-05) was calculated based on Skillet Fork flows and the TMDL target for manganese of 150 µg/L (Table 12).

Table 12. Manganese Load Capacity (IL_CA-05)

Skillet Fork Flow (cfs)	Allowable Load (lbs/day)
5	4.0
10	8.1
50	40.5
100	80.9
200	161.8
400	323.6
600	485.4
800	647.3
1000	809.1

The maximum manganese concentrations were examined for each flow duration interval, as shown in Table 13, in order to estimate the percent reduction in existing loads required to meet the 150 µg/L target. Reductions of up to 91% in current loads are needed at both lower and higher river flows to meet the target.

Table 13. Required Reductions in Existing Loads under Different Flow Conditions (IL_CA-05)

Flow Percentile Interval	Skillet Fork Flow (cfs)	# samples > 150/# samples	Maximum manganese concentration (µg/L)	Percent Reduction to Meet Target
0-20	420 – 54,000	17 / 18	660	77%
20-40	100 – 420	20 / 20	560	73%
40-60	28 – 100	17 / 17	1000	85%
60-80	6 – 28	8 / 9	820	82%
80-100	0.1 – 6	18 / 18	1600	91%

6.3.1.c *Skillet Fork (IL_CA-06)*

The manganese loading capacity for Skillet Fork (IL_CA-06) was calculated based on Skillet Fork flows and the TMDL target for manganese of 1,000 µg/L (Table 14).

Table 14. Manganese Load Capacity (IL_CA-06)

Skillet Fork Flow (cfs)	Allowable Load (lbs/day)
2	10.8
4	21.6
22	118.7
45	242.7
90	485.4
179	965.5
269	1,450.9
359	1,936.4
448	2,416.4

The maximum manganese concentrations were examined for each flow duration interval, as shown in Table 15, in order to estimate the percent reduction in existing loads required to meet the 1,000 µg/L target. A greater reduction is needed at lower river flows to meet the target. During these lower flow periods, manganese measurements were observed to exceed 1,000 µg/L more frequently. Reductions of up to 86% in current loads are needed.

Table 15. Required Reductions in Existing Loads under Different Flow Conditions (IL_CA-06)

Flow Percentile Interval	Skillet Fork Flow (cfs)	# samples > 1,000/# samples	Maximum manganese concentration (µg/L)	Percent Reduction to Meet Target
0-20	190 -- 24000	0 / 18	660	0%
20-40	45 – 190	0 / 22	640	0%
40-60	12 – 45	1 / 15	5300	81%
60-80	2.7 – 12	2 / 10	1400	29%
80-100	0.1 -- 2.7	5 / 17	7000	86%

6.3.1.d *Brush Creek (IL_CAR-01)*

The manganese loading capacity for Brush Creek (IL_CAR-01) was calculated based on estimated Brush Creek flows and the TMDL target for manganese of 1,000 µg/L (Table 16).

Table 16. Manganese Load Capacity (IL_CAR-01)

Brush Creek Flow (cfs)	Allowable Load (lbs/day)
0.2	1.1
0.6	3.2
3	16.2
10	53.9
40	215.8
140	755.1
5000	26,968.9

The maximum manganese concentrations were examined for each flow duration interval, as shown in Table 17, in order to estimate the percent reduction in existing loads required to meet the 1,000 µg/L target. A greater reduction is needed at lower river flows to meet the target. During these lower flow periods, manganese measurements were observed to exceed 1,000 µg/L more frequently. Reductions of up to 57% in current loads are needed.

Table 17. Required Reductions in Existing Loads under Different Flow Conditions (IL_CAR-01)

Flow Percentile Interval	Brush Creek Flow (cfs)	# samples > 1,000/# samples	Maximum manganese concentration (µg/L)	Percent Reduction to Meet Target
0-60	2.7 -- 5000	0 / 2	290	0%
60-100	0.1 – 2.7	4 / 5	2300	57%

6.3.1.e *Horse Creek (IL_CAN-01)*

The manganese loading capacity for Horse Creek (IL_CAN-01) was calculated based on estimated Horse Creek flows and the TMDL target for manganese of 1,000 µg/L (Table 18).

Table 18. Manganese Load Capacity (IL_CAN-01)

Horse Creek Flow (cfs)	Allowable Load (lbs/day)
0.3	1.6
1	5.4
5	27.0
20	107.9
70	377.6
250	1,348.4
9,500	51,240.9

The maximum manganese concentrations were examined for each flow duration interval, as shown in Table 19, in order to estimate the percent reduction in existing loads required to meet the 1,000 µg/L target. A greater reduction is needed at lower river flows to meet the target. During these lower flow periods, manganese measurements were observed to exceed 1,000 µg/L more frequently. Reductions of up to 33% in current loads are needed.

Table 19. Required Reductions in Existing Loads under Different Flow Conditions (IL_CAN-01)

Flow Percentile Interval	Horse Creek Flow (cfs)	# samples > 1,000/# samples	Maximum manganese concentration (µg/L)	Percent Reduction to Meet Target
0-75	1.5 – 9500	0 / 4	420	0%
75-100	0.1 – 1.5	2 / 5	1500	33%

6.3.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

6.3.2.a *Skillet Fork (IL_CA-03)*

There are no permitted dischargers of manganese in the Skillet Fork segment IL_CA-03 watershed, and therefore the wasteload allocation did not need to be calculated.

The remainder of the loading capacity is given to the load allocation for nonpoint sources and the MOS (Table 20). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall manganese load.

Table 20. Manganese TMDL for Skillet Fork (Segment IL_CA-03)

Flow (cfs)	Allowable Load (lbs/day)	MOS (10%) (lbs/day)	Wasteload Allocation (WLA) (lbs/day)	Load Allocation (LA) (lbs/day)
11	61	6	0	55
23	122	12	0	110
113	611	61	0	550
226	1,221	122	0	1,099
453	2,443	244	0	2,198
906	4,885	489	0	4,397
1,359	7,328	733	0	6,595
1,811	9,771	977	0	8,794
2,264	12,213	1,221	0	10,992

6.3.2.b *Skillet Fork (IL_CA-05)*

There are no permitted dischargers of manganese in the Skillet Fork segment IL_CA-05 watershed, and therefore the wasteload allocation did not need to be calculated.

The remainder of the loading capacity is given to the load allocation for nonpoint sources and the MOS (Table 21). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall manganese load.

Table 21. Manganese TMDL for Skillet Fork (Segment IL_CA-05)

Flow (cfs)	Allowable Load (lbs/day)	MOS (10%) (lbs/day)	Wasteload Allocation (WLA) (lbs/day)	Load Allocation (LA) (lbs/day)
5	4.0	0.40	0.00	3.64
10	8.1	0.81	0.00	7.28
50	40.5	4.05	0.00	36.41
100	80.9	8.09	0.00	72.82
200	161.8	16.18	0.00	145.63
400	323.6	32.36	0.00	291.26
600	485.4	48.54	0.00	436.90
800	647.3	64.73	0.00	582.53
1000	809.1	80.91	0.00	728.16

6.3.2.c *Skillet Fork (IL_CA-06)*

There are no permitted dischargers of manganese in the Skillet Fork segment IL_CA-06 watershed, and therefore the wasteload allocation did not need to be calculated.

The remainder of the loading capacity is given to the load allocation for nonpoint sources and the MOS (Table 22). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall manganese load.

Table 22. Manganese TMDL for Skillet Fork (Segment IL_CA-06)

Flow (cfs)	Allowable Load (lbs/day)	MOS (10%) (lbs/day)	Wasteload Allocation (WLA) (lbs/day)	Load Allocation (LA) (lbs/day)
2	10.8	1.1	0.00	10
4	21.6	2.2	0.00	19
22	118.7	11.9	0.00	107
45	242.7	24.3	0.00	218
90	485.4	48.5	0.00	437
179	965.5	96.5	0.00	869
269	1,450.9	145.1	0.00	1,306
359	1,936.4	193.6	0.00	1,743
448	2,416.4	241.6	0.00	2,175

6.3.2.d *Brush Creek (IL_CAR-01)*

There are no permitted dischargers of manganese in the Brush Creek (Segment IL_CAR-01) watershed, and therefore the wasteload allocation did not need to be calculated.

The remainder of the loading capacity is given to the load allocation for nonpoint sources and the MOS (Table 23). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall manganese load.

Table 23. Manganese TMDL for Brush Creek(Segment IL_CAR-01)

Flow (cfs)	Allowable Load (lbs/day)	MOS (10%) (lbs/day)	Wasteload Allocation (WLA) (lbs/day)	Load Allocation (LA) (lbs/day)
0.2	1.1	0.1	0.00	0.97
0.6	3.2	0.3	0.00	2.91
3	16.2	1.6	0.00	14.56
10	53.9	5.4	0.00	48.54
40	215.8	21.6	0.00	194.18
140	755.1	75.5	0.00	679.62
5,000	26,968.9	2,696.9	0.00	24271.99

6.3.2.e *Horse Creek (IL_CAN-01)*

There are no permitted dischargers of manganese in the Horse Creek (Segment IL_CAN-01) watershed, and therefore the wasteload allocation did not need to be calculated.

The remainder of the loading capacity is given to the load allocation for nonpoint sources and the MOS (Table 24). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall manganese load.

Table 24. Manganese TMDL for Horse Creek (Segment IL_CAN-01)

Flow (cfs)	Allowable Load (lbs/day)	MOS (lbs/day)	Wasteload Allocation (WLA) (lbs/day)	Load Allocation (LA) (lbs/day)
0.3	1.6	0.2	0.00	1.5
1	5.4	0.5	0.00	4.9
5	27.0	2.7	0.00	24.3
20	107.9	10.8	0.00	97.1
70	377.6	37.8	0.00	339.8
250	1,348.4	134.8	0.00	1,213.6
9,500	51,240.9	5,124.1	0.00	46,116.8

6.3.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Figures 3 through 7 provide a graphical depiction of the data compared to the load capacity, showing that exceedances of the TMDL target largely occur over the full range of flow conditions. TMDL development utilizing the load-duration approach applies to the full range of flow conditions; therefore critical conditions were addressed during TMDL development.

6.3.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The manganese standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the river.

6.3.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The manganese TMDL contains a combination of both types. An implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no loss of manganese that enters the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDL also contains an explicit margin of safety of 10%. This 10% margin of safety was included in addition to the implicit margin of safety to address potential uncertainty in the effectiveness of load reduction alternatives. This margin of safety can be reviewed in the future as new data are developed.

6.4 pH TMDL

A pH TMDL was developed for three segments of Skillet Fork (IL_CA-03, IL_CA-05, and IL_CA-06).

6.4.1 Calculation of Loading Capacity

Because pH is not a load, but rather a measure of acidity and/or alkalinity of a given solution, this TMDL uses an *other appropriate measure* (40 CFR section 130.2(i)) rather than an actual mass-per-unit time measure. For this TMDL, the State's numeric pH criterion (6.5 – 9.0 SU) is used as the TMDL target. Thus, the TMDL ensures that both point and nonpoint source activities meet the pH criterion at the point of discharge.

6.4.1.a *Skillet Fork (IL_CA-03)*

Within the Skillet Fork (IL_CA-03) watershed, 3 of 99 (3%) pH measurements taken between 1994 and 2005 were below the 6.5 SU minimum water quality standard. None of the measurements exceeded the 9.0 SU maximum water quality standard. The pH measurements were collected downstream of the point source dischargers, therefore point sources are a potential source. In addition to the point sources, naturally acidic soils in the watershed, described in the Stage 1 report are a potential source contributing to low instream pH.

6.4.1.b *Skillet Fork (IL_CA-05)*

Within the Skillet Fork (IL_CA-05) watershed, 7 of 89 (8%) pH measurements taken between 1994 and 2005 were below the 6.5 SU minimum water quality standard. None of the measurements exceeded the 9.0 SU maximum water quality standard. The pH measurements were collected downstream of the point source dischargers, therefore point sources are a potential source. In addition to the point sources, naturally acidic soils in the watershed, described in the Stage 1 report are a potential source contributing to low instream pH.

6.4.1.c *Skillet Fork (IL_CA-06)*

Within the Skillet Fork (IL_CA-06) watershed, 9 of 88 (10%) pH measurements taken between 1994 and 2005 were below the 6.5 SU minimum water quality standard. None of the measurements exceeded the 9.0 SU maximum water quality standard. The pH measurements were collected downstream of the point source dischargers, therefore point sources are a potential source. In addition to the point sources, naturally acidic soils in the watershed, described in the Stage 1 report are a potential source contributing to low instream pH.

6.4.2 Allocation

A TMDL consists of wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

6.4.2.a *Skillet Fork (IL_CA-03)*

Within the IL_CA-03 watershed, the pH target for nonpoint sources equals 6.5 – 9.0 standard units (SU). The pH target for the fifteen NPDES permitted dischargers with pH permit limits equals 6.5 – 9.0 SU (the current pH permit limit for these facilities is 6.0 –

9.0 SU). These point source dischargers are shown in Table 25. Because segment IL_CA-03 is the most downstream segment of Skillet Fork, many of the dischargers located in this segment's watershed, are also found within the watersheds for upstream segments (e.g., IL_CA-05, IL_CA-06). As such, some of these dischargers appear in more than one table.

Table 25. Point Sources with a pH Limit for Skillet Fork (Segment IL_CA-03)

NPDES ID	Facility Name
IL0004294	Trunkline Gas Co.-Johnsonville
IL0024643	Beaver Creek School STP
IL0046957	Bluford STP
IL0054496	Springerton STP
IL0068977	IL DNR-S.A. Forbes State Park Shower Bldg STP
IL0073903	IL DNR Stephen Forbes State Park Concession Bldg.
ILG580029	Xenia STP
ILG580080	Dahlgren STP
ILG580105	Enfield West STP
ILG580108	Enfield East STP
ILG580129	Belle Rive STP
ILG580146	Iuka STP
ILG580195	Mill Shoals STP
ILG580220	Wayne City South STP
IL0068829	IL DOT-I64 Jefferson Co West STP

The Margin of Safety for this segment is discussed in section 6.4.5.

6.4.2.b *Skillet Fork (IL_CA-05)*

Within the IL_CA-03 watershed, the pH target for nonpoint sources equals 6.5 – 9.0 SU. The pH target for the seven NPDES permitted dischargers with pH permit limits equals 6.5 – 9.0 SU (the current permit limits for these facilities are 6.0 – 9.0 SU). These point source dischargers are shown in Table 26.

Table 26. Point Sources with a pH Limit for Skillet Fork (Segment IL_CA-05)

NPDES ID	Facility Name
IL0004294	Trunkline Gas Co.-Johnsonville
IL0046957	Bluford STP
IL0068977	IL DNR-S.A. Forbes State Park Shower Bldg STP
IL0073903	IL DNR Stephen Forbes State Park Concession Bldg.
ILG580029	Xenia STP
ILG580146	Iuka STP
ILG580220	Wayne City South STP

The Margin of Safety for this segment is discussed in section 6.4.5.

6.4.2.c *Skillet Fork (IL_CA-06)*

Within the IL_CA-03 watershed, the pH target for nonpoint sources equals 6.5 – 9.0 SU. The pH target for the four NPDES permitted dischargers with pH permit limits equals 6.5 – 9.0 SU (the current permit limits for these facilities are 6.0 – 9.0 SU). These point source dischargers are presented in Table 27.

Table 27. Point Sources with a pH Limit for Skillet Fork (Segment IL_CA-06)

NPDES ID	Facility Name
IL0068977	IL DNR-S.A. Forbes State Park Shower Bldg STP
IL0073903	IL DNR Stephen Forbes State Park Concession Bldg.
ILG580029	Xenia STP
ILG580146	Iuka STP

The Margin of Safety for this segment is discussed in section 6.4.5.

6.4.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. TMDL development utilizing this approach applies to the full range of environmental conditions; therefore critical conditions were addressed during TMDL development.

6.4.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The pH allocations will be applicable for all seasons to ensure the target is met throughout the year.

6.4.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. This pH TMDL incorporates an implicit margin of safety. The allocations used in this TMDL ensure that point and nonpoint sources must individually meet the pH target of 6.5 to 9.0 SU. If both point and nonpoint sources are consistent with these allocations, then water quality standards in Skillet Fork segment CA-03, CA-05, and CA-06 will be met.

7. PUBLIC PARTICIPATION AND INVOLVEMENT

The TMDL process included numerous opportunities for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to notify stakeholders about the upcoming TMDLs, and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (see the Stage 1 Report). As quarterly progress reports were produced during the first stage of the TMDL process, the Agency posted them to their website for public review.

The draft Stage 1 Report for this watershed was available to the public for review beginning in December 2004. In February 2005, a public meeting was announced for presentation of the Stage 1 findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Monday, March 14, 2005 in Wayne City, Illinois at the Community Center. In addition to the meeting's sponsors, 18 individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage 1 findings by LimnoTech. This was followed by a general question and answer session.

The draft TMDL and Implementation Plan for this watershed was posted on the IEPA website and a public meeting was held at 6:00 pm on Thursday July 19, 2007 in Wayne City, Illinois at the Community Center. Attendees registered and listened to a presentation on the Stage 3 findings by LimnoTech. This was followed by a general question and answer session.

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8. IMPLEMENTATION PLAN

Total Maximum Daily Loads (TMDLs) were developed for the Skillet Fork watershed, to address a number of water quality impairments in the listed streams. Specifically, TMDLs were developed for manganese for Skillet Fork (IL_CA-03, IL_CA-05, IL_CA-06), Brush Creek (IL_CAR-01) and Horse Creek (IL_CAN-01), for fecal coliform for Skillet Fork (IL_CA-05, IL_CA-06), and for pH for Skillet Fork (IL_CA-03, IL_CA-05 and IL_CA-06). Dissolved oxygen assessments were also completed for Skillet Fork (IL_CA-03, IL_CA-05, IL_CA-06, IL_CA-09), Brush Creek (IL_CAR-01), Dums Creek (IL_CAW-04) and Horse Creek (IL_CAN-01). The dissolved oxygen assessment determined that low flow was the cause of the low dissolved oxygen and TMDLs were not completed for dissolved oxygen. The TMDLs that were completed, determined that significant reductions in existing fecal coliform and manganese loadings were needed to meet water quality objectives. Low pH was determined to be caused by natural background conditions or permitted point sources. The next step in the TMDL process is to develop an implementation plan that includes both accountability and the potential for adaptive management. This section identifies a number of alternative actions to be considered by local stakeholders for TMDL implementation; these alternative actions are summarized, and recommendations are presented for implementation actions and additional monitoring.

8.1 EXISTING CONTROLS

The local Natural Resource Conservation Service (NRCS), Farm Service Agency (FSA), and Soil and Water Conservation District (SWCD) offices have information on existing best management practices within the watershed, and can be contacted to understand what efforts have been made or are planned to control nonpoint sources.

Prior to TMDL development, information on land uses and agricultural practices was obtained as part of the Watershed Characterization (LTI, 2005). Information on participation in the Conservation Reserve Program (CRP) was obtained through calls to county agencies. It was estimated that there are:

- 20,000-30,000 acres in Jefferson County in the CRP (Jefferson County NRCS);
- 13,000 acres in White County (White County FSA);
- 33,000 acres in Hamilton County in the CRP (Hamilton County FSA), with most of these located in the northwest part of the county;
- 50,000 acres in Wayne County in the CRP (Wayne Co. NRCS); and
- many CRP acres in Marion County, especially in the Skillet Fork watershed due to the poorer soils in the county (Marion County SWCD).

Note that these area estimates are for the entire county rather than the portion of the county that was in the Skillet Fork watershed. Watershed-specific estimates were not available.

8.2 IMPLEMENTATION APPROACH

The approach to be taken for TMDL development and implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps, with the first three steps corresponding to TMDL development and the latter two steps corresponding to implementation:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply appropriate models (e.g. QUAL2E) to define the load-response relationship and determine the maximum allowable pollutant load that the lakes can assimilate and still attain water quality standards.
3. Compare the maximum allowable load to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards.
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.
5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. The Association of Illinois Soil and Water Conservation Districts (SWCDs), using Section 319 grant funding, have made available a Watershed Liaison to provide educational, informational, and technical assistance to local agencies and communities. The liaison can assist in establishing local watershed planning groups, as well as acting as an overall facilitator for coordination between local, state, and Federal agencies.

The adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there are never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps One through Three described above have been completed; this plan represents Step Four of the process. Step Five is briefly described in the last section of this document, and will be conducted as implementation proceeds.

8.3 IMPLEMENTATION ALTERNATIVES

Based on the objectives for the TMDLs, information obtained at the public meetings, and experience in other watersheds, a number of alternatives have been identified for the implementation phase of these TMDLs. As discussed earlier in this plan, a number of BMPs, including filter strips, grade stabilization structures, ponds, and conservation tillage, have been implemented in this watershed (LTI, 2004). No comprehensive inventory of BMPs was identified in preparing this plan and it is not known whether any study of the effectiveness of the BMPs has been undertaken.

For the dissolved oxygen assessment, the primary cause of low D.O. was determined to be low flow. Implementation alternatives are therefore focused on improving aeration, improving flow rate and decreasing water temperature. The alternatives include:

- Conservation Buffers
- Streambank Enhancement and Protection

For the pH TMDLs, implementation alternatives were focused on controlling point source discharges and reducing the contributions from naturally acidic soils:

- Conservation Buffers
- Streambank Enhancement and Protection
- Sediment Control Basins
- Grassed Waterways
- Conservation Tillage
- Wetland Restoration
- Point Source Controls

For the manganese TMDLs, the primary sources are natural sources, including soils and groundwater. As described below, these sediments are also the cause of sedimentation/siltation, TSS, and phosphorus impairments in Skillet Fork, Brush Creek, and Horse Creek and the phosphorus impairment in Skillet Fork, and implementation measures are focused on ways to control erosion. The load duration curve analysis demonstrated that manganese reductions are needed over the full range of flows. Soils naturally enriched in manganese can settle in the river and contribute to manganese exceedances during low flow, anoxic conditions, as the metal is released into the water column. The extent to which this mechanism contributes to the low flow exceedances of manganese is not known; however, controls targeted at reducing wet weather loads manganese may also reduce sedimentation and subsequent release during low flow periods.

Fine sediments covering the stream substrate (sedimentation/siltation) reduce suitable habitat for fish and other biological communities by filling in pools and reducing available cover for juvenile and adult fish. Sedimentation of riffle areas compromises reproductive success of fish communities by covering gravel substrate necessary for spawning conditions. The filling in of riffle areas also affects the fish communities' food source, macroinvertebrates, which have difficulty thriving in areas with predominately sand and silt substrate as opposed to a substrate composed of gravel, cobble/rubble, and sand mixture. In addition, sedimentation (TSS) can increase turbidity in the water column, causing reduced light penetration necessary for photosynthesis in aquatic plants, reduced feeding capacity of aquatic macroinvertebrates due to clogged gilled surfaces, and reduce the visibility of predator fish species to find prey. Sedimentation can impact the physical attributes of the stream and act as a transport mechanism for other pollutants that will impact the water chemistry.

Phosphorus enters the stream mainly bound to soil particles that transport it during runoff from overgrazed pastures adjacent to the stream channel, and nutrient rich manure spread within close proximity of the stream. Phosphorus loading in water bodies can cause eutrophication of streams and reservoirs, and is characterized by excessive plant growth, dense algal growth, and higher fluctuations of DO levels due to algal oxygen production during photosynthesis, consumption of oxygen during respiration at night, and bacterial consumption of oxygen in the decaying process of dead algae and plant material. Severe dissolved oxygen fluctuations stress fish and aquatic insects.

Implementation alternatives for manganese, sedimentation/siltation, TSS and phosphorus were focused on measures to reduce erosion, including:

- Conservation Buffers
- Streambank Enhancement and Protection
- Sediment Control Basins
- Grassed Waterways
- Conservation Tillage
- Wetland Restoration

For the fecal coliform TMDLs, implementation alternatives focused on livestock, failing septic systems, and permitted point sources:

- Point Source Controls
- Private Sewage Disposal System Inspection and Maintenance Program
- Restriction of Livestock Access
- Conservation Buffers
- Wetland Restoration

Each of these alternatives is described briefly in this section, including information about their costs and effectiveness in reducing loadings of the constituents of concern. Costs have been updated from their original sources, based on literature citations, to 2006 costs using the Engineering News Record Construction Cost Index, as provided by the Natural Resource Conservation Service (NRCS)[3]. Some of the measures described below are most applicable to a single pollutant, while others will have broader applicability.

It should be noted that there is usually a wide range in the effectiveness of the various practices; this is largely due to variations in climate, soils, crops, topography, design, construction, and maintenance of the practices (NRCS, 2006).

8.3.1 Conservation Buffers

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants (NRCS, 1999), generally by slowing the rate of runoff, while filtering sediment and nutrients. Additional benefits may include the creation of wildlife habitat, improved aesthetics, and potential economic benefits from marketing specialty forest crops (Trees Forever, 2005). This category of controls includes buffer strips, field borders, filter strips, vegetative barriers, riparian buffers, etc. (NRCS, 1999).

Filter strips and similar vegetative control methods can be very effective in reducing sediment transport to streams. The relative gross effectiveness of filter strips in reducing sediment has been reported as 65% (EPA, 2003). Vegetated filter strips and riparian buffers can also be used to reduce bacteria; riparian buffer zones have bacteria removal efficiencies of 43-57% (Commonwealth of Virginia, 2003).

Conservation buffers can help stabilize a stream and reduce its water temperature (NRCS, undated). Riparian buffers can work to improve instream dissolved oxygen concentrations by promoting increased infiltration and baseflow, and by lowering stream temperature.

[3] http://www.economics.nrcs.usda.gov/cost/priceindexes/index.html

Costs of conservation buffers vary from about $200/acre for filter strips of introduced grasses or direct seeding of riparian buffers, to approximately $360/acre for filter strips of native grasses or planting bare root riparian buffers, to more than $1,030/acre for riparian buffers using bare root stock shrubs (NRCS, 2005).

The Conservation Practices Cost-Share Program (CPP), part of the Illinois Conservation 2000 Program, provides cost sharing for conservation practices including field borders and filter strips (http://www.agr.state.il.us/Environment/conserv/index.html). The Department of Agriculture distributes funding for the cost-share program to Illinois' soil and water conservation districts (SWCDs), which prioritize and select projects. The Illinois Buffer Partnership offers cost sharing for installation of streamside buffer plantings at selected sites. An additional program that may be of interest is the Visual Investments to Enhance Watersheds (VIEW), which involves a landscape design consultant in the assessment and design of targeted BMPs within a watershed. Sponsored by Trees Forever (www.treesforever.org), VIEW guides a committee of local stakeholders through a watershed landscape planning process (Trees Forever, 2005). Additional funding for conservation buffers may be available through other sources such as the Conservation Reserve Program.

8.3.2 Streambank Enhancement and Protection

Erosion of the banks and beds of tributary streams is a potentially significant source of sediment to the waterbodies in the Skillet Fork Watershed. This sediment load contributes to the manganese impairments and possibly the pH impairments given the acidic nature of the local soils. Further, it can also increase fecal coliform loads. Streambank stabilization, including grade stabilization to reduce erosive velocities and shear stresses, is a key measure in reducing loads.

A recent aerial assessment report of Skillet Fork noted extensive channelization, severely incised channels, and geotechnical problems throughout Skillet Fork (IDOA, 2005). This study recommends additional study in the downstream areas (approximately 5 miles in length), and grade control structures and bank stabilization practices, including rock riffle grade controls and stone toe protection, in the remainder of the stream. Using costs presented in the report, the estimated cost to stabilize the segments described is approximately $14 million

Because of the potential cost of stabilizing streambanks throughout the watershed, additional study is recommended to prioritize sites for streambank stabilization. Such study should include direct observations of bank conditions, as well as an assessment of stream hydraulics and geomorphology to support identification and design of effective stabilization measures.

8.3.3 Sediment Control Basins

Sediment control basins trap sediments (and constituents bound to that sediment) before they reach surface waters (EPA, 2003). As the pH and manganese impairments have been attributed to natural contributions from local soils, sediment control basins could help reduce loads from these sources. Basins could be installed throughout the watershed, in areas selected to minimize disruption to existing croplands. Costs for these basins can vary widely depending on location and size; estimates prepared for another Illinois watershed range from $1,200 to more than $200,000 per basin (Zahniser Institute, undated). This same study estimated a trapping efficiency for sediment of 75%. Siting considerations and costs are driven mainly by the size of the basin required, land availability, and land acquisition costs.

8.3.4 Grassed Waterways

Grassed waterways are another alternative to consider for this watershed. A grassed waterway is a natural or constructed channel that is planted with suitable vegetation to reduce erosion (NRCS, 2000). Grassed waterways are used to convey runoff without causing erosion or flooding, to reduce gully erosion, and to improve water quality. They may be used in combination with filter strips, and are effective at reducing soil loss, with typical reductions between 60 and 80 percent (Lin et al, 1999). Grassed waterways cost approximately $1,800/acre, not including costs for tile or seeding (MCSWCD, 2006).

8.3.5 Conservation Tillage

The objective of conservation tillage is to provide profitable crop production while minimizing soil erosion (UIUC, 2005). This reduction in erosion also reduces the amount of other constituents such as manganese lost from the land and delivered to waterbodies. The Natural Resources Conservation Service (NRCS) has replaced the term conservation tillage with the term crop residue management, or the year-round management of residue to maintain the level of cover needed for adequate control of erosion. This often requires more than 30% residue cover after planting (UIUC, 2005). Conservation tillage/crop residue management systems are recognized as cost-effective means of significantly reducing soil erosion and maintaining productivity. The most recent Illinois Soil Transect Survey (IDOA, 2004) suggests that approximately 77% of land under soybean production and 71% of the land in small grain production in the Skillet Fork watershed is farmed using reduced till, mulch till, or no-till, while approximately 52% of corn fields are farmed with conventional methods. Additional conservation tillage measures could be considered as part of this implementation plan, particularly for cornfields.

Conservation tillage practices have been reported to reduce sediment loads by 75% (EPA, 2003). A wide range of costs has been reported for conservation tillage practices, ranging from $12/acre to $83/acre in capital costs (EPA, 2003). For no-till, costs per acre provided in the Illinois Agronomy Handbook for machinery and labor range from $36 to $66 per acre, depending on the farm size and planting methods used (UIUC, 2005). In general, the total cost per acre for machinery and labor decreases as the amount of tillage decreases and farm size increases (UIUC, 2005).

8.3.6 Wetland Restoration

Wetland restoration involves the rehabilitation of a drained or degraded wetland to its natural condition, including its vegetation, soils and hydrology. Wetland restoration can be an effective BMP for reducing loads of sediments, nutrients and other pollutants (Johnston et al., 1990; Braskerud et al., 2005).

A wetland restoration project may be as simple as breaking drain tiles and blocking drainage ditches, or it may require more engineering effort to restore hydrology and hydric vegetation communities. In addition to improving water quality, wetland restoration provides additional benefits for flood control, habitat and recreation. Costs for wetland restoration vary widely, depending on the acreage, the nature of the work, and land/easement costs. However, a general unit cost of $500 to $1,200 per acre has been suggested (FWS, 2006) for simple restoration projects in Illinois.

8.3.7 Point Source Controls

There are six sewage treatment operations (STPs) with the potential to discharge fecal coliform in the watershed upstream of the sampling stations on various stream segments (LTI, 2006). Two of these STPs have a permit limit specified for fecal coliform. Available discharge monitoring data were reviewed for these two facilities and no fecal violations were noted. The four facilities without fecal coliform limitations currently have disinfection exemptions, and as such do not employ a disinfection process that would reduce fecal coliform counts in their effluents. IEPA will examine disinfection exemptions as part of TMDL implementation.

All six NPDES permitted dischargers have permit limits for pH, and for carbonaceous biochemical oxygen demand (CBOD); two also have permit limits for ammonia nitrogen, which also exerts an oxygen demand. Available discharge monitoring data were reviewed for these facilities and no permit violations were noted. None of the discharges has limits for manganese, however. IEPA will evaluate the need for additional point source controls through the NPDES permitting program; permits might need to be modified to ensure consistency with the WLA. Table 28 presents a summary of the six point sources in the Skillet Fork watershed and relevant permit information.

Table 28. Point Source Summary

Facility Name (NPDES ID)	Permit limits					Permit Expiration Date
	CBOD5 mg/L	**Ammonia** mg/L	**Fecal coliform** #/100 mL	**pH** S.U.	**Manganese**	
Bluford STP (IL0046957)	25 month avg. 40 weekly avg.	N/A	Year-round disinfection exemption	6.0 – 9.0	N/A	12/31/2010
Xenia STP (ILG580029)	25 month avg. 40 weekly avg.	N/A	Year-round disinfection exemption	6.0 – 9.0	N/A	12/31/2007
IL DNR-S.A. Forbes State Park Shower Building STP (IL0068977)	10 month avg. 20 daily max.	Apr-Oct: 1.5 avg 3.0 max Nov-Feb: 4.0 avg 8.0 max Mar: 3.5 avg 8.0 max	400 max.	6.0 – 9.0	N/A	10/31/2004
IL DNR-S.A. Forbes State Park Concession Building STP (IL0073903)	10 month avg. 20 daily max.	Apr-May: 2.3 avg 8.6 week 13.1 max Jun-Aug: 2.3 avg 8.1 week 13.1 max Sep-Oct: 2.3 avg 8.6 week 13.1 max Nov-Feb: 4.0 avg 15.0 max Mar: 3.5 avg 8.6 week 15.0 max	400 max.	6.0 – 9.0	N/A	8/31/2010
Iuka STP (ILG580146)	25 month avg. 40 weekly avg.	N/A	Year-round disinfection exemption	6.0 – 9.0	N/A	12/31/2007
Wayne City South STP (IL0068829)	25 month avg. 40 weekly avg.	N/A	Year-round disinfection exemption	6.0 – 9.0	N/A	12/31/2007

N/A – no applicable permit limits

8.3.8 Private Sewage Disposal System Inspection and Maintenance Program

All county health departments serving the Skillet Fork watershed were contacted during the early stages of the TMDL project (LTI, 2005). Based on calls made to the county health departments, it was determined that most of the urbanized areas are served by public sewer, with areas outside municipal boundaries served primarily by private septic systems. None of the county health officials contacted were able to estimate the percent of septic systems that are failing, and many noted that they only inspect a system if a complaint is made about it. Very few complaints (1-2 per year at most) have been received by the health departments. Several county health departments (Marion, Jefferson/Wayne, and Egyptian (White)) mentioned that there might be straight pipes in the watershed; however, none had an estimate of how many were in existence.

IEPA is developing a permitting program for individual private sewage disposal systems. The proposed general permit is intended to minimize discharges to the ground surface and receiving waters, and includes requirements designed to protect surface waters (IEPA, 2006).

A more proactive program to maintain functioning systems and address nonfunctioning systems could be developed to minimize the potential for releases from private sewage disposal systems. The U.S. EPA has developed guidance for managing private sewage disposal systems (EPA, 2005). This guidance includes procedures for assessing existing conditions, assessing public health and environmental risks, selecting a management approach, and implementing a management program (including funding information).

This alternative would require the commitment of staff time for County Health Department personnel; cost depends on whether the additional inspection activities could be accomplished by existing staff or would require additional personnel.

8.3.9 Restrict Livestock Access to Lake and Tributaries

Livestock are a source of bacteria, and are present within the Skillet Fork watershed (LTI, 2004). In addition, livestock can cause or exacerbate streambank erosion and trample riparian buffers. The 2002 Census of Agriculture (USDA, 2002) indicates there are several thousand livestock head in the counties making up the Skillet Fork watershed, including in the vicinity of these segments of Skillet Fork and upstream in the watershed. Several hog concentrated animal feeding operations (CAFOs) are located in White County (LTI, 2004). Telephone calls to local agencies suggested that most cattle within the watershed might be free range, with perhaps one-third or fewer fenced away from local waterbodies.

One recommended component of TMDL implementation would be to restrict livestock access to the creek. This could be accomplished by fencing and installation of alternative systems for livestock watering. Livestock exclusion and other grazing management measures have been shown to reduce fecal coliform counts by 29 to 46% (EPA, 2003). The principal direct costs of providing grazing practices range from relatively low variable costs of dispersed salt blocks to higher capital and maintenance costs of supplementary water supply improvements. Improving the distribution of grazing pressure by developing a planned grazing system or strategically locating water troughs, salt, or feeding areas to draw cattle away from riparian zones can result in improved utilization of existing forage, better water quality, and improved riparian habitat. Fencing costs are estimated as $3,500 to $4,000 per mile (USEPA, 2003). Capital costs for pipeline watering range from $0.32 to $2.60 per foot, while watering tanks and troughs range from $291 to $1,625 each (EPA, 2003).

8.4 IDENTIFYING PRIORITY AREAS FOR CONTROLS

Priority areas for locating controls were identified through a review of available information. Information reviewed included: tributary water quality data; an aerial assessment report; and GIS-based information. Based on this review, it is recommended that streambank stabilization be initiated in the Skillet Fork watershed to reduce bank erosion, and that this work occur concurrently with watershed controls in priority areas. Additional data collection is also recommended, to help focus control efforts.

8.4.1 Tributary Monitoring

Available water quality data obtained as part of the Stage 1 Watershed Characterization work were reviewed and little tributary monitoring data were identified. Additional data collection is therefore recommended to help understand where loads are being generated in the watershed and focus control efforts. Specific data collection recommendations are provided in the Monitoring and Adaptive Management section later in this Implementation Plan.

8.4.2 Aerial Assessment Report

A recent aerial assessment report of Skillet Fork noted extensive channelization, severely incised channels, and geotechnical problems throughout Skillet Fork (IDOA, 2005). This study recommends additional study in the downstream areas (approximately 5 miles in length), and grade control structures and bank stabilization practices, including rock riffle grade controls and stone toe protection, in the remainder of the stream. Using costs presented in the report, the estimated cost to stabilize the segments described is approximately $14 million.

Because of the potential cost of stabilizing streambanks throughout the watershed, additional study is recommended to prioritize sites for streambank stabilization. Such study should include direct observations of bank conditions, as well as an assessment of stream hydraulics and geomorphology to support identification and design of effective stabilization measures.

8.4.3 GIS Analysis

GIS soils, land use and topography data were analyzed to identify areas that are expected to generate the highest sediment and associated pollutant loads. Within the GIS, maps were generated to show areas with steep slopes, defined as slopes greater than 9%, and highly erodible soils; these maps are included as Figure 10 and Figure 11, respectively. Finally, priority areas for best management practices (BMPs) were defined as agricultural areas that have both steep slopes and highly erodible soils, and these are shown in Figure 12. These maps serve as a good starting point for selecting areas to target for implementing control projects, to maximize the benefit of the controls. Other locations that should be investigated for control projects are those that have either erodible soils or steep slopes, because both of these characteristics make soil more prone to erosion.

GIS analysis was also used to investigate the presence of hydric soils in the watershed to determine whether wetland restoration or creation is a viable option within this watershed. To support this analysis, areas having hydric soils, which are not already developed, forested, or covered by water or wetlands were identified. A significant proportion (30%) of the Dums Creek watershed was identified as being potentially suitable for wetland restoration or creation. Although data on hydric soils were not available for all counties, using available data it was determined that at least 15% of the soils in the Skillet Fork watershed are potentially suitable for wetland restoration or creation. Lesser areas were identified in the Brush Creek and Horse Creek watersheds, about 11% and 5%, respectively. These areas are shown in Figure 13.

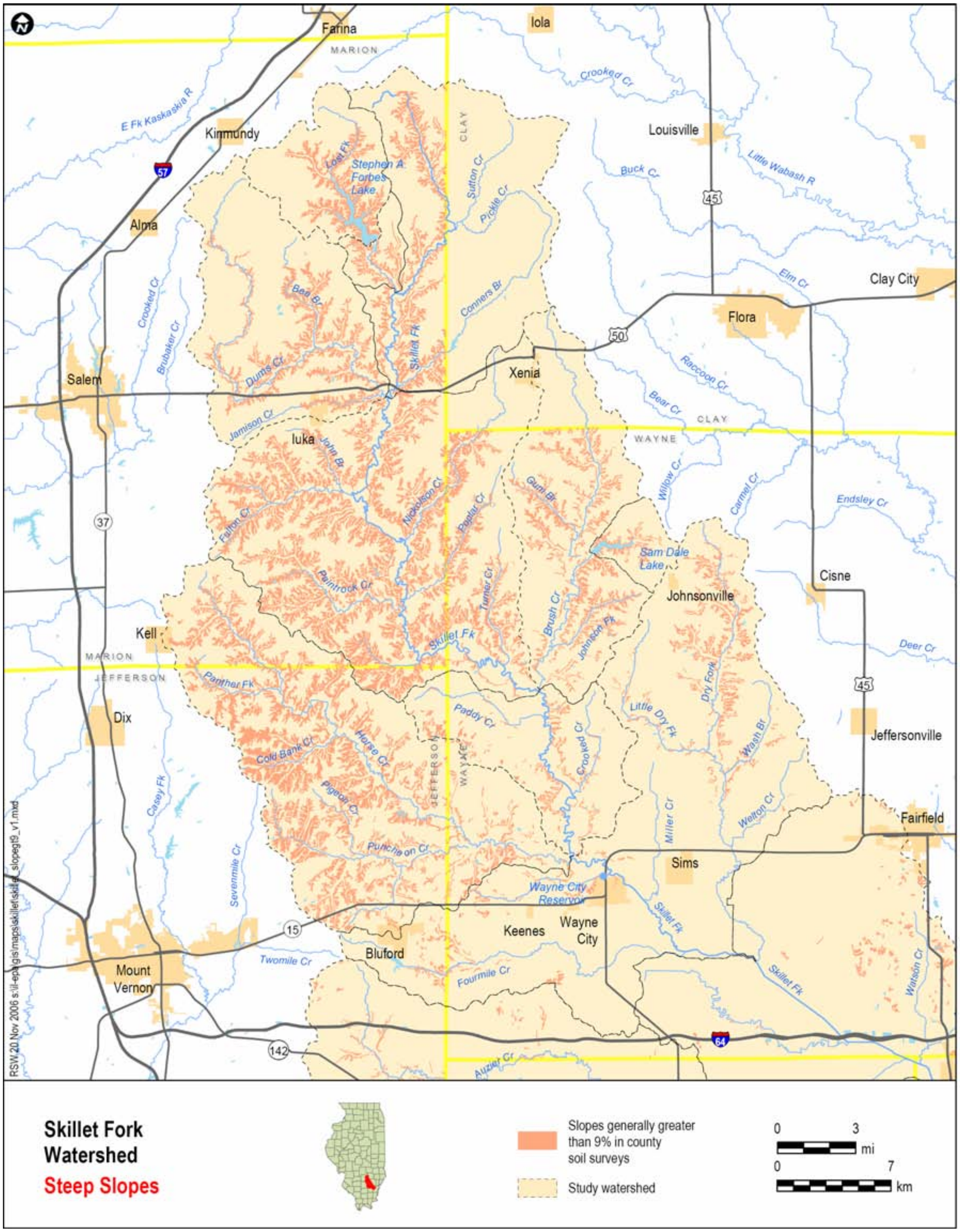

Figure 10. Areas with Steep Slopes

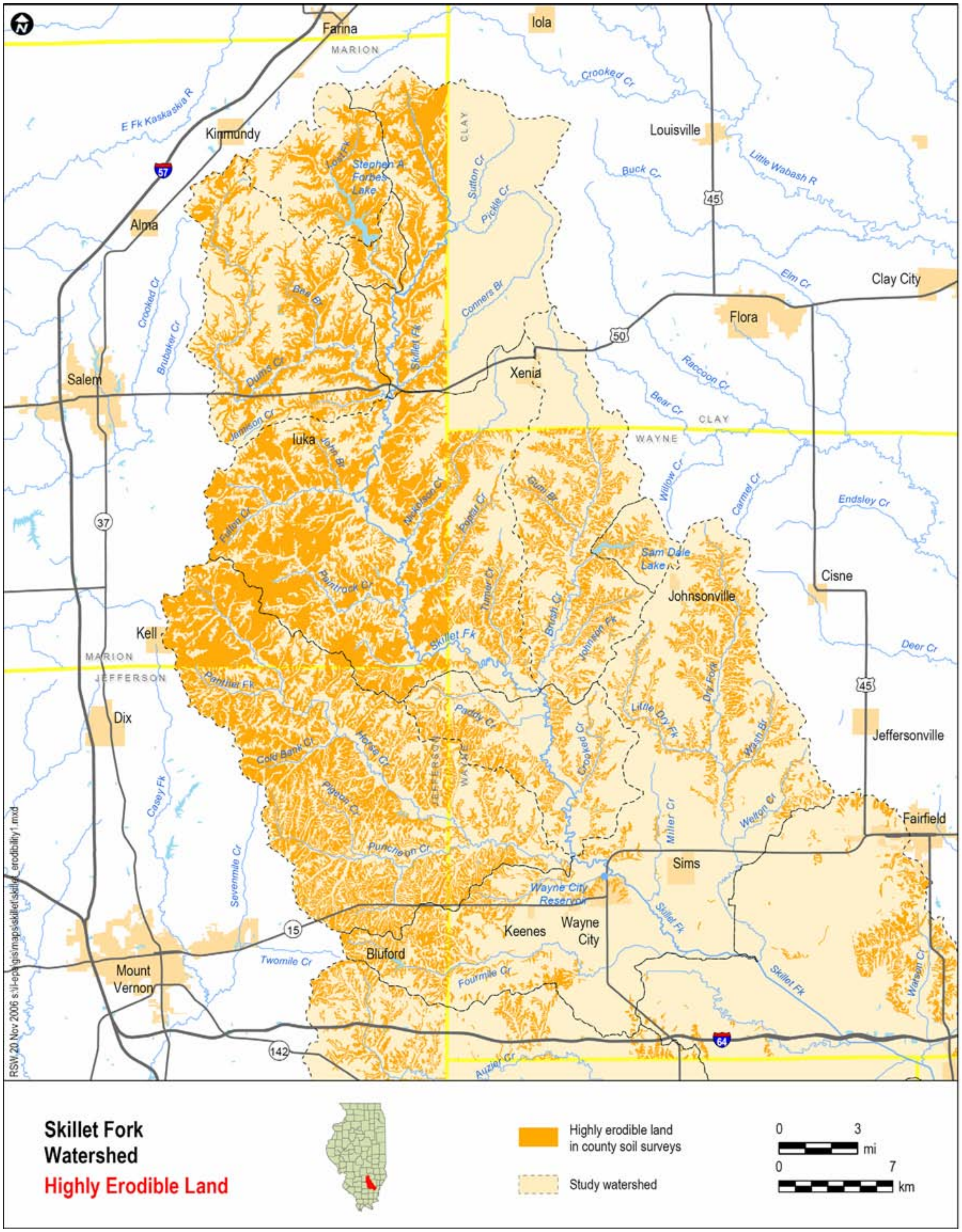

Figure 11. Areas of Highly Erodible Land

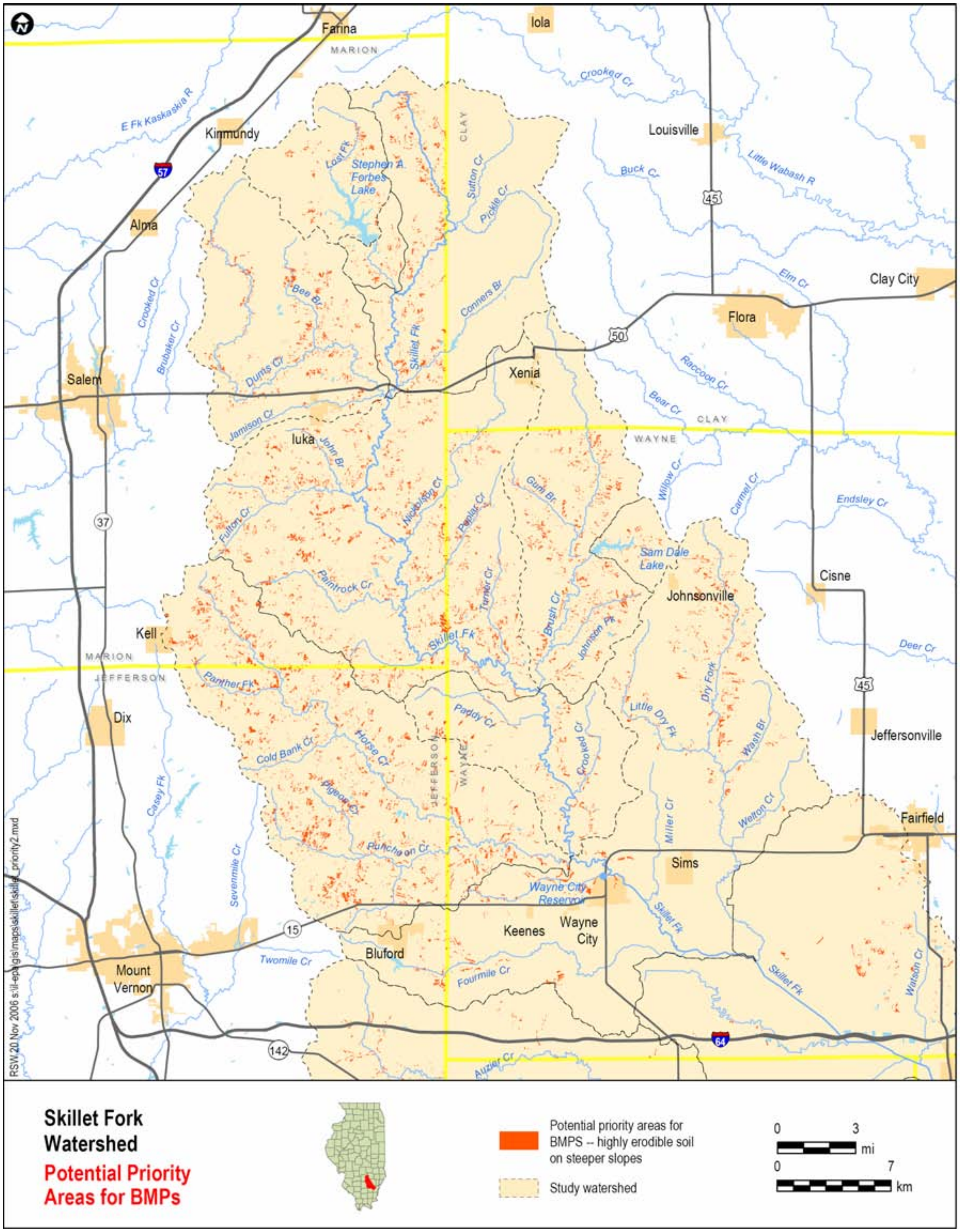

Figure 12. Potential Priority Areas for BMPs

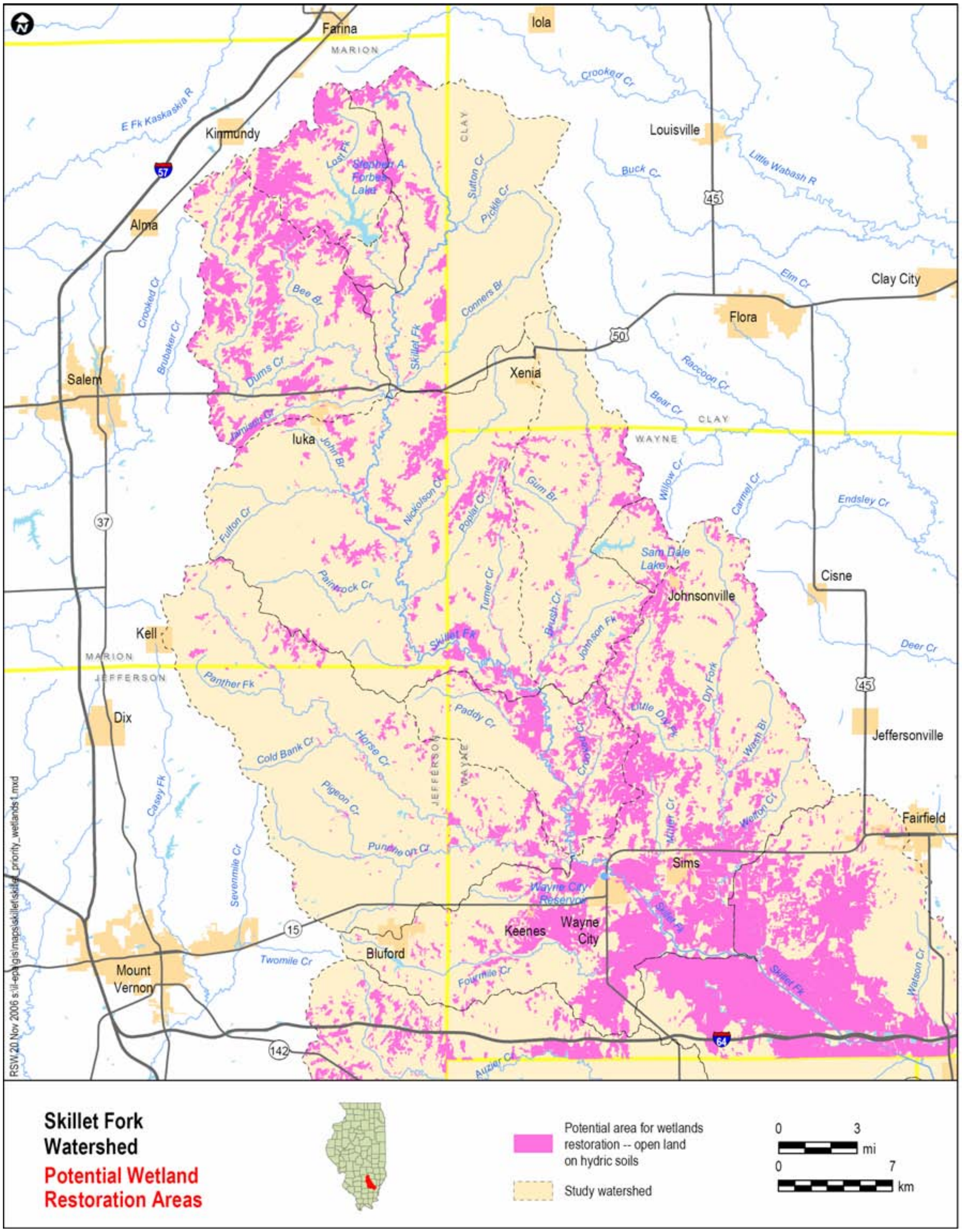

Figure 13. Potential Wetland Restoration Areas

8.5 REASONABLE ASSURANCE

The U.S. EPA requires states to provide reasonable assurance that the load reductions identified in the TMDL will be met. Reasonable assurance for point sources means that NPDES permits will be consistent with any applicable wasteload allocation contained in the TMDL. In terms of reasonable assurance for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permits for the point source dischargers in the watershed will be modified if necessary to ensure they are consistent with the applicable wasteload allocations presented in the TMDL. Permit information for these facilities is summarized in Table 29.

Table 29. Permitted Dischargers

NPDES ID	Facility Name	Disinfection exemption?	Average design flow (MGD)	Permit expiration date
IL0046957	Bluford STP	Year-round since 1989	0.06	12-31-10
IL0068977	IL DNR-Stephen Forbes State Park Shower Bldg STP	No	0.004	7-31-10
IL0073903	IL DNR Stephen Forbes State Park Concession Bldg.	No	0.006	8-31-10
ILG580029	Xenia STP	Year-round since 1990	0.055	12-31-07
ILG580146	Iuka STP	Year-round since 1993	0.043	12-31-07
ILG580220	Wayne City South STP	Year-round since 1994	0.19	12-31-07

For nonpoint sources, reasonable assurance means that nonpoint source controls are specific to the pollutant of concern, implemented according to an expeditious schedule and supported by reliable delivery mechanisms and adequate funding (U.S. EPA, 1999).

One of the most important aspects of implementing nonpoint source controls is obtaining adequate funding to implement voluntary or incentive-based programs. Funding is available from a variety of sources, including those listed below. It should be noted that the programs listed are based on the 2002 Farm Bill, which expires on September 30, 2007. It is currently unknown what conservation programs will be included in a future farm bill.

- *Illinois Nutrient Management Planning Program*, cosponsored by the Illinois Department of Agriculture (IDOA) and IEPA (http://www.agr.state.il.us/Environment/LandWater/tmdl.html). This program targets funding to Soil and Water Conservation Districts (SWCDs) for use in impaired waters. The nutrient management plan practice cost share is only available to landowners/operators with land in TMDL watersheds. The dollar amount allocated to each eligible SWCD is based on their portion of the total number of cropland acres in eligible watersheds.

- *Clean Water Act Section 319 grants* to address nonpoint source pollution (http://www.epa.state.il.us/water/financial-assistance/non-point.html). Section 319 of the Clean Water Act provides Federal funding for states for the implementation of approved nonpoint source (NPS) management programs. Funding under these grants has been used in Illinois to finance projects that demonstrate cost-effective solutions to NPS problems. Projects must address water quality issues relating directly to NPS pollution. Funds can be used for the implementation of watershed management plans, including the development of information/education programs, and for the installation of best management practices.

- *Conservation 2000* (http://www.epa.state.il.us/water/conservation-2000/), which funds nine programs across three state natural resource agencies (IEPA, IDOA, and the Department of Natural Resources). Conservation 2000 is a six-year, $100 million initiative designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water resources while providing additional high-quality opportunities for outdoor recreation. This program includes the Priority Lake and Watershed Implementation Program and the Clean Lakes Program.

- *Conservation Practices Cost-Share Program*. (http:/www.agr.state.il.us/Environment/conserv/index.html). Another component of Conservation 2000, the Conservation Practices Program (CPP) focuses on conservation practices, such as terraces, filter strips and grass waterways, that are aimed at reducing soil loss on Illinois cropland. IDOA distributes funding for the cost-share program to Illinois' SWCDs, which prioritize and select projects. Construction costs are divided between the state and landowners.

- *Conservation Reserve Program* administered by the Farm Service Agency (http://www.nrcs.usda.gov/programs/crp/). The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation.

- *Wetlands Reserve Program* (http://www.nrcs.usda.gov/programs/wrp/). NRCS's Wetlands Reserve Program (WRP) is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The NRCS provides technical and financial support to help landowners with their wetland restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection. Figure 13 shows potential wetland restoration areas. These are areas with hydric soils that are not currently developed, covered by water, or forested.

- *Environmental Quality Incentive Program* sponsored by NRCS (general information at http://www.nrcs.usda.gov/PROGRAMS/EQIP/; Illinois information and materials at http://www.il.nrcs.usda.gov/programs/eqip/). The Environmental Quality Incentives Program (EQIP) provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical assistance to eligible participants to install or implement structural and management practices on eligible agricultural land. EQIP may cost-share up to 75 percent of the costs of certain conservation practices (for example, fencing off livestock from stream access, grassed waterways, nutrient management, riparian buffers, and wetland resoration). Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive.

- *Wildlife Habitat Incentives Program* (WHIP) (http://www.il.nrcs.usda.gov/programs/whip/index.html). WHIP is an NRCS program for developing and improving wildlife habitat, primarily on private lands. It provides both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat.
- *Funding for Private Sewage Systems.* EPA guidance (2005) indicates that funding might be available through programs such as the USDA Rural Utilities Service. (http://www.epa.gov/owm/septic/pubs/onsite_handbook.pdf)

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability
- Use the results of future monitoring to conduct adaptive management.

8.6 MONITORING AND ADAPTIVE MANAGEMENT

Future monitoring is needed to assess the effectiveness of different restoration alternatives and to conduct adaptive management. The Illinois EPA conducts a variety of lake and stream monitoring programs (IEPA, 2002) and data available through these programs will be useful for assessing improvement. Ongoing stream monitoring programs include: a statewide 213-station Ambient Water Quality Monitoring Network (AWQMN); an Intensive Basin Survey Program that covers all major watersheds on a five-year rotation basis; and a Facility-Related Stream Survey Program that conducts approximately 20-30 stream surveys each year. Skillet Fork is monitored at three locations (near Carmi, Wayne City, and Iuka) as part of the AWQMN, and is on the Intensive Basin Survey list for 2006 monitoring. Beyond this IEPA monitoring, local agencies and watershed organizations are encouraged to conduct additional monitoring to assess sources of pollutants and evaluate changes in water quality in the lake.

The following monitoring is recommended for fecal coliform to assess sources of bacteria.

- Fecal coliform monitoring in Skillet Fork and major tributaries. This monitoring should be conducted during wet and dry weather because that is when elevated fecal coliform concentrations have been observed. Sites should be selected to include locations downstream of potential fecal coliform loads, such as livestock operations or areas that have higher concentrations of septic systems. Suggested locations for initial monitoring include three tributaries that drain directly to segment CA 06 and monitoring within segment CA 06 to assess water quality from upstream areas:

  - Nickolson Creek at Dago Hill Road;
  - Paintrock Creek at Malachi Road;
  - Poplar Creek at Klomp Road;
  - Skillet Fork segment CA 06 at the River Road bridge or near the end of Seed House Road if access is adequate.

- Fecal coliform monitoring is also recommended at two tributaries to segment CA 05:
  - Four Mile Creek at IL Hwy 242; and
  - Miller Creek at Co. Rd. 600N.

The results of this monitoring will help guide future monitoring and implementation efforts. For example, if elevated fecal coliform concentrations are found in the tributaries, and not at the upstream end of segment CA 06, then implementation efforts should be focused in the tributary watersheds. If elevated fecal coliform concentrations are observed at the upstream end of CA 06, then additional monitoring and implementation efforts should be focused on upstream areas of the watershed.

If elevated fecal coliform concentrations are observed during dry weather, then dry weather monitoring at additional upstream Skillet Fork locations is recommended. Sampling at bridge crossings progressively moving upstream from segment CA 05 will provide insight on spatial trends in fecal concentrations and will help identify stream reaches that are receiving significant fecal loads.

Dry weather fecal coliform monitoring is also recommended in Skillet Fork and tributaries upstream and downstream of the STP outfalls listed in Table 29. This monitoring will help assess the contributions of these sources to the fecal coliform impairment.

These activities will provide additional information to identify or confirm potential sources of the pollutants of concern, and assist in targeting implementation efforts.

In addition to the fecal coliform monitoring discussed above, monitoring for manganese, dissolved oxygen and pH is also recommended to assess the effectiveness of controls as they are implemented. Specifically:

- Manganese monitoring is recommended during dry and wet weather at the following locations:
  - Skillet Fork at station CA 03, CA 05 and CA 06.
  - Horse Creek at station CAN 01
  - Brush Creek at station CAR 01
- Dissolved oxygen monitoring is recommended during dry weather at the following locations:

- Skillet Fork at station CA 03, CA 05, CA 06, and CA 09
- Horse Creek at station CAN 01
- Brush Creek at station CAR 01
- Dums Creek at station CAW 01

- pH monitoring is recommended during dry and wet weather at the following locations:
  - Skillet Fork at station CA 03, CA 05 and CA 06.

Continued monitoring efforts will provide the basis for assessment of the effectiveness of the TMDLs, as well as future adaptive management decisions. As various alternatives are implemented, the monitoring will determine their effectiveness and identify which alternatives should be expanded, and which require adjustments to meet the TMDL goals.

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Attachment 1

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TITLE01             Skillet Fork TMDL
TITLE02             Final Calibration
TITLE03   NO        CONSERVATIVE MINERAL   I
TITLE04   NO        CONSERVATIVE MINERAL  II
TITLE05   NO        CONSERVATIVE MINERAL III
TITLE06   NO        TEMPERATURE
TITLE07  YES        5-DAY BIOCHEMICAL OXYGEN DEMAND
TITLE08   NO        ALGAE AS CHL-A IN UG/L
TITLE09   NO        PHOSPHORUS CYCLE AS P IN MG/L
TITLE10               (ORGANIC-P; DISSOLVED-P)
TITLE11  YES        NITROGEN CYCLE AS N IN MG/L
TITLE12               (ORGANIC-N; AMMONIA-N; NITRITE-N;' NITRATE-N)
TITLE13  YES        DISSOLVED OXYGEN IN MG/L
TITLE14   NO        FECAL COLIFORM IN NO./100 ML
TITLE15   NO        ARBITRARY NON-CONSERVATIVE
ENDTITLE
LIST DATA INPUT
NOWRITE OPTIONAL SUMMARY
NO FLOW AUGMENTATION
STEADY STATE
NO TRAPEZOIDAL CHANNELS
NO PRINT LCD/SOLAR DATA
NO PLOT DO AND BOD
FIXED DNSTM CONC (YES=1)=        0.          5D-ULT BOD CONV K COEF
=     0.230
INPUT METRIC             =        0.          OUTPUT METRIC
=        0.
NUMBER OF REACHES        =       26.          NUMBER OF JUNCTIONS
=        3.
NUM OF HEADWATERS        =        4.          NUMBER OF POINT LOADS
=       44.
TIME STEP (HOURS)        =        1.          LNTH. COMP. ELEMENT
(MI)=      0.75
MAXIMUM ROUTE TIME (HRS)=        60.          TIME INC. FOR RPT2
(HRS)=       1.0
LATITUDE OF BASIN (DEG) =     38.36           LONGITUDE OF BASIN
(DEG)=     88.58
STANDARD MERIDIAN (DEG) =        0.           DAY OF YEAR START TIME
=      285.
EVAP. COEF.,(AE)         =   0.00068          EVAP. COEF.,(BE)
=   0.00027
ELEV. OF BASIN (ELEV)    =     510.0          DUST ATTENUATION COEF.
=      0.06
ENDATA1
O UPTAKE BY NH3 OXID(MG O/MG N)=  3.43   O UPTAKE BY NO2 OXID(MG O/MG
N)=   1.14
O PROD  BY ALGAE (MG O/MG A)   =   1.8   O UPTAKE BY ALGAE (MG O/MG
A)  =   1.90
N CONTENT OF ALGAE (MG N/MG A) =   0.09  P CONTENT OF ALGAE (MG P/MG
A) =  0.014
ALG MAX SPEC GROWTH RATE(1/DAY)=   2.0   ALGAE RESPIRATION RATE
(1/DAY) =  0.105
```

N HALF SATURATION CONST (MG/L) =   0.03 P HALF SATURATION CONST (MG/L)= 0.005
LIN ALG SHADE CO (1/H-UGCHA/L) = 0.003 NLIN SHADE (1/H-(UGCHA/L)**2/3)= 0.000
LIGHT FUNCTION OPTION (LFNOPT) =   2.0 LIGHT SATURATION COEF (INT/MIN)=   0.66
DAILY AVERAGING OPTION (LAVOPT)=   3.0 LIGHT AVERAGING FACTOR (INT) =   0.9
NUMBER OF DAYLIGHT HOURS (DLH) =   14.2 TOTAL DAILY SOLAR RADTN (INT) = 1500.
ALGY GROWTH CALC OPTION(LGROPT)=   2.0 ALGAL PREF FOR NH3-N (PREFN) =   0.1
ALG/TEMP SOLR RAD FACTOR(TFACT)=   0.45 NITRIFICATION INHIBITION COEF =   0.6
ENDATA1A
THETA   SOD RATE 1.060
ENDATA1B
STREAM REACH   1. RCH= CA09 to SKIL-1   FROM   97.13   TO   90.40
STREAM REACH   2. RCH= CA09 to SKIL-4   FROM   90.40   TO   86.90
STREAM REACH   3. RCH= CA09 to SKIL-6   FROM   86.90   TO   83.20
STREAM REACH   4. RCH= CA09 to Dums Cr   FROM   83.20   TO   77.35
STREAM REACH   5. RCH= Dums to SKIL-5   FROM   25.39   TO   16.00
STREAM REACH   6. RCH= Dums to SKIL-7   FROM   16.00   TO   4.20
STREAM REACH   7. RCH= Dums to SF   FROM   4.20   TO   0.00
STREAM REACH   8. RCH= Non-impaired 3   FROM   77.35   TO   66.70
STREAM REACH   9. RCH= CA06 to SKIL-15   FROM   66.70   TO   63.40
STREAM REACH   10. RCH= CA06 to TurnerC   FROM   63.40   TO   52.80
STREAM REACH   11. RCH= CA06 to Brush C   FROM   52.80   TO   50.07
STREAM REACH   12. RCH= Brush to SKIL-9   FROM   21.27   TO   12.70
STREAM REACH   13. RCH= Brush to SKIL16   FROM   12.70   TO   1.30
STREAM REACH   14. RCH= Brush to SF   FROM   1.30   TO   0.00
STREAM REACH   15. RCH= Non-impaired 2   FROM   50.07   TO   38.13
STREAM REACH   16. RCH= Horse to SKIL18   FROM   28.22   TO   20.00
STREAM REACH   17. RCH= Horse to SKIL19   FROM   20.00   TO   13.60
STREAM REACH   18. RCH= Horse to SKIL21   FROM   13.60   TO

```
      4.00
STREAM REACH    19. RCH= Horse to SF       FROM          4.00    TO
      0.00
STREAM REACH    20. RCH= CA05 to SKIL-23   FROM         38.13    TO
     35.80
STREAM REACH    21. RCH= CA05 to SKIL-1    FROM         35.80    TO
     31.90
STREAM REACH    22. RCH= CA05 to SKIL-4    FROM         31.90    TO
     27.17
STREAM REACH    23. RCH= Non-impaired 1a   FROM         27.17    TO
     19.50
STREAM REACH    24. RCH= Non-impaired 1b   FROM         19.50    TO
      7.20
STREAM REACH    25. RCH= CA03 to SKIL-27   FROM          7.20    TO
      3.10
STREAM REACH    26. RCH= CA03 to L Wab R   FROM          3.10    TO
      0.00
ENDATA2
ENDATA3
FLAG FIELD RCH=  1.         9.          1.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  2.         4.          2.2.6.2.
FLAG FIELD RCH=  3.         5.          2.6.2.2.6.
FLAG FIELD RCH=  4.         8.          2.2.6.2.2.2.6.3.
FLAG FIELD RCH=  5.        12.          1.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  6.        16.
2.2.2.2.2.2.2.2.2.2.6.2.2.6.2.6.
FLAG FIELD RCH=  7.         6.          2.2.6.2.2.6.
FLAG FIELD RCH=  8.        14.          4.2.2.6.2.2.2.2.6.2.2.2.2.2.
FLAG FIELD RCH=  9.         4.          6.2.2.2.
FLAG FIELD RCH= 10.        14.          6.6.2.2.2.6.2.2.2.2.2.2.2.2.
FLAG FIELD RCH= 11.         4.          6.2.2.3.
FLAG FIELD RCH= 12.        11.          1.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH= 13.        15.
2.2.2.6.2.2.6.2.2.2.2.2.2.6.2.
FLAG FIELD RCH= 14.         2.          2.2.
FLAG FIELD RCH= 15.        16.
4.2.6.2.2.6.2.2.2.6.2.2.2.2.2.3.
FLAG FIELD RCH= 16.        11.          1.2.2.2.2.2.2.2.6.6.2.
FLAG FIELD RCH= 17.         9.          2.2.2.2.2.6.2.2.2.
FLAG FIELD RCH= 18.        13.          2.2.2.2.2.2.2.6.2.2.6.2.2.
FLAG FIELD RCH= 19.         5.          6.2.2.2.2.
FLAG FIELD RCH= 20.         3.          4.2.2.
FLAG FIELD RCH= 21.         5.          6.2.2.6.2.
FLAG FIELD RCH= 22.         7.          6.2.6.2.2.2.2.
FLAG FIELD RCH= 23.        10.          6.2.2.2.2.2.2.2.2.6.
FLAG FIELD RCH= 24.        17.
6.6.6.2.2.6.6.2.6.6.2.2.2.2.2.2.2.
FLAG FIELD RCH= 25.         5.          6.2.2.2.6.
FLAG FIELD RCH= 26.         4.          2.2.2.5.
ENDATA4
HYDRAULICS RCH=  1.     100.0     0.0856     1.00        0.73   0.000
  0.020
```

```
HYDRAULICS RCH=  2.     100.0     0.0856     1.00        0.73   0.000
  0.020
HYDRAULICS RCH=  3.     100.0     0.0329     1.00        1.24   0.000
  0.020
HYDRAULICS RCH=  4.     100.0     0.0066     1.00        2.29   0.000
  0.020
HYDRAULICS RCH=  5.     100.0     0.8333     1.00        0.24   0.000
  0.020
HYDRAULICS RCH=  6.     100.0     0.1972     1.00        0.39   0.000
  0.020
HYDRAULICS RCH=  7.     100.0     0.0491     1.00        0.69   0.000
  0.020
HYDRAULICS RCH=  8.     100.0     0.1576     1.00        0.47   0.000
  0.020
HYDRAULICS RCH=  9.     100.0     0.4630     1.00        0.18   0.000
  0.020
HYDRAULICS RCH= 10.     100.0     0.0031     1.00        4.89   0.000
  0.020
HYDRAULICS RCH= 11.     100.0     0.0069     1.00        2.44   0.000
  0.020
HYDRAULICS RCH= 12.     100.0     0.0486     1.00        1.21   0.000
  0.020
HYDRAULICS RCH= 13.     100.0     0.0299     1.00        1.52   0.000
  0.020
HYDRAULICS RCH= 14.     100.0     0.0183     1.00        1.40   0.000
  0.020
HYDRAULICS RCH= 15.     100.0     0.4000     1.00        0.25   0.000
  0.020
HYDRAULICS RCH= 16.     100.0     0.0134     1.00        1.75   0.000
  0.020
HYDRAULICS RCH= 17.     100.0     0.0134     1.00        1.75   0.000
  0.020
HYDRAULICS RCH= 18.     100.0     0.0134     1.00        1.75   0.000
  0.020
HYDRAULICS RCH= 19.     100.0     0.0099     1.00        1.81   0.000
  0.020
HYDRAULICS RCH= 20.     100.0     0.0038     1.00        3.86   0.000
  0.020
HYDRAULICS RCH= 21.     100.0     0.0021     1.00        5.86   0.000
  0.020
HYDRAULICS RCH= 22.     100.0     0.0021     1.00        5.86   0.000
  0.020
HYDRAULICS RCH= 23.     100.0     0.0083     1.00        2.01   0.000
  0.020
HYDRAULICS RCH= 24.     100.0     0.0083     1.00        2.01   0.000
  0.020
HYDRAULICS RCH= 25.     100.0     0.0033     1.00        3.39   0.000
  0.020
HYDRAULICS RCH= 26.     100.0     0.0022     1.00        5.10   0.000
  0.020
ENDATA5
TEMP/LCD          1.     510.00   0.06   0.10   80.0   60.0  29.59
```

```
2.0
ENDATA5A
REACT COEF RCH=   1.   0.230   0.000  0.0883  1.   1.352  0.0000
0.0000
REACT COEF RCH=   2.   0.230   0.000  0.0883  1.   1.100  0.0000
0.0000
REACT COEF RCH=   3.   0.230   0.000  0.0883  1.   0.335  0.0000
0.0000
REACT COEF RCH=   4.   0.230   0.000  0.0883  1.   0.300  0.0000
0.0000
REACT COEF RCH=   5.   0.230   0.000  0.0585  1.   3.935  0.0000
0.0000
REACT COEF RCH=   6.   0.230   0.000  0.0585  1.   0.976  0.0000
0.0000
REACT COEF RCH=   7.   0.230   0.000  0.0585  1.   1.000  0.0000
0.0000
REACT COEF RCH=   8.   0.230   0.000  0.0585  1.   0.320  0.0000
0.0000
REACT COEF RCH=   9.   0.230   0.000  0.0288  1.   0.320  0.0000
0.0000
REACT COEF RCH=  10.   0.230   0.000  0.0288  1.   0.070  0.0000
0.0000
REACT COEF RCH=  11.   0.230   0.000  0.0288  1.   0.050  0.0000
0.0000
REACT COEF RCH=  12.   0.230   0.000  0.0520  1.   0.260  0.0000
0.0000
REACT COEF RCH=  13.   0.230   0.000  0.0520  1.   0.231  0.0000
0.0000
REACT COEF RCH=  14.   0.230   0.000  0.0520  1.   0.230  0.0000
0.0000
REACT COEF RCH=  15.   0.230   0.000  0.0297  1.   1.300  0.0000
0.0000
REACT COEF RCH=  16.   0.230   0.000  0.0557  1.   1.087  0.0000
0.0000
REACT COEF RCH=  17.   0.230   0.000  0.0557  1.   0.280  0.0000
0.0000
REACT COEF RCH=  18.   0.230   0.000  0.0557  1.   0.229  0.0000
0.0000
REACT COEF RCH=  19.   0.230   0.000  0.0557  1.   0.280  0.0000
0.0000
REACT COEF RCH=  20.   0.230   0.000  0.0920  1.   0.136  0.0000
0.0000
REACT COEF RCH=  21.   0.230   0.000  0.0920  1.   0.300  0.0000
0.0000
REACT COEF RCH=  22.   0.230   0.000  0.0920  1.   0.300  0.0000
0.0000
REACT COEF RCH=  23.   0.230   0.000  0.0920  1.   0.989  0.0000
0.0000
REACT COEF RCH=  24.   0.230   0.000  0.0920  1.   0.600  0.0000
0.0000
REACT COEF RCH=  25.   0.230   0.000  0.0920  1.   1.565  0.0000
0.0000
```

REACT COEF RCH= 26.   0.230   0.000 0.0920 1.   3.000 0.0000
0.0000
ENDATA6
N AND P COEF   RCH= 1.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 2.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 3.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 4.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 5.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 6.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 7.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 8.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 9.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 10.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 11.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 12.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 13.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 14.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 15.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 16.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 17.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 18.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 19.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 20.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 21.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 22.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 23.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 24.0   0.1   0.0   0.5   0.0   3.0   0.1
0.0   0.0
N AND P COEF   RCH= 25.0   0.1   0.0   0.5   0.0   3.0   0.1

```
0.0    0.0
N AND P COEF   RCH= 26.0    0.1    0.0    0.5    0.0    3.0    0.1
0.0    0.0
ENDATA6A
ALG/OTHER COEF RCH=  1.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH=  2.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH=  3.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH=  4.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH=  5.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH=  6.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH=  7.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH=  8.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH=  9.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 10.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 11.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 12.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 13.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 14.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 15.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 16.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 17.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 18.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 19.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 20.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 21.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 22.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 23.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 24.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
```

```
ALG/OTHER COEF RCH= 25.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ALG/OTHER COEF RCH= 26.0   15.0    2.0    0.1    0.0    0.0    0.0
0.0
ENDATA6B
INITIAL COND-1 RCH=   1.  75.20   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=   2.  75.20   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=   3.  69.80   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=   4.  75.02   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=   5.  82.40   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=   6.  73.04   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=   7.  71.60   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=   8.  72.59   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=   9.  71.96   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  10.  72.50   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  11.  73.33   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  12.  70.16   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  13.  70.70   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  14.  70.79   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  15.  76.28   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  16.  74.30   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  17.  74.30   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  18.  72.32   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  19.  71.53   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  20.  73.69   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  21.  75.85   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  22.  75.85   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  23.  77.47   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  24.  77.47   5.00   1.00   0.00   0.00   0.00
```

```
0.000    0.0
INITIAL COND-1 RCH=  25.  76.80   5.00   1.00   0.00   0.00   0.00
0.000    0.0
INITIAL COND-1 RCH=  26.  78.69   5.00   1.00   0.00   0.00   0.00
0.000    0.0
ENDATA7
INITIAL COND-2 RCH=   1.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=   2.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=   3.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=   4.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=   5.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=   6.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=   7.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=   8.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=   9.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  10.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  11.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  12.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  13.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  14.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  15.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  16.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  17.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  18.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  19.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  20.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  21.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  22.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  23.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
```

```
INITIAL COND-2 RCH=  24.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  25.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
INITIAL COND-2 RCH=  26.    0.0    0.0   0.01    0.0    0.0    0.0
0.0
ENDATA7A
INCR INFLOW-1  RCH=   1.  0.000  70.00   0.0  00.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=   2.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=   3.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=   4.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=   5.  0.000  70.00   0.0  00.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=   6.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=   7.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=   8.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=   9.  0.000  70.00   0.0  00.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  10.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  11.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  12.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  13.  0.000  70.00   0.0  00.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  14.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  15.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  16.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  17.  0.000  70.00   0.0  00.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  18.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  19.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  20.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  21.  0.000  70.00   0.0  00.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  22.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  23.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
```

```
 0.0   0.0
INCR INFLOW-1  RCH=  24.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  25.  0.000  70.00   0.0  00.0   0.0   0.0   0.0
 0.0   0.0
INCR INFLOW-1  RCH=  26.  0.000  70.00   0.0   0.0   0.0   0.0   0.0
 0.0   0.0
ENDATA8
INCR INFLOW-2  RCH=   1.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=   2.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=   3.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=   4.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=   5.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=   6.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=   7.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=   8.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=   9.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  10.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  11.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  12.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  13.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  14.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  15.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  16.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  17.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  18.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  19.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  20.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  21.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  22.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
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INCR INFLOW-2  RCH=  23.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  24.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  25.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
INCR INFLOW-2  RCH=  26.   0.00   0.00   0.00   0.00   0.00   0.00
0.00
ENDATA8A
Junction              1.         Dums Creek to SF       26.
61.       60.
Junction              2.         Brush Creek   SF       96.
125.      124.
Junction              3.         Horse Creek   SF      140.
179.      178.
ENDATA9
HEADWTR-1 HDW=   1. CA09               0.237 75.20  4.10  1.00  0.0
0.0   0.0
HEADWTR-1 HDW=   2. Dums Creek         0.160 82.40 10.20  1.00  0.0
0.0   0.0
HEADWTR-1 HDW=   3. Brush Creek        0.210 70.20  1.56  1.00  0.0
0.0   0.0
HEADWTR-1 HDW=   4. Horse Creek        0.252 74.30  6.74  1.00  0.0
0.0   0.0
ENDATA10
HEADWTR-2 HDW=   1.  0.00   0.0  0.00  0.00  0.66  0.00  0.00  0.00
0.00
HEADWTR-2 HDW=   2.  0.00   0.0  0.00  0.00  0.04  0.00  0.00  0.00
0.00
HEADWTR-2 HDW=   3.  0.00   0.0  0.00  0.00  0.25  0.00  0.00  0.00
0.00
HEADWTR-2 HDW=   4.  0.00   0.0  0.00  0.00  0.14  0.00  0.00  0.00
0.00
ENDATA10A
POINTLD-1 PTL=   1. Sutton Crk  0.00 0.23701  77.0   7.0  35.0   0.0
 0.0   0.0
POINTLD-1 PTL=   2. Bobbies Br  0.00 0.23701  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=   3. Lost Fork   0.00 0.23701  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=   4. Crabapple B 0.00 0.23701  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=   5. Conners Br  0.00 0.23701  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=   6. Tadlock Br  0.00 0.16001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=   7. Bee Br      0.00 0.16001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=   8. White Oak B 0.00 0.16001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=   9. Bear Br     0.00 0.16001  77.0   7.0   1.0   0.0
 0.0   0.0
```

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POINTLD-1 PTL=  10. Jamison Cr  0.50 0.03094  77.0   7.0  20.0   0.0
 0.0   0.0
POINTLD-1 PTL=  11. Middleton B 0.00 0.33501  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  12. Fulton Cr   0.00 0.33501  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  13. Nickolson C 0.50 0.08510  77.0   7.0   0.0   0.0
 0.0   0.0
POINTLD-1 PTL=  14. Poplar Cr   0.00 0.26001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  15. Paintrock C 0.00 0.26001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  16. Lick Br     0.00 0.26001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  17. Turner Cr   0.00 0.26001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  18. Gum Br      0.00 0.21001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  19. Bob Br      0.00 0.21001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  20. Johnson Frk 0.00 0.21001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  21. Paddy Cr    0.00 0.24001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  22. Possum Cr   0.00 0.24001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  23. Crooked Cr  0.00 0.24001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  24. Salty Br    0.00 0.25201  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  25. Panther Frk 0.00 0.25201  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  26. Coal Bank C 0.00 0.25201  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  27. Elm Cr      0.00 0.25201  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  28. Puncheon Cr 0.50 0.04796  77.0   7.0  4.51   0.0
 0.0   0.0
POINTLD-1 PTL=  29. Gregory Br  0.00 0.25201  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  30. Shoe Cr     0.00 0.59001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  31. Miller Cr   0.00 0.59001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  32. unnamed WC  0.50 0.13925  77.0   7.0  12.0   0.0
 0.0   0.0
POINTLD-1 PTL=  33. Fourmile Cr 0.00 0.59001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  34. Dry Fork    0.50 0.00774  77.0   7.0   4.0   0.0
 0.0   0.0
POINTLD-1 PTL=  35. Haw Cr      0.00 1.30001  77.0   7.0   1.0   0.0
 0.0   0.0
```

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POINTLD-1 PTL=  36. Boyd Cr      0.00 1.30001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  37. unnamed MS  0.00 1.30001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  38. Big Cr      0.50 0.01702  77.0   7.0  6.50   0.0
 0.0   0.0
POINTLD-1 PTL=  39. Southern O  0.50 0.01934  77.0   7.0   0.0   0.0
 0.0   0.0
POINTLD-1 PTL=  40. Prairie Cr  0.00 1.30001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  41. Beaver Cr   0.50 0.00774  77.0   7.0  38.0   0.0
 0.0   0.0
POINTLD-1 PTL=  42. Lost Cr     0.50 0.15472  77.0   7.0   9.1   0.0
 0.0   0.0
POINTLD-1 PTL=  43. 7mile Limek 0.00 0.94001  77.0   7.0   1.0   0.0
 0.0   0.0
POINTLD-1 PTL=  44. Wilson Cr   0.00 0.94001  77.0   7.0   1.0   0.0
 0.0   0.0
ENDATA11
POINTLD-2 PTL=   1.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=   2.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=   3.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=   4.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=   5.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=   6.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=   7.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=   8.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=   9.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  10.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  11.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  12.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  13.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  14.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  15.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  16.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  17.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
```

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0.00
POINTLD-2 PTL=  18.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  19.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  20.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  21.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  22.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  23.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  24.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  25.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  26.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  27.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  28.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  29.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  30.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  31.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  32.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  33.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  34.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  35.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  36.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  37.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  38.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  39.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  40.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  41.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  42.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
POINTLD-2 PTL=  43.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
```

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0.00
POINTLD-2 PTL=  44.  0.00   0.0  0.00  0.00  0.15  0.00  0.00  0.00
0.00
ENDATA11A
ENDATA12
ENDATA13
ENDATA13A
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                                                     * * * QUAL-2E  STREAM
QUALITY ROUTING MODEL * * *
                                                                 Version
3.22  --  May 1996

          $$$ (PROBLEM TITLES) $$$

         CARD TYPE                                     QUAL-2E PROGRAM TITLES
         TITLE01                Skillet Fork TMDL
         TITLE02                Final Calibration
         TITLE03   NO           CONSERVATIVE MINERAL   I
         TITLE04   NO           CONSERVATIVE MINERAL  II
         TITLE05   NO           CONSERVATIVE MINERAL III
         TITLE06   NO           TEMPERATURE
         TITLE07  YES           5-DAY BIOCHEMICAL OXYGEN DEMAND
         TITLE08   NO           ALGAE AS CHL-A IN UG/L
         TITLE09   NO           PHOSPHORUS CYCLE AS P IN MG/L
         TITLE10                  (ORGANIC-P; DISSOLVED-P)
         TITLE11  YES           NITROGEN CYCLE AS N IN MG/L
         TITLE12                  (ORGANIC-N; AMMONIA-N; NITRITE-N;'
NITRATE-N)
         TITLE13  YES           DISSOLVED OXYGEN IN MG/L
         TITLE14   NO           FECAL COLIFORM IN NO./100 ML
         TITLE15   NO           ARBITRARY NON-CONSERVATIVE
         ENDTITLE

          $$$ DATA TYPE 1 (CONTROL DATA) $$$

         CARD TYPE                                            CARD TYPE
         LIST DATA INPUT              0.00000
            0.00000
         NOWRITE OPTIONAL SUMMARY     0.00000
            0.00000
         NO FLOW AUGMENTATION         0.00000
            0.00000
         STEADY STATE                 0.00000
            0.00000
         NO TRAPEZOIDAL CHANNELS      0.00000
            0.00000
         NO PRINT LCD/SOLAR DATA      0.00000
            0.00000
         NO PLOT DO AND BOD           0.00000
            0.00000
         FIXED DNSTM CONC (YES=1)=    0.00000          5D-ULT BOD CONV
K COEF  =   0.23000
         INPUT METRIC             =   0.00000          OUTPUT METRIC
        =   0.00000
         NUMBER OF REACHES        =  26.00000          NUMBER OF
JUNCTIONS     =   3.00000
         NUM OF HEADWATERS        =   4.00000          NUMBER OF POINT
LOADS   =  44.00000
         TIME STEP (HOURS)        =   1.00000          LNTH. COMP.
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ELEMENT (MI)=   0.75000
         MAXIMUM ROUTE TIME (HRS)=  60.00000          TIME INC. FOR
RPT2 (HRS)=   1.00000
         LATITUDE OF BASIN (DEG) =  38.36000          LONGITUDE OF
BASIN (DEG)=  88.58000
         STANDARD MERIDIAN (DEG) =   0.00000          DAY OF YEAR
START TIME  = 285.00000
         EVAP. COEF.,(AE)        =   0.00068          EVAP.
COEF.,(BE)        =   0.00027
         ELEV. OF BASIN (ELEV)   = 510.00000          DUST
ATTENUATION COEF.  =   0.06000
         ENDATA1                     0.00000
            0.00000

          $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION
CONSTANTS) $$$

         CARD TYPE                                           CARD
TYPE
         O UPTAKE BY NH3 OXID(MG O/MG N)=    3.4300          O UPTAKE
BY NO2 OXID(MG O/MG N)=    1.1400
         O PROD  BY ALGAE (MG O/MG A)   =    1.8000          O UPTAKE
BY ALGAE (MG O/MG A)  =    1.9000
         N CONTENT OF ALGAE (MG N/MG A) =    0.0900          P
CONTENT OF ALGAE (MG P/MG A) =    0.0140
         ALG MAX SPEC GROWTH RATE(1/DAY)=    2.0000          ALGAE
RESPIRATION RATE (1/DAY) =    0.1050
         N HALF SATURATION CONST (MG/L) =    0.0300          P HALF
SATURATION CONST  (MG/L)=    0.0050
         LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0030          NLIN
SHADE(1/FT-(UGCHA/L)**2/3)=    0.0000
         LIGHT FUNCTION OPTION (LFNOPT) =    2.0000          LIGHT
SAT'N COEF (BTU/FT2-MIN) =    0.6600
         DAILY AVERAGING OPTION (LAVOPT)=    3.0000          LIGHT
AVERAGING FACTOR  (INT)  =    0.9000
         NUMBER OF DAYLIGHT HOURS (DLH) =   14.2000          TOTAL
DAILY SOLR RAD (BTU/FT-2)= 1500.0000
         ALGY GROWTH CALC OPTION(LGROPT)=    2.0000          ALGAL
PREF FOR NH3-N (PREFN)   =    0.1000
         ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4500
NITRIFICATION INHIBITION COEF  =    0.6000
         ENDATA1A                            0.0000
                           0.0000

          $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE
COEFFICIENTS) $$$

         CARD TYPE     RATE CODE     THETA VALUE

         THETA( 1)      BOD DECA        1.047     DFLT
         THETA( 2)      BOD SETT        1.024     DFLT
         THETA( 3)      OXY TRAN        1.024     DFLT
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          THETA( 4)      SOD RATE        1.060     USER
          THETA( 5)      ORGN DEC        1.047     DFLT
          THETA( 6)      ORGN SET        1.024     DFLT
          THETA( 7)      NH3 DECA        1.083     DFLT
          THETA( 8)      NH3 SRCE        1.074     DFLT
          THETA( 9)      NO2 DECA        1.047     DFLT
          THETA(10)      PORG DEC        1.047     DFLT
          THETA(11)      PORG SET        1.024     DFLT
          THETA(12)      DISP SRC        1.074     DFLT
          THETA(13)      ALG GROW        1.047     DFLT
          THETA(14)      ALG RESP        1.047     DFLT
          THETA(15)      ALG SETT        1.024     DFLT
          THETA(16)      COLI DEC        1.047     DFLT
          THETA(17)      ANC DECA        1.000     DFLT
          THETA(18)      ANC SETT        1.024     DFLT
          THETA(19)      ANC SRCE        1.000     DFLT
          ENDATA1B

           $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

          CARD TYPE           REACH ORDER AND IDENT              R.
MI/KM            R. MI/KM
          STREAM REACH    1.0  RCH= CA09 to SKIL-1    FROM
97.1    TO           90.4
          STREAM REACH    2.0  RCH= CA09 to SKIL-4    FROM
90.4    TO           86.9
          STREAM REACH    3.0  RCH= CA09 to SKIL-6    FROM
86.9    TO           83.2
          STREAM REACH    4.0  RCH= CA09 to Dums Cr   FROM
83.2    TO           77.3
          STREAM REACH    5.0  RCH= Dums to SKIL-5    FROM
25.4    TO           16.0
          STREAM REACH    6.0  RCH= Dums to SKIL-7    FROM
16.0    TO            4.2
          STREAM REACH    7.0  RCH= Dums to SF        FROM
4.2    TO            0.0
          STREAM REACH    8.0  RCH= Non-impaired 3    FROM
77.3    TO           66.7
          STREAM REACH    9.0  RCH= CA06 to SKIL-15   FROM
66.7    TO           63.4
          STREAM REACH   10.0  RCH= CA06 to TurnerC   FROM
63.4    TO           52.8
          STREAM REACH   11.0  RCH= CA06 to Brush C   FROM
52.8    TO           50.1
          STREAM REACH   12.0  RCH= Brush to SKIL-9   FROM
21.3    TO           12.7
          STREAM REACH   13.0  RCH= Brush to SKIL16   FROM
12.7    TO            1.3
          STREAM REACH   14.0  RCH= Brush to SF       FROM
1.3    TO            0.0
          STREAM REACH   15.0  RCH= Non-impaired 2    FROM
50.1    TO           38.1
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         STREAM REACH    16.0  RCH= Horse to SKIL18   FROM
28.2    TO          20.0
         STREAM REACH    17.0  RCH= Horse to SKIL19   FROM
20.0    TO          13.6
         STREAM REACH    18.0  RCH= Horse to SKIL21   FROM
13.6    TO           4.0
         STREAM REACH    19.0  RCH= Horse to SF       FROM
4.0    TO           0.0
         STREAM REACH    20.0  RCH= CA05 to SKIL-23   FROM
38.1    TO          35.8
         STREAM REACH    21.0  RCH= CA05 to SKIL-1    FROM
35.8    TO          31.9
         STREAM REACH    22.0  RCH= CA05 to SKIL-4    FROM
31.9    TO          27.2
         STREAM REACH    23.0  RCH= Non-impaired 1a   FROM
27.2    TO          19.5
         STREAM REACH    24.0  RCH= Non-impaired 1b   FROM
19.5    TO           7.2
         STREAM REACH    25.0  RCH= CA03 to SKIL-27   FROM
7.2    TO          3.1
         STREAM REACH    26.0  RCH= CA03 to L Wab R   FROM
3.1    TO          0.0
         ENDATA2          0.0
0.0                 0.0

          $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION
SOURCES) $$$

         CARD TYPE                  REACH  AVAIL HDWS TARGET
ORDER OF AVAIL SOURCES
         ENDATA3                     0.         0.       0.0   0.   0.
  0.   0.   0.   0.

          $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

         CARD TYPE        REACH ELEMENTS/REACH
COMPUTATIONAL FLAGS
         FLAG FIELD        1.        9.
1.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD        2.        4.
2.2.6.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD        3.        5.
2.6.2.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD        4.        8.
2.2.6.2.2.2.6.3.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD        5.       12.
1.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.
         FLAG FIELD        6.       16.
2.2.2.2.2.2.2.2.2.2.6.2.2.6.2.6.0.0.0.0.
         FLAG FIELD        7.        6.
2.2.6.2.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD        8.       14.
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4.2.2.6.2.2.2.2.6.2.2.2.2.2.0.0.0.0.0.0.
         FLAG FIELD       9.        4.
6.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      10.       14.
6.6.2.2.2.6.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
         FLAG FIELD      11.        4.
6.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      12.       11.
1.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      13.       15.
2.2.2.6.2.2.6.2.2.2.2.2.2.6.2.0.0.0.0.0.
         FLAG FIELD      14.        2.
2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      15.       16.
4.2.6.2.2.6.2.2.2.6.2.2.2.2.2.3.0.0.0.0.
         FLAG FIELD      16.       11.
1.2.2.2.2.2.2.2.6.6.2.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      17.        9.
2.2.2.2.2.6.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      18.       13.
2.2.2.2.2.2.2.6.2.2.6.2.2.0.0.0.0.0.0.0.
         FLAG FIELD      19.        5.
6.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      20.        3.
4.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      21.        5.
6.2.2.6.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      22.        7.
6.2.6.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      23.       10.
6.2.2.2.2.2.2.2.2.6.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      24.       17.
6.6.6.2.2.6.6.2.6.6.2.2.2.2.2.2.2.0.0.0.
         FLAG FIELD      25.        5.
6.2.2.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
         FLAG FIELD      26.        4.
2.2.2.5.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
         ENDATA4          0.        0.
0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

          $$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY
AND DEPTH) $$$

         CARD TYPE        REACH  COEF-DSPN  COEFQV    EXPOQV
COEFQH   EXPOQH     CMANN
         HYDRAULICS        1.    100.00     0.086     1.000     0.730
    0.000     0.020
         HYDRAULICS        2.    100.00     0.086     1.000     0.730
    0.000     0.020
         HYDRAULICS        3.    100.00     0.033     1.000     1.240
    0.000     0.020
         HYDRAULICS        4.    100.00     0.007     1.000     2.290
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    0.000     0.020
         HYDRAULICS          5.     100.00     0.833     1.000     0.240
    0.000     0.020
         HYDRAULICS          6.     100.00     0.197     1.000     0.390
    0.000     0.020
         HYDRAULICS          7.     100.00     0.049     1.000     0.690
    0.000     0.020
         HYDRAULICS          8.     100.00     0.158     1.000     0.470
    0.000     0.020
         HYDRAULICS          9.     100.00     0.463     1.000     0.180
    0.000     0.020
         HYDRAULICS         10.     100.00     0.003     1.000     4.890
    0.000     0.020
         HYDRAULICS         11.     100.00     0.007     1.000     2.440
    0.000     0.020
         HYDRAULICS         12.     100.00     0.049     1.000     1.210
    0.000     0.020
         HYDRAULICS         13.     100.00     0.030     1.000     1.520
    0.000     0.020
         HYDRAULICS         14.     100.00     0.018     1.000     1.400
    0.000     0.020
         HYDRAULICS         15.     100.00     0.400     1.000     0.250
    0.000     0.020
         HYDRAULICS         16.     100.00     0.013     1.000     1.750
    0.000     0.020
         HYDRAULICS         17.     100.00     0.013     1.000     1.750
    0.000     0.020
         HYDRAULICS         18.     100.00     0.013     1.000     1.750
    0.000     0.020
         HYDRAULICS         19.     100.00     0.010     1.000     1.810
    0.000     0.020
         HYDRAULICS         20.     100.00     0.004     1.000     3.860
    0.000     0.020
         HYDRAULICS         21.     100.00     0.002     1.000     5.860
    0.000     0.020
         HYDRAULICS         22.     100.00     0.002     1.000     5.860
    0.000     0.020
         HYDRAULICS         23.     100.00     0.008     1.000     2.010
    0.000     0.020
         HYDRAULICS         24.     100.00     0.008     1.000     2.010
    0.000     0.020
         HYDRAULICS         25.     100.00     0.003     1.000     3.390
    0.000     0.020
         HYDRAULICS         26.     100.00     0.002     1.000     5.100
    0.000     0.020
         ENDATA5             0.       0.00     0.000     0.000     0.000
    0.000     0.000

          $$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY
DATA) $$$

         CARD TYPE                           DUST      CLOUD    DRY
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BULB  WET BULB     ATM                 SOLAR RAD
                         REACH   ELEVATION     COEF      COVER
TEMP      TEMP    PRESSURE     WIND   ATTENUATION
         TEMP/LCD           1.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD           2.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD           3.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD           4.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD           5.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD           6.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD           7.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD           8.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD           9.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          10.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          11.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          12.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          13.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          14.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          15.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          16.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          17.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          18.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          19.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          20.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          21.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          22.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          23.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          24.      510.00      0.06       0.10
80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          25.      510.00      0.06       0.10
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80.00     60.00     29.59      2.00      1.00
         TEMP/LCD          26.      510.00      0.06      0.10
80.00     60.00     29.59      2.00      1.00
         ENDATA5A           0.        0.00      0.00      0.00
0.00      0.00      0.00      0.00      0.00

          $$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION
AND REAERATION) $$$

         CARD TYPE        REACH     K1        K3        SOD
K2OPT     K2      COEQK2    OR   EXPQK2
                                                        RATE
              TSIV COEF  OR    SLOPE

              FOR OPT 8      FOR OPT 8
         REACT COEF         1.       0.23      0.00      0.088
1.      1.35      0.000        0.00000
         REACT COEF         2.       0.23      0.00      0.088
1.      1.10      0.000        0.00000
         REACT COEF         3.       0.23      0.00      0.088
1.      0.34      0.000        0.00000
         REACT COEF         4.       0.23      0.00      0.088
1.      0.30      0.000        0.00000
         REACT COEF         5.       0.23      0.00      0.058
1.      3.93      0.000        0.00000
         REACT COEF         6.       0.23      0.00      0.058
1.      0.98      0.000        0.00000
         REACT COEF         7.       0.23      0.00      0.058
1.      1.00      0.000        0.00000
         REACT COEF         8.       0.23      0.00      0.058
1.      0.32      0.000        0.00000
         REACT COEF         9.       0.23      0.00      0.029
1.      0.32      0.000        0.00000
         REACT COEF        10.       0.23      0.00      0.029
1.      0.07      0.000        0.00000
         REACT COEF        11.       0.23      0.00      0.029
1.      0.05      0.000        0.00000
         REACT COEF        12.       0.23      0.00      0.052
1.      0.26      0.000        0.00000
         REACT COEF        13.       0.23      0.00      0.052
1.      0.23      0.000        0.00000
         REACT COEF        14.       0.23      0.00      0.052
1.      0.23      0.000        0.00000
         REACT COEF        15.       0.23      0.00      0.030
1.      1.30      0.000        0.00000
         REACT COEF        16.       0.23      0.00      0.056
1.      1.09      0.000        0.00000
         REACT COEF        17.       0.23      0.00      0.056
1.      0.28      0.000        0.00000
         REACT COEF        18.       0.23      0.00      0.056
1.      0.23      0.000        0.00000
         REACT COEF        19.       0.23      0.00      0.056
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1.      0.28      0.000         0.00000
         REACT COEF        20.      0.23      0.00      0.092
1.      0.14      0.000         0.00000
         REACT COEF        21.      0.23      0.00      0.092
1.      0.30      0.000         0.00000
         REACT COEF        22.      0.23      0.00      0.092
1.      0.30      0.000         0.00000
         REACT COEF        23.      0.23      0.00      0.092
1.      0.99      0.000         0.00000
         REACT COEF        24.      0.23      0.00      0.092
1.      0.60      0.000         0.00000
         REACT COEF        25.      0.23      0.00      0.092
1.      1.57      0.000         0.00000
         REACT COEF        26.      0.23      0.00      0.092
1.      3.00      0.000         0.00000
         ENDATA6            0.      0.00      0.00      0.000
0.      0.00      0.000         0.00000

          $$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

         CARD TYPE            REACH    CKNH2    SETNH2     CKNH3
SNH3     CKNO2     CKPORG   SETPORG     SPO4
         N AND P COEF          1.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF          2.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF          3.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF          4.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF          5.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF          6.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF          7.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF          8.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF          9.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF         10.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF         11.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF         12.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF         13.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF         14.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF         15.       0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
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         N AND P COEF        16.      0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF        17.      0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF        18.      0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF        19.      0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF        20.      0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF        21.      0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF        22.      0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF        23.      0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF        24.      0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF        25.      0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         N AND P COEF        26.      0.10      0.00      0.50
0.00      3.00      0.10      0.00      0.00
         ENDATA6A             0.      0.00      0.00      0.00
0.00      0.00      0.00      0.00      0.00

          $$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

         CARD TYPE             REACH    ALPHAO    ALGSET    EXCOEF
CK5     CKANC    SETANC    SRCANC

CKCOLI
         ALG/OTHER COEF        1.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF        2.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF        3.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF        4.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF        5.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF        6.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF        7.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF        8.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF        9.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       10.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       11.     15.00      2.00      0.10
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0.00      0.00      0.00      0.00
         ALG/OTHER COEF       12.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       13.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       14.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       15.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       16.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       17.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       18.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       19.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       20.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       21.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       22.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       23.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       24.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       25.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ALG/OTHER COEF       26.     15.00      2.00      0.10
0.00      0.00      0.00      0.00
         ENDATA6B              0.      0.00      0.00      0.00
0.00      0.00      0.00      0.00

          $$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

         CARD TYPE           REACH    TEMP       D.O.      BOD
CM-1      CM-2      CM-3      ANC      COLI
         INITIAL COND-1        1.     75.20      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1        2.     75.20      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1        3.     69.80      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1        4.     75.02      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1        5.     82.40      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1        6.     73.04      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1        7.     71.60      5.00      1.00
0.00      0.00      0.00      0.00      0.00
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         INITIAL COND-1       8.     72.59      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1       9.     71.96      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      10.     72.50      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      11.     73.33      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      12.     70.16      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      13.     70.70      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      14.     70.79      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      15.     76.28      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      16.     74.30      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      17.     74.30      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      18.     72.32      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      19.     71.53      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      20.     73.69      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      21.     75.85      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      22.     75.85      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      23.     77.47      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      24.     77.47      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      25.     76.80      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         INITIAL COND-1      26.     78.69      5.00      1.00
0.00      0.00      0.00      0.00      0.00
         ENDATA7              0.      0.00      0.00      0.00
0.00      0.00      0.00      0.00      0.00

          $$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A,
NITROGEN, AND PHOSPHORUS) $$$

         CARD TYPE           REACH    CHL-A     ORG-N     NH3-N
NO2-N     NO3-N     ORG-P     DIS-P
         INITIAL COND-2       1.      0.00      0.00      0.01
0.00      0.00      0.00      0.00
         INITIAL COND-2       2.      0.00      0.00      0.01
0.00      0.00      0.00      0.00
         INITIAL COND-2       3.      0.00      0.00      0.01
0.00      0.00      0.00      0.00
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          INITIAL COND-2         4.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2         5.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2         6.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2         7.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2         8.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2         9.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        10.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        11.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        12.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        13.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        14.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        15.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        16.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        17.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        18.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        19.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        20.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        21.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        22.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        23.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        24.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        25.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          INITIAL COND-2        26.      0.00       0.00       0.01
0.00       0.00       0.00       0.00
          ENDATA7A               0.      0.00       0.00       0.00
0.00       0.00       0.00       0.00

           $$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

          CARD TYPE             REACH    FLOW       TEMP       D.O.
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BOD       CM-1      CM-2       CM-3       ANC       COLI
          INCR INFLOW-1        1.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1        2.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1        3.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1        4.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1        5.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1        6.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1        7.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1        8.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1        9.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       10.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       11.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       12.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       13.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       14.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       15.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       16.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       17.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       18.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       19.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       20.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       21.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       22.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       23.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       24.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       25.     0.000     70.00      0.00
0.00       0.00      0.00     0.00       0.00      0.00
          INCR INFLOW-1       26.     0.000     70.00      0.00
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0.00 0.00 0.00 0.00 0.00 0.00
ENDATA8 0. 0.000 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INCR INFLOW-2	1.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	2.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	3.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	4.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	5.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	6.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	7.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	8.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	9.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	10.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	11.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	12.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	13.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	14.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	15.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	16.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	17.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	18.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	19.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	20.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	21.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	22.	0.00	0.00	0.00				

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0.00      0.00      0.00      0.00
         INCR INFLOW-2        23.       0.00      0.00      0.00
0.00      0.00      0.00      0.00
         INCR INFLOW-2        24.       0.00      0.00      0.00
0.00      0.00      0.00      0.00
         INCR INFLOW-2        25.       0.00      0.00      0.00
0.00      0.00      0.00      0.00
         INCR INFLOW-2        26.       0.00      0.00      0.00
0.00      0.00      0.00      0.00
         ENDATA8A              0.       0.00      0.00      0.00
0.00      0.00      0.00      0.00

          $$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

         CARD TYPE              JUNCTION ORDER AND IDENT
UPSTRM   JUNCTION    TRIB
         Junction               1.         Dums Creek to SF        26.
      61.        60.
         Junction               2.         Brush Creek   SF        96.
     125.       124.
         Junction               3.         Horse Creek   SF       140.
     179.       178.
         ENDATA9                0.                                  0.
       0.         0.

          $$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

         CARD TYPE    HDWTR     NAME                 FLOW      TEMP
D.O.       BOD      CM-1      CM-2      CM-3
                      ORDER
         HEADWTR-1      1.   CA09                    0.24     75.20
4.10      1.00      0.00      0.00      0.00
         HEADWTR-1      2.   Dums Creek              0.16     82.40
10.20      1.00      0.00      0.00      0.00
         HEADWTR-1      3.   Brush Creek             0.21     70.20
1.56      1.00      0.00      0.00      0.00
         HEADWTR-1      4.   Horse Creek             0.25     74.30
6.74      1.00      0.00      0.00      0.00
         ENDATA10       0.                           0.00      0.00
0.00      0.00      0.00      0.00      0.00

          $$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL,
NITROGEN, PHOSPHORUS,
                             COLIFORM AND SELECTED NON-CONSERVATIVE
CONSTITUENT) $$$

         CARD TYPE     HDWTR     ANC     COLI    CHL-A    ORG-N
NH3-N    NO2-N    NO3-N    ORG-P    DIS-P
                       ORDER
         HEADWTR-2       1.     0.00 0.00E+00     0.00     0.00
0.66     0.00     0.00     0.00     0.00
         HEADWTR-2       2.     0.00 0.00E+00     0.00     0.00
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0.04      0.00     0.00     0.00     0.00
          HEADWTR-2       3.      0.00 0.00E+00     0.00     0.00
0.25      0.00     0.00     0.00     0.00
          HEADWTR-2       4.      0.00 0.00E+00     0.00     0.00
0.14      0.00     0.00     0.00     0.00
          ENDATA10A       0.      0.00 0.00E+00     0.00     0.00
0.00      0.00     0.00     0.00     0.00

           $$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE
CHARACTERISTICS) $$$

                        POINT
          CARD TYPE      LOAD    NAME              EFF      FLOW
TEMP      D.O.      BOD     CM-1     CM-2     CM-3
                        ORDER
          POINTLD-1      1.   Sutton Crk          0.00     0.24
77.00      7.00    35.00     0.00     0.00     0.00
          POINTLD-1      2.   Bobbies Br          0.00     0.24
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1      3.   Lost Fork           0.00     0.24
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1      4.   Crabapple B         0.00     0.24
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1      5.   Conners Br          0.00     0.24
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1      6.   Tadlock Br          0.00     0.16
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1      7.   Bee Br              0.00     0.16
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1      8.   White Oak B         0.00     0.16
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1      9.   Bear Br             0.00     0.16
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1     10.   Jamison Cr          0.50     0.03
77.00      7.00    20.00     0.00     0.00     0.00
          POINTLD-1     11.   Middleton B         0.00     0.34
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1     12.   Fulton Cr           0.00     0.34
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1     13.   Nickolson C         0.50     0.09
77.00      7.00     0.00     0.00     0.00     0.00
          POINTLD-1     14.   Poplar Cr           0.00     0.26
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1     15.   Paintrock C         0.00     0.26
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1     16.   Lick Br             0.00     0.26
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1     17.   Turner Cr           0.00     0.26
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1     18.   Gum Br              0.00     0.21
77.00      7.00     1.00     0.00     0.00     0.00
          POINTLD-1     19.   Bob Br              0.00     0.21
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77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     20.   Johnson Frk         0.00     0.21
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     21.   Paddy Cr            0.00     0.24
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     22.   Possum Cr           0.00     0.24
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     23.   Crooked Cr          0.00     0.24
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     24.   Salty Br            0.00     0.25
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     25.   Panther Frk         0.00     0.25
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     26.   Coal Bank C         0.00     0.25
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     27.   Elm Cr              0.00     0.25
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     28.   Puncheon Cr         0.50     0.05
77.00     7.00     4.51     0.00     0.00     0.00
         POINTLD-1     29.   Gregory Br          0.00     0.25
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     30.   Shoe Cr             0.00     0.59
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     31.   Miller Cr           0.00     0.59
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     32.   unnamed WC          0.50     0.14
77.00     7.00    12.00     0.00     0.00     0.00
         POINTLD-1     33.   Fourmile Cr         0.00     0.59
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     34.   Dry Fork            0.50     0.01
77.00     7.00     4.00     0.00     0.00     0.00
         POINTLD-1     35.   Haw Cr              0.00     1.30
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     36.   Boyd Cr             0.00     1.30
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     37.   unnamed MS          0.00     1.30
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     38.   Big Cr              0.50     0.02
77.00     7.00     6.50     0.00     0.00     0.00
         POINTLD-1     39.   Southern O          0.50     0.02
77.00     7.00     0.00     0.00     0.00     0.00
         POINTLD-1     40.   Prairie Cr          0.00     1.30
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     41.   Beaver Cr           0.50     0.01
77.00     7.00    38.00     0.00     0.00     0.00
         POINTLD-1     42.   Lost Cr             0.50     0.15
77.00     7.00     9.10     0.00     0.00     0.00
         POINTLD-1     43.   7mile Limek         0.00     0.94
77.00     7.00     1.00     0.00     0.00     0.00
         POINTLD-1     44.   Wilson Cr           0.00     0.94
77.00     7.00     1.00     0.00     0.00     0.00
         ENDATA11       0.                       0.00     0.00
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0.00 0.00 0.00 0.00 0.00 0.00

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	POINT LOAD ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	N03-N	ORG-P	DIS-P
POINTLD-2	1.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	2.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	3.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	4.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	5.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	6.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	7.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	8.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	9.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	10.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	11.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	12.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	13.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	14.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	15.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	16.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	17.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	18.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	19.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	20.	0.00	0.00E+00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
POINTLD-2	21.	0.00	0.00E+00	0.00	0.00					

```
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       22.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       23.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       24.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       25.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       26.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       27.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       28.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       29.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       30.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       31.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       32.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       33.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       34.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       35.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       36.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       37.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       38.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       39.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       40.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       41.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       42.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       43.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           POINTLD-2       44.     0.00 0.00E+00     0.00      0.00
0.15       0.00      0.00      0.00      0.00
           ENDATA11A        0.     0.00 0.00E+00     0.00      0.00
0.00       0.00      0.00      0.00      0.00

            $$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$
```

```
                              DAM   RCH   ELE    ADAM    BDAM
FDAM    HDAM

         ENDATA12              0.    0.    0.    0.00    0.00
0.00    0.00

          $$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

              CARD TYPE              TEMP       D.O.       BOD
CM-1      CM-2      CM-3       ANC      COLI

         ENDATA13                    DOWNSTREAM BOUNDARY
CONCENTRATIONS ARE UNCONSTRAINED

          $$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

              CARD TYPE              CHL-A     ORG-N     NH3-N
NO2-N     NH3-N     ORG-P     DIS-P

         ENDATA13A                   DOWNSTREAM BOUNDARY
CONCENTRATIONS ARE UNCONSTRAINED


 STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE
SUMMARY:

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                                                     NUMBER OF
            VARIABLE               ITERATION       NONCONVERGENT
                                                     ELEMENTS

    NITRIFICATION INHIBITION          1                227
    NITRIFICATION INHIBITION          2                223
    NITRIFICATION INHIBITION          3                194
    NITRIFICATION INHIBITION          4                121
    NITRIFICATION INHIBITION          5                 78
    NITRIFICATION INHIBITION          6                 28
    NITRIFICATION INHIBITION          7                  7
    NITRIFICATION INHIBITION          8                  4
    NITRIFICATION INHIBITION          9                  0
    NITRIFICATION INHIBITION         10                  0


         STREAM QUALITY SIMULATION
                                         OUTPUT PAGE NUMBER     1
         QUAL-2E STREAM QUALITY ROUTING MODEL
                              Version 3.22  --  May 1996
                                                        ***** STEADY STATE
SIMULATION *****
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** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	97.13	96.38	0.24	0.00	0.00	0.020	2.259	0.730	16.003	46.26	69.15	11.68	0.12
2	1	2	96.38	95.63	0.24	0.00	0.00	0.020	2.259	0.730	16.003	46.26	69.15	11.68	0.12
3	1	3	95.63	94.88	0.24	0.00	0.00	0.020	2.259	0.730	16.003	46.26	69.15	11.68	0.12
4	1	4	94.88	94.13	0.24	0.00	0.00	0.020	2.259	0.730	16.003	46.26	69.15	11.68	0.12
5	1	5	94.13	93.38	0.24	0.00	0.00	0.020	2.259	0.730	16.003	46.26	69.15	11.68	0.12
6	1	6	93.38	92.63	0.24	0.00	0.00	0.020	2.259	0.730	16.003	46.26	69.15	11.68	0.12
7	1	7	92.63	91.88	0.24	0.00	0.00	0.020	2.259	0.730	16.003	46.26	69.15	11.68	0.12
8	1	8	91.88	91.13	0.24	0.00	0.00	0.020	2.259	0.730	16.003	46.26	69.15	11.68	0.12
9	1	9	91.13	90.38	0.24	0.00	0.00	0.020	2.259	0.730	16.003	46.26	69.15	11.68	0.12
10	2	1	90.40	89.65	0.24	0.00	0.00	0.020	2.259	0.730	16.003	46.26	69.15	11.68	0.12
11	2	2	89.65	88.90	0.24	0.00	0.00	0.020	2.259	0.730	16.003	46.26	69.15	11.68	0.12
12	2	3	88.90	88.15	0.47	0.24	0.00	0.041	1.130	0.730	16.003	46.26	69.15	11.68	0.24
13	2	4	88.15	87.40	0.47	0.00	0.00	0.041	1.130	0.730	16.003	46.26	69.15	11.68	0.24
14	3	1	86.90	86.15	0.47	0.00	0.00	0.016	2.939	1.240	24.512	120.36	106.89	30.40	0.14
15	3	2	86.15	85.40	0.71	0.24	0.00	0.023	1.959	1.240	24.512	120.36	106.89	30.40	0.21
16	3	3	85.40	84.65	0.71	0.00	0.00	0.023	1.959	1.240	24.512	120.36	106.89	30.40	0.21
17	3	4	84.65	83.90	0.71	0.00	0.00	0.023	1.959	1.240	24.512	120.36	106.89	30.40	0.21
18	3	5	83.90	83.15	0.95	0.24	0.00	0.031	1.469	1.240	24.512	120.36	106.89	30.40	0.29

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 19   4   1   83.20   82.45    0.95    0.00    0.00   0.006   7.325
 2.290   66.164      600.00      280.15      151.52     0.10
 20   4   2   82.45   81.70    0.95    0.00    0.00   0.006   7.325
 2.290   66.164      600.00      280.15      151.52     0.10
 21   4   3   81.70   80.95    1.19    0.24    0.00   0.008   5.860
 2.290   66.164      600.00      280.15      151.52     0.12
 22   4   4   80.95   80.20    1.19    0.00    0.00   0.008   5.860
 2.290   66.164      600.00      280.15      151.52     0.12
 23   4   5   80.20   79.45    1.19    0.00    0.00   0.008   5.860
 2.290   66.164      600.00      280.15      151.52     0.12
 24   4   6   79.45   78.70    1.19    0.00    0.00   0.008   5.860
 2.290   66.164      600.00      280.15      151.52     0.12
 25   4   7   78.70   77.95    1.42    0.24    0.00   0.009   4.883
 2.290   66.164      600.00      280.15      151.52     0.14
 26   4   8   77.95   77.20    1.42    0.00    0.00   0.009   4.883
 2.290   66.164      600.00      280.15      151.52     0.14


 27   5   1   25.39   24.64    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31
 28   5   2   24.64   23.89    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31
 29   5   3   23.89   23.14    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31
 30   5   4   23.14   22.39    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31
 31   5   5   22.39   21.64    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31
 32   5   6   21.64   20.89    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31
 33   5   7   20.89   20.14    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31
 34   5   8   20.14   19.39    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31
 35   5   9   19.39   18.64    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31
 36   5  10   18.64   17.89    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31
 37   5  11   17.89   17.14    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31
 38   5  12   17.14   16.39    0.16    0.00    0.00   0.133   0.344
 0.240    5.000        4.75       21.70        1.20     0.31


         STREAM QUALITY SIMULATION
                                  OUTPUT PAGE NUMBER     2
         QUAL-2E STREAM QUALITY ROUTING MODEL
                         Version 3.22  --  May 1996
                                                 ***** STEADY STATE
SIMULATION *****
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** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
39	6	1	16.00	15.25	0.16	0.00	0.00	0.032	1.453	0.390	13.003	20.08	54.58	5.07	0.11
40	6	2	15.25	14.50	0.16	0.00	0.00	0.032	1.453	0.390	13.003	20.08	54.58	5.07	0.11
41	6	3	14.50	13.75	0.16	0.00	0.00	0.032	1.453	0.390	13.003	20.08	54.58	5.07	0.11
42	6	4	13.75	13.00	0.16	0.00	0.00	0.032	1.453	0.390	13.003	20.08	54.58	5.07	0.11
43	6	5	13.00	12.25	0.16	0.00	0.00	0.032	1.453	0.390	13.003	20.08	54.58	5.07	0.11
44	6	6	12.25	11.50	0.16	0.00	0.00	0.032	1.453	0.390	13.003	20.08	54.58	5.07	0.11
45	6	7	11.50	10.75	0.16	0.00	0.00	0.032	1.453	0.390	13.003	20.08	54.58	5.07	0.11
46	6	8	10.75	10.00	0.16	0.00	0.00	0.032	1.453	0.390	13.003	20.08	54.58	5.07	0.11
47	6	9	10.00	9.25	0.16	0.00	0.00	0.032	1.453	0.390	13.003	20.08	54.58	5.07	0.11
48	6	10	9.25	8.50	0.16	0.00	0.00	0.032	1.453	0.390	13.003	20.08	54.58	5.07	0.11
49	6	11	8.50	7.75	0.32	0.16	0.00	0.063	0.726	0.390	13.003	20.08	54.58	5.07	0.22
50	6	12	7.75	7.00	0.32	0.00	0.00	0.063	0.726	0.390	13.003	20.08	54.58	5.07	0.22
51	6	13	7.00	6.25	0.32	0.00	0.00	0.063	0.726	0.390	13.003	20.08	54.58	5.07	0.22
52	6	14	6.25	5.50	0.48	0.16	0.00	0.095	0.484	0.390	13.003	20.08	54.58	5.07	0.33
53	6	15	5.50	4.75	0.48	0.00	0.00	0.095	0.484	0.390	13.003	20.08	54.58	5.07	0.33
54	6	16	4.75	4.00	0.64	0.16	0.00	0.126	0.363	0.390	13.003	20.08	54.58	5.07	0.44
55	7	1	4.20	3.45	0.64	0.00	0.00	0.031	1.458	0.690	29.517	80.65	122.35	20.37	0.18
56	7	2	3.45	2.70	0.64	0.00	0.00	0.031	1.458	0.690	29.517	80.65	122.35	20.37	0.18
57	7	3	2.70	1.95	0.80	0.16	0.00	0.039	1.167	0.690	29.517	80.65	122.35	20.37	0.22
58	7	4	1.95	1.20	0.80	0.00	0.00	0.039	1.167						

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0.690   29.517        80.65      122.35       20.37     0.22
59   7   5    1.20    0.45    0.80    0.00    0.00   0.039   1.167
0.690   29.517        80.65      122.35       20.37     0.22
60   7   6    0.45   -0.30    0.83    0.03    0.00   0.041   1.123
0.690   29.517        80.65      122.35       20.37     0.23


61   8   1   77.35   76.60    2.25    0.00    0.00   0.355   0.129
0.470   13.500        25.13       57.18        6.35     1.45
62   8   2   76.60   75.85    2.25    0.00    0.00   0.355   0.129
0.470   13.500        25.13       57.18        6.35     1.45
63   8   3   75.85   75.10    2.25    0.00    0.00   0.355   0.129
0.470   13.500        25.13       57.18        6.35     1.45
64   8   4   75.10   74.35    2.59    0.34    0.00   0.408   0.112
0.470   13.500        25.13       57.18        6.35     1.66
65   8   5   74.35   73.60    2.59    0.00    0.00   0.408   0.112
0.470   13.500        25.13       57.18        6.35     1.66
66   8   6   73.60   72.85    2.59    0.00    0.00   0.408   0.112
0.470   13.500        25.13       57.18        6.35     1.66
67   8   7   72.85   72.10    2.59    0.00    0.00   0.408   0.112
0.470   13.500        25.13       57.18        6.35     1.66
68   8   8   72.10   71.35    2.59    0.00    0.00   0.408   0.112
0.470   13.500        25.13       57.18        6.35     1.66
69   8   9   71.35   70.60    2.92    0.34    0.00   0.461   0.099
0.470   13.500        25.13       57.18        6.35     1.88
70   8  10   70.60   69.85    2.92    0.00    0.00   0.461   0.099
0.470   13.500        25.13       57.18        6.35     1.88
71   8  11   69.85   69.10    2.92    0.00    0.00   0.461   0.099
0.470   13.500        25.13       57.18        6.35     1.88
72   8  12   69.10   68.35    2.92    0.00    0.00   0.461   0.099
0.470   13.500        25.13       57.18        6.35     1.88
73   8  13   68.35   67.60    2.92    0.00    0.00   0.461   0.099
0.470   13.500        25.13       57.18        6.35     1.88
74   8  14   67.60   66.85    2.92    0.00    0.00   0.461   0.099
0.470   13.500        25.13       57.18        6.35     1.88


75   9   1   66.70   65.95    3.01    0.09    0.00   1.393   0.033
0.180   11.999         8.55       48.94        2.16     2.55
76   9   2   65.95   65.20    3.01    0.00    0.00   1.393   0.033
0.180   11.999         8.55       48.94        2.16     2.55
77   9   3   65.20   64.45    3.01    0.00    0.00   1.393   0.033
0.180   11.999         8.55       48.94        2.16     2.55
78   9   4   64.45   63.70    3.01    0.00    0.00   1.393   0.033
0.180   11.999         8.55       48.94        2.16     2.55


        STREAM QUALITY SIMULATION
                                 OUTPUT PAGE NUMBER     3
        QUAL-2E STREAM QUALITY ROUTING MODEL
                         Version 3.22  --  May 1996
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***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
79	10	1	63.40	62.65	3.27	0.26	0.00	0.010	4.524	4.890	65.967	1277.42	299.96	322.58	0.29
80	10	2	62.65	61.90	3.53	0.26	0.00	0.011	4.191	4.890	65.967	1277.42	299.96	322.58	0.31
81	10	3	61.90	61.15	3.53	0.00	0.00	0.011	4.191	4.890	65.967	1277.42	299.96	322.58	0.31
82	10	4	61.15	60.40	3.53	0.00	0.00	0.011	4.191	4.890	65.967	1277.42	299.96	322.58	0.31
83	10	5	60.40	59.65	3.53	0.00	0.00	0.011	4.191	4.890	65.967	1277.42	299.96	322.58	0.31
84	10	6	59.65	58.90	3.79	0.26	0.00	0.012	3.903	4.890	65.967	1277.42	299.96	322.58	0.34
85	10	7	58.90	58.15	3.79	0.00	0.00	0.012	3.903	4.890	65.967	1277.42	299.96	322.58	0.34
86	10	8	58.15	57.40	3.79	0.00	0.00	0.012	3.903	4.890	65.967	1277.42	299.96	322.58	0.34
87	10	9	57.40	56.65	3.79	0.00	0.00	0.012	3.903	4.890	65.967	1277.42	299.96	322.58	0.34
88	10	10	56.65	55.90	3.79	0.00	0.00	0.012	3.903	4.890	65.967	1277.42	299.96	322.58	0.34
89	10	11	55.90	55.15	3.79	0.00	0.00	0.012	3.903	4.890	65.967	1277.42	299.96	322.58	0.34
90	10	12	55.15	54.40	3.79	0.00	0.00	0.012	3.903	4.890	65.967	1277.42	299.96	322.58	0.34
91	10	13	54.40	53.65	3.79	0.00	0.00	0.012	3.903	4.890	65.967	1277.42	299.96	322.58	0.34
92	10	14	53.65	52.90	3.79	0.00	0.00	0.012	3.903	4.890	65.967	1277.42	299.96	322.58	0.34
93	11	1	52.80	52.05	4.05	0.26	0.00	0.028	1.641	2.440	59.397	573.91	254.54	144.93	0.45
94	11	2	52.05	51.30	4.05	0.00	0.00	0.028	1.641	2.440	59.397	573.91	254.54	144.93	0.45
95	11	3	51.30	50.55	4.05	0.00	0.00	0.028	1.641	2.440	59.397	573.91	254.54	144.93	0.45
96	11	4	50.55	49.80	4.05	0.00	0.00	0.028	1.641	2.440	59.397	573.91	254.54	144.93	0.45

```
 97  12   1   21.27   20.52    0.21    0.00    0.00   0.010   4.491
 1.210   17.005       81.48       76.92       20.58     0.09
 98  12   2   20.52   19.77    0.21    0.00    0.00   0.010   4.491
 1.210   17.005       81.48       76.92       20.58     0.09
 99  12   3   19.77   19.02    0.21    0.00    0.00   0.010   4.491
 1.210   17.005       81.48       76.92       20.58     0.09
100  12   4   19.02   18.27    0.21    0.00    0.00   0.010   4.491
 1.210   17.005       81.48       76.92       20.58     0.09
101  12   5   18.27   17.52    0.21    0.00    0.00   0.010   4.491
 1.210   17.005       81.48       76.92       20.58     0.09
102  12   6   17.52   16.77    0.21    0.00    0.00   0.010   4.491
 1.210   17.005       81.48       76.92       20.58     0.09
103  12   7   16.77   16.02    0.21    0.00    0.00   0.010   4.491
 1.210   17.005       81.48       76.92       20.58     0.09
104  12   8   16.02   15.27    0.21    0.00    0.00   0.010   4.491
 1.210   17.005       81.48       76.92       20.58     0.09
105  12   9   15.27   14.52    0.21    0.00    0.00   0.010   4.491
 1.210   17.005       81.48       76.92       20.58     0.09
106  12  10   14.52   13.77    0.21    0.00    0.00   0.010   4.491
 1.210   17.005       81.48       76.92       20.58     0.09
107  12  11   13.77   13.02    0.21    0.00    0.00   0.010   4.491
 1.210   17.005       81.48       76.92       20.58     0.09


108  13   1   12.70   11.95    0.21    0.00    0.00   0.006   7.299
 1.520   22.003      132.44       99.17       33.44     0.07
109  13   2   11.95   11.20    0.21    0.00    0.00   0.006   7.299
 1.520   22.003      132.44       99.17       33.44     0.07
110  13   3   11.20   10.45    0.21    0.00    0.00   0.006   7.299
 1.520   22.003      132.44       99.17       33.44     0.07
111  13   4   10.45    9.70    0.42    0.21    0.00   0.013   3.650
 1.520   22.003      132.44       99.17       33.44     0.14
112  13   5    9.70    8.95    0.42    0.00    0.00   0.013   3.650
 1.520   22.003      132.44       99.17       33.44     0.14
113  13   6    8.95    8.20    0.42    0.00    0.00   0.013   3.650
 1.520   22.003      132.44       99.17       33.44     0.14
114  13   7    8.20    7.45    0.63    0.21    0.00   0.019   2.433
 1.520   22.003      132.44       99.17       33.44     0.20
115  13   8    7.45    6.70    0.63    0.00    0.00   0.019   2.433
 1.520   22.003      132.44       99.17       33.44     0.20
116  13   9    6.70    5.95    0.63    0.00    0.00   0.019   2.433
 1.520   22.003      132.44       99.17       33.44     0.20
117  13  10    5.95    5.20    0.63    0.00    0.00   0.019   2.433
 1.520   22.003      132.44       99.17       33.44     0.20
118  13  11    5.20    4.45    0.63    0.00    0.00   0.019   2.433
 1.520   22.003      132.44       99.17       33.44     0.20

         STREAM QUALITY SIMULATION
                                 OUTPUT PAGE NUMBER     4
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***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
119	13	12	4.45	3.70	0.63	0.00	0.00	0.019	2.433	1.520	22.003	132.44	99.17	33.44	0.20
120	13	13	3.70	2.95	0.63	0.00	0.00	0.019	2.433	1.520	22.003	132.44	99.17	33.44	0.20
121	13	14	2.95	2.20	0.84	0.21	0.00	0.025	1.825	1.520	22.003	132.44	99.17	33.44	0.27
122	13	15	2.20	1.45	0.84	0.00	0.00	0.025	1.825	1.520	22.003	132.44	99.17	33.44	0.27
123	14	1	1.30	0.55	0.84	0.00	0.00	0.015	2.982	1.400	39.032	216.39	165.65	54.64	0.16
124	14	2	0.55	-0.20	0.84	0.00	0.00	0.015	2.982	1.400	39.032	216.39	165.65	54.64	0.16
125	15	1	50.07	49.32	4.89	0.00	0.00	1.955	0.023	0.250	10.000	9.90	41.58	2.50	4.71
126	15	2	49.32	48.57	4.89	0.00	0.00	1.955	0.023	0.250	10.000	9.90	41.58	2.50	4.71
127	15	3	48.57	47.82	5.13	0.24	0.00	2.051	0.022	0.250	10.000	9.90	41.58	2.50	4.94
128	15	4	47.82	47.07	5.13	0.00	0.00	2.051	0.022	0.250	10.000	9.90	41.58	2.50	4.94
129	15	5	47.07	46.32	5.13	0.00	0.00	2.051	0.022	0.250	10.000	9.90	41.58	2.50	4.94
130	15	6	46.32	45.57	5.37	0.24	0.00	2.147	0.021	0.250	10.000	9.90	41.58	2.50	5.17
131	15	7	45.57	44.82	5.37	0.00	0.00	2.147	0.021	0.250	10.000	9.90	41.58	2.50	5.17
132	15	8	44.82	44.07	5.37	0.00	0.00	2.147	0.021	0.250	10.000	9.90	41.58	2.50	5.17
133	15	9	44.07	43.32	5.37	0.00	0.00	2.147	0.021	0.250	10.000	9.90	41.58	2.50	5.17
134	15	10	43.32	42.57	5.61	0.24	0.00	2.243	0.020	0.250	10.000	9.90	41.58	2.50	5.40
135	15	11	42.57	41.82	5.61	0.00	0.00	2.243	0.020	0.250	10.000	9.90	41.58	2.50	5.40
136	15	12	41.82	41.07	5.61	0.00	0.00	2.243	0.020						

```
 0.250   10.000        9.90       41.58        2.50     5.40
137  15  13   41.07   40.32    5.61   0.00    0.00   2.243   0.020
 0.250   10.000        9.90       41.58        2.50     5.40
138  15  14   40.32   39.57    5.61   0.00    0.00   2.243   0.020
 0.250   10.000        9.90       41.58        2.50     5.40
139  15  15   39.57   38.82    5.61   0.00    0.00   2.243   0.020
 0.250   10.000        9.90       41.58        2.50     5.40
140  15  16   38.82   38.07    5.61   0.00    0.00   2.243   0.020
 0.250   10.000        9.90       41.58        2.50     5.40


141  16   1   28.22   27.47    0.25   0.00    0.00   0.003  13.573
 1.750   42.644      295.52      182.73       74.63     0.04
142  16   2   27.47   26.72    0.25   0.00    0.00   0.003  13.573
 1.750   42.644      295.52      182.73       74.63     0.04
143  16   3   26.72   25.97    0.25   0.00    0.00   0.003  13.573
 1.750   42.644      295.52      182.73       74.63     0.04
144  16   4   25.97   25.22    0.25   0.00    0.00   0.003  13.573
 1.750   42.644      295.52      182.73       74.63     0.04
145  16   5   25.22   24.47    0.25   0.00    0.00   0.003  13.573
 1.750   42.644      295.52      182.73       74.63     0.04
146  16   6   24.47   23.72    0.25   0.00    0.00   0.003  13.573
 1.750   42.644      295.52      182.73       74.63     0.04
147  16   7   23.72   22.97    0.25   0.00    0.00   0.003  13.573
 1.750   42.644      295.52      182.73       74.63     0.04
148  16   8   22.97   22.22    0.25   0.00    0.00   0.003  13.573
 1.750   42.644      295.52      182.73       74.63     0.04
149  16   9   22.22   21.47    0.50   0.25    0.00   0.007   6.786
 1.750   42.644      295.52      182.73       74.63     0.08
150  16  10   21.47   20.72    0.76   0.25    0.00   0.010   4.524
 1.750   42.644      295.52      182.73       74.63     0.12
151  16  11   20.72   19.97    0.76   0.00    0.00   0.010   4.524
 1.750   42.644      295.52      182.73       74.63     0.12


152  17   1   20.00   19.25    0.76   0.00    0.00   0.010   4.524
 1.750   42.644      295.52      182.73       74.63     0.12
153  17   2   19.25   18.50    0.76   0.00    0.00   0.010   4.524
 1.750   42.644      295.52      182.73       74.63     0.12
154  17   3   18.50   17.75    0.76   0.00    0.00   0.010   4.524
 1.750   42.644      295.52      182.73       74.63     0.12
155  17   4   17.75   17.00    0.76   0.00    0.00   0.010   4.524
 1.750   42.644      295.52      182.73       74.63     0.12
156  17   5   17.00   16.25    0.76   0.00    0.00   0.010   4.524
 1.750   42.644      295.52      182.73       74.63     0.12

         STREAM QUALITY SIMULATION
                                  OUTPUT PAGE NUMBER     5
         QUAL-2E STREAM QUALITY ROUTING MODEL
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                                                  ***** STEADY STATE
SIMULATION *****
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** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	BOTTOM WIDTH FT	VOLUME K-FT-3	X-SECT AREA K-FT-2	FLOW AREA FT-2	DSPRSN COEF FT-2/S
157	17	6	16.25	15.50	1.01	0.25	0.00	0.014	3.393	1.750	42.644	295.52	182.73	74.63	0.16
158	17	7	15.50	14.75	1.01	0.00	0.00	0.014	3.393	1.750	42.644	295.52	182.73	74.63	0.16
159	17	8	14.75	14.00	1.01	0.00	0.00	0.014	3.393	1.750	42.644	295.52	182.73	74.63	0.16
160	17	9	14.00	13.25	1.01	0.00	0.00	0.014	3.393	1.750	42.644	295.52	182.73	74.63	0.16
161	18	1	13.60	12.85	1.01	0.00	0.00	0.014	3.393	1.750	42.644	295.52	182.73	74.63	0.16
162	18	2	12.85	12.10	1.01	0.00	0.00	0.014	3.393	1.750	42.644	295.52	182.73	74.63	0.16
163	18	3	12.10	11.35	1.01	0.00	0.00	0.014	3.393	1.750	42.644	295.52	182.73	74.63	0.16
164	18	4	11.35	10.60	1.01	0.00	0.00	0.014	3.393	1.750	42.644	295.52	182.73	74.63	0.16
165	18	5	10.60	9.85	1.01	0.00	0.00	0.014	3.393	1.750	42.644	295.52	182.73	74.63	0.16
166	18	6	9.85	9.10	1.01	0.00	0.00	0.014	3.393	1.750	42.644	295.52	182.73	74.63	0.16
167	18	7	9.10	8.35	1.01	0.00	0.00	0.014	3.393	1.750	42.644	295.52	182.73	74.63	0.16
168	18	8	8.35	7.60	1.26	0.25	0.00	0.017	2.715	1.750	42.644	295.52	182.73	74.63	0.21
169	18	9	7.60	6.85	1.26	0.00	0.00	0.017	2.715	1.750	42.644	295.52	182.73	74.63	0.21
170	18	10	6.85	6.10	1.26	0.00	0.00	0.017	2.715	1.750	42.644	295.52	182.73	74.63	0.21
171	18	11	6.10	5.35	1.31	0.05	0.00	0.018	2.615	1.750	42.644	295.52	182.73	74.63	0.21
172	18	12	5.35	4.60	1.31	0.00	0.00	0.018	2.615	1.750	42.644	295.52	182.73	74.63	0.21
173	18	13	4.60	3.85	1.31	0.00	0.00	0.018	2.615	1.750	42.644	295.52	182.73	74.63	0.21
174	19	1	4.00	3.25	1.56	0.25	0.00	0.015	2.968	1.810	55.807	400.00	235.33	101.01	0.19
175	19	2	3.25	2.50	1.56	0.00	0.00	0.015	2.968						

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 1.810   55.807      400.00      235.33      101.01     0.19
176  19   3    2.50    1.75    1.56   0.00    0.00   0.015   2.968
 1.810   55.807      400.00      235.33      101.01     0.19
177  19   4    1.75    1.00    1.56   0.00    0.00   0.015   2.968
 1.810   55.807      400.00      235.33      101.01     0.19
178  19   5    1.00    0.25    1.56   0.00    0.00   0.015   2.968
 1.810   55.807      400.00      235.33      101.01     0.19


179  20   1   38.13   37.38    7.17   0.00    0.00   0.027   1.683
 3.860   68.176     1042.11      300.55      263.16     0.64
180  20   2   37.38   36.63    7.17   0.00    0.00   0.027   1.683
 3.860   68.176     1042.11      300.55      263.16     0.64
181  20   3   36.63   35.88    7.17   0.00    0.00   0.027   1.683
 3.860   68.176     1042.11      300.55      263.16     0.64


182  21   1   35.80   35.05    7.76   0.59    0.00   0.016   2.813
 5.860   81.261     1885.71      368.21      476.19     0.54
183  21   2   35.05   34.30    7.76   0.00    0.00   0.016   2.813
 5.860   81.261     1885.71      368.21      476.19     0.54
184  21   3   34.30   33.55    7.76   0.00    0.00   0.016   2.813
 5.860   81.261     1885.71      368.21      476.19     0.54
185  21   4   33.55   32.80    8.35   0.59    0.00   0.018   2.614
 5.860   81.261     1885.71      368.21      476.19     0.58
186  21   5   32.80   32.05    8.35   0.00    0.00   0.018   2.614
 5.860   81.261     1885.71      368.21      476.19     0.58


187  22   1   31.90   31.15    8.49   0.14    0.00   0.018   2.571
 5.860   81.261     1885.71      368.21      476.19     0.59
188  22   2   31.15   30.40    8.49   0.00    0.00   0.018   2.571
 5.860   81.261     1885.71      368.21      476.19     0.59
189  22   3   30.40   29.65    9.08   0.59    0.00   0.019   2.404
 5.860   81.261     1885.71      368.21      476.19     0.64
190  22   4   29.65   28.90    9.08   0.00    0.00   0.019   2.404
 5.860   81.261     1885.71      368.21      476.19     0.64
191  22   5   28.90   28.15    9.08   0.00    0.00   0.019   2.404
 5.860   81.261     1885.71      368.21      476.19     0.64
192  22   6   28.15   27.40    9.08   0.00    0.00   0.019   2.404
 5.860   81.261     1885.71      368.21      476.19     0.64

         STREAM QUALITY SIMULATION
                                  OUTPUT PAGE NUMBER     6
         QUAL-2E STREAM QUALITY ROUTING MODEL
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                                                         ** HYDRAULICS
SUMMARY **
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ELE RCH ELE   BEGIN     END             POINT    INCR              TRVL
                                  BOTTOM       X-SECT   DSPRSN
ORD NUM NUM     LOC     LOC    FLOW    SRCE    FLOW      VEL     TIME
 DEPTH    WIDTH       VOLUME       AREA         AREA      COEF
               MILE    MILE     CFS     CFS     CFS      FPS      DAY
    FT       FT       K-FT-3      K-FT-2         FT-2   FT-2/S

193  22   7   27.40   26.65    9.08    0.00    0.00   0.019   2.404
 5.860   81.261     1885.71      368.21       476.19     0.64


194  23   1   27.17   26.42    9.09    0.01    0.00   0.075   0.608
 2.010   59.941      477.11      253.29       120.48     1.03
195  23   2   26.42   25.67    9.09    0.00    0.00   0.075   0.608
 2.010   59.941      477.11      253.29       120.48     1.03
196  23   3   25.67   24.92    9.09    0.00    0.00   0.075   0.608
 2.010   59.941      477.11      253.29       120.48     1.03
197  23   4   24.92   24.17    9.09    0.00    0.00   0.075   0.608
 2.010   59.941      477.11      253.29       120.48     1.03
198  23   5   24.17   23.42    9.09    0.00    0.00   0.075   0.608
 2.010   59.941      477.11      253.29       120.48     1.03
199  23   6   23.42   22.67    9.09    0.00    0.00   0.075   0.608
 2.010   59.941      477.11      253.29       120.48     1.03
200  23   7   22.67   21.92    9.09    0.00    0.00   0.075   0.608
 2.010   59.941      477.11      253.29       120.48     1.03
201  23   8   21.92   21.17    9.09    0.00    0.00   0.075   0.608
 2.010   59.941      477.11      253.29       120.48     1.03
202  23   9   21.17   20.42    9.09    0.00    0.00   0.075   0.608
 2.010   59.941      477.11      253.29       120.48     1.03
203  23  10   20.42   19.67   10.39    1.30    0.00   0.086   0.532
 2.010   59.941      477.11      253.29       120.48     1.18


204  24   1   19.50   18.75   11.69    1.30    0.00   0.097   0.473
 2.010   59.941      477.11      253.29       120.48     1.33
205  24   2   18.75   18.00   12.99    1.30    0.00   0.108   0.425
 2.010   59.941      477.11      253.29       120.48     1.47
206  24   3   18.00   17.25   13.00    0.02    0.00   0.108   0.425
 2.010   59.941      477.11      253.29       120.48     1.47
207  24   4   17.25   16.50   13.00    0.00    0.00   0.108   0.425
 2.010   59.941      477.11      253.29       120.48     1.47
208  24   5   16.50   15.75   13.00    0.00    0.00   0.108   0.425
 2.010   59.941      477.11      253.29       120.48     1.47
209  24   6   15.75   15.00   13.02    0.02    0.00   0.108   0.424
 2.010   59.941      477.11      253.29       120.48     1.48
210  24   7   15.00   14.25   14.32    1.30    0.00   0.119   0.386
 2.010   59.941      477.11      253.29       120.48     1.62
211  24   8   14.25   13.50   14.32    0.00    0.00   0.119   0.386
 2.010   59.941      477.11      253.29       120.48     1.62
212  24   9   13.50   12.75   14.33    0.01    0.00   0.119   0.385
 2.010   59.941      477.11      253.29       120.48     1.63
213  24  10   12.75   12.00   14.48    0.15    0.00   0.120   0.381
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 2.010   59.941      477.11      253.29      120.48     1.64
214  24  11   12.00   11.25   14.48   0.00    0.00   0.120   0.381
 2.010   59.941      477.11      253.29      120.48     1.64
215  24  12   11.25   10.50   14.48   0.00    0.00   0.120   0.381
 2.010   59.941      477.11      253.29      120.48     1.64
216  24  13   10.50    9.75   14.48   0.00    0.00   0.120   0.381
 2.010   59.941      477.11      253.29      120.48     1.64
217  24  14    9.75    9.00   14.48   0.00    0.00   0.120   0.381
 2.010   59.941      477.11      253.29      120.48     1.64
218  24  15    9.00    8.25   14.48   0.00    0.00   0.120   0.381
 2.010   59.941      477.11      253.29      120.48     1.64
219  24  16    8.25    7.50   14.48   0.00    0.00   0.120   0.381
 2.010   59.941      477.11      253.29      120.48     1.64
220  24  17    7.50    6.75   14.48   0.00    0.00   0.120   0.381
 2.010   59.941      477.11      253.29      120.48     1.64


221  25   1    7.20    6.45   15.42   0.94    0.00   0.051   0.900
 3.390   89.389     1200.00      380.83      303.03     1.08
222  25   2    6.45    5.70   15.42   0.00    0.00   0.051   0.900
 3.390   89.389     1200.00      380.83      303.03     1.08
223  25   3    5.70    4.95   15.42   0.00    0.00   0.051   0.900
 3.390   89.389     1200.00      380.83      303.03     1.08
224  25   4    4.95    4.20   15.42   0.00    0.00   0.051   0.900
 3.390   89.389     1200.00      380.83      303.03     1.08
225  25   5    4.20    3.45   16.36   0.94    0.00   0.054   0.849
 3.390   89.389     1200.00      380.83      303.03     1.14


226  26   1    3.10    2.35   16.36   0.00    0.00   0.036   1.273
 5.100   89.127     1800.00      393.33      454.55     1.07
227  26   2    2.35    1.60   16.36   0.00    0.00   0.036   1.273
 5.100   89.127     1800.00      393.33      454.55     1.07
228  26   3    1.60    0.85   16.36   0.00    0.00   0.036   1.273
 5.100   89.127     1800.00      393.33      454.55     1.07
229  26   4    0.85    0.10   16.36   0.00    0.00   0.036   1.273
 5.100   89.127     1800.00      393.33      454.55     1.07



         STREAM QUALITY SIMULATION
                                      OUTPUT PAGE NUMBER     7
         QUAL-2E STREAM QUALITY ROUTING MODEL
                              Version 3.22  --  May 1996
                                                         ***** STEADY STATE
SIMULATION *****

                                                         ** REACTION
COEFFICIENT SUMMARY **

RCH ELE      DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3
 NH3    NO2   ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
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NUM NUM    SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY
SRCE  DECAY  DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
          MG/L      1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY
MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

  1   1   8.33   1   1.49   0.28   0.00   0.11   0.12   0.00   0.62
0.00   3.23   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   2   8.33   1   1.49   0.28   0.00   0.11   0.12   0.00   0.62
0.00   3.27   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   3   8.33   1   1.49   0.28   0.00   0.11   0.12   0.00   0.63
0.00   3.31   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   4   8.33   1   1.49   0.28   0.00   0.11   0.12   0.00   0.63
0.00   3.33   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   5   8.33   1   1.49   0.28   0.00   0.11   0.12   0.00   0.64
0.00   3.33   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   6   8.33   1   1.49   0.28   0.00   0.11   0.12   0.00   0.64
0.00   3.34   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   7   8.33   1   1.49   0.28   0.00   0.11   0.12   0.00   0.64
0.00   3.34   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   8   8.33   1   1.49   0.28   0.00   0.11   0.12   0.00   0.64
0.00   3.34   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  1   9   8.33   1   1.49   0.28   0.00   0.11   0.12   0.00   0.64
0.00   3.34   0.00   0.00   0.00   0.00   0.00   0.00   0.00


  2   1   8.33   1   1.35   0.28   0.00   0.11   0.12   0.00   0.63
0.00   3.29   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   2   8.33   1   1.21   0.28   0.00   0.11   0.12   0.00   0.61
0.00   3.19   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   3   8.33   1   1.21   0.28   0.00   0.11   0.12   0.00   0.43
0.00   2.24   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  2   4   8.33   1   1.21   0.28   0.00   0.11   0.12   0.00   0.24
0.00   1.24   0.00   0.00   0.00   0.00   0.00   0.00   0.00


  3   1   8.82   1   0.73   0.24   0.00   0.09   0.10   0.00   0.04
0.00   0.25   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   2   8.82   1   0.34   0.24   0.00   0.09   0.10   0.00   0.05
0.00   0.30   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   3   8.82   1   0.34   0.24   0.00   0.09   0.10   0.00   0.00
0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   4   8.82   1   0.34   0.24   0.00   0.09   0.10   0.00   0.00
0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  3   5   8.82   1   0.34   0.24   0.00   0.09   0.10   0.00   0.11
0.00   0.64   0.00   0.00   0.00   0.00   0.00   0.00   0.00


  4   1   8.34   1   0.35   0.28   0.00   0.11   0.12   0.00   0.00
0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   2   8.34   1   0.33   0.28   0.00   0.11   0.12   0.00   0.43
0.00   2.24   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   3   8.34   1   0.33   0.28   0.00   0.11   0.12   0.00   0.54
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0.00   2.84   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   4   8.34   1   0.33   0.28   0.00   0.11   0.12   0.00   0.55
0.00   2.87   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   5   8.34   1   0.33   0.28   0.00   0.11   0.12   0.00   0.55
0.00   2.89   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   6   8.34   1   0.33   0.28   0.00   0.11   0.12   0.00   0.55
0.00   2.90   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   7   8.34   1   0.33   0.28   0.00   0.11   0.12   0.00   0.57
0.00   2.98   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  4   8   8.34   1   0.33   0.28   0.00   0.11   0.12   0.00   0.56
0.00   2.93   0.00   0.00   0.00   0.00   0.00   0.00   0.00


  5   1   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.93
0.00   4.25   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   2   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.91
0.00   4.15   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   3   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.89
0.00   4.09   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   4   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.89
0.00   4.06   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   5   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.88
0.00   4.05   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   6   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.88
0.00   4.05   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   7   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.88
0.00   4.05   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   8   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.88
0.00   4.05   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5   9   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.88
0.00   4.05   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  10   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.88
0.00   4.05   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  11   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.88
0.00   4.05   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  5  12   7.74   1   4.76   0.33   0.00   0.09   0.14   0.00   0.88
0.00   4.05   0.00   0.00   0.00   0.00   0.00   0.00   0.00


         STREAM QUALITY SIMULATION
                                  OUTPUT PAGE NUMBER     8
         QUAL-2E STREAM QUALITY ROUTING MODEL
                          Version 3.22  --  May 1996
                                                    ***** STEADY STATE
SIMULATION *****

                                                    ** REACTION
COEFFICIENT SUMMARY **

RCH ELE      DO   K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3
 NH3    NO2   ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
```

```
NUM NUM    SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY
SRCE  DECAY  DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
          MG/L      1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY
MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

  6   1   8.52   1   2.62   0.26   0.00   0.07   0.11   0.00   0.58
0.00   3.18   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6   2   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.52
0.00   2.86   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6   3   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.49
0.00   2.65   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6   4   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.47
0.00   2.55   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6   5   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.46
0.00   2.50   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6   6   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.46
0.00   2.49   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6   7   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.46
0.00   2.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6   8   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.46
0.00   2.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6   9   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.46
0.00   2.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6  10   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.46
0.00   2.49   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6  11   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.55
0.00   2.98   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6  12   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.51
0.00   2.77   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6  13   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.48
0.00   2.63   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6  14   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.54
0.00   2.93   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6  15   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.51
0.00   2.78   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  6  16   8.52   1   1.04   0.26   0.00   0.07   0.11   0.00   0.54
0.00   2.94   0.00   0.00   0.00   0.00   0.00   0.00   0.00


  7   1   8.65   1   1.04   0.25   0.00   0.07   0.11   0.00   0.50
0.00   2.79   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  7   2   8.65   1   1.05   0.25   0.00   0.07   0.11   0.00   0.54
0.00   3.05   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  7   3   8.65   1   1.05   0.25   0.00   0.07   0.11   0.00   0.56
0.00   3.12   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  7   4   8.65   1   1.05   0.25   0.00   0.07   0.11   0.00   0.56
0.00   3.13   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  7   5   8.65   1   1.05   0.25   0.00   0.07   0.11   0.00   0.56
0.00   3.14   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  7   6   8.65   1   1.05   0.25   0.00   0.07   0.11   0.00   0.56
0.00   3.14   0.00   0.00   0.00   0.00   0.00   0.00   0.00
```

8	1	8.56	1	0.52	0.26	0.00	0.07	0.11	0.00	0.58	0.00	3.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	2	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.57	0.00	3.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	3	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.56	0.00	3.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	4	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.56	0.00	3.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	5	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.54	0.00	2.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	6	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.52	0.00	2.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	7	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.49	0.00	2.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	8	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.46	0.00	2.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	9	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.48	0.00	2.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	10	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.44	0.00	2.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	11	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.41	0.00	2.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	12	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.36	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	13	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.31	0.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	14	8.56	1	0.34	0.26	0.00	0.07	0.11	0.00	0.26	0.00	1.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00

9	1	8.62	1	0.34	0.25	0.00	0.03	0.11	0.00	0.27	0.00	1.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	2	8.62	1	0.34	0.25	0.00	0.03	0.11	0.00	0.24	0.00	1.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	3	8.62	1	0.34	0.25	0.00	0.03	0.11	0.00	0.21	0.00	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	4	8.62	1	0.34	0.25	0.00	0.03	0.11	0.00	0.18	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 9
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996
***** STEADY STATE SIMULATION *****

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
10	1	8.57	1	0.21	0.26	0.00	0.03	0.11	0.00	0.47	0.00	2.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	2	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.51	0.00	2.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	3	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.53	0.00	2.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	4	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.54	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	5	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.55	0.00	3.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	6	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.56	0.00	3.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	7	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.57	0.00	3.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	8	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.57	0.00	3.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	9	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.57	0.00	3.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	10	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.57	0.00	3.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	11	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.57	0.00	3.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	12	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.57	0.00	3.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	13	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.57	0.00	3.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	14	8.57	1	0.07	0.26	0.00	0.03	0.11	0.00	0.58	0.00	3.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	1	8.49	1	0.06	0.26	0.00	0.03	0.11	0.00	0.59	0.00	3.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	2	8.49	1	0.05	0.26	0.00	0.03	0.11	0.00	0.58	0.00	3.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	3	8.49	1	0.05	0.26	0.00	0.03	0.11	0.00	0.56	0.00	3.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	4	8.49	1	0.05	0.26	0.00	0.03	0.11	0.00	0.54	0.00	2.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	1	8.79	1	0.27	0.24	0.00	0.06	0.11	0.00	0.26	0.00	1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	2	8.79	1	0.27	0.24	0.00	0.06	0.11	0.00	0.28	0.00	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	3	8.79	1	0.27	0.24	0.00	0.06	0.11	0.00	0.31									

0.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
12	4	8.79	1	0.27	0.24	0.00	0.06	0.11	0.00	0.34
0.00	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
12	5	8.79	1	0.27	0.24	0.00	0.06	0.11	0.00	0.35
0.00	2.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
12	6	8.79	1	0.27	0.24	0.00	0.06	0.11	0.00	0.36
0.00	2.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
12	7	8.79	1	0.27	0.24	0.00	0.06	0.11	0.00	0.36
0.00	2.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
12	8	8.79	1	0.27	0.24	0.00	0.06	0.11	0.00	0.36
0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
12	9	8.79	1	0.27	0.24	0.00	0.06	0.11	0.00	0.37
0.00	2.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
12	10	8.79	1	0.27	0.24	0.00	0.06	0.11	0.00	0.37
0.00	2.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
12	11	8.79	1	0.27	0.24	0.00	0.06	0.11	0.00	0.37
0.00	2.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

13	1	8.73	1	0.25	0.25	0.00	0.06	0.11	0.00	0.35
0.00	1.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
13	2	8.73	1	0.24	0.25	0.00	0.06	0.11	0.00	0.41
0.00	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
13	3	8.73	1	0.24	0.25	0.00	0.06	0.11	0.00	0.43
0.00	2.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
13	4	8.73	1	0.24	0.25	0.00	0.06	0.11	0.00	0.49
0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
13	5	8.73	1	0.24	0.25	0.00	0.06	0.11	0.00	0.46
0.00	2.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
13	6	8.73	1	0.24	0.25	0.00	0.06	0.11	0.00	0.44
0.00	2.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
13	7	8.73	1	0.24	0.25	0.00	0.06	0.11	0.00	0.48
0.00	2.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
13	8	8.73	1	0.24	0.25	0.00	0.06	0.11	0.00	0.46
0.00	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
13	9	8.73	1	0.24	0.25	0.00	0.06	0.11	0.00	0.45
0.00	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
13	10	8.73	1	0.24	0.25	0.00	0.06	0.11	0.00	0.44
0.00	2.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
13	11	8.73	1	0.24	0.25	0.00	0.06	0.11	0.00	0.44
0.00	2.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

STREAM QUALITY SIMULATION
OUTPUT PAGE NUMBER 10
QUAL-2E STREAM QUALITY ROUTING MODEL
Version 3.22 -- May 1996
***** STEADY STATE SIMULATION *****

** REACTION COEFFICIENT SUMMARY **

```
RCH ELE     DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3
 NH3    NO2   ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
NUM NUM    SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY
SRCE  DECAY  DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
          MG/L      1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY
MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

 13  12   8.73   1   0.24   0.25   0.00   0.06   0.11   0.00   0.43
0.00   2.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 13  13   8.73   1   0.24   0.25   0.00   0.06   0.11   0.00   0.43
0.00   2.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 13  14   8.73   1   0.24   0.25   0.00   0.06   0.11   0.00   0.48
0.00   2.72   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 13  15   8.73   1   0.24   0.25   0.00   0.06   0.11   0.00   0.46
0.00   2.62   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 14   1   8.73   1   0.24   0.25   0.00   0.06   0.11   0.00   0.40
0.00   2.25   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 14   2   8.73   1   0.24   0.25   0.00   0.06   0.11   0.00   0.40
0.00   2.30   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 15   1   8.24   1   0.80   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15   2   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15   3   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.49   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15   4   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.49   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15   5   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.49   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15   6   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.50   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15   7   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.50   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15   8   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.49   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15   9   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.49   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15  10   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.50   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15  11   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.50   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15  12   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.50   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15  13   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.50   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15  14   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.49   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15  15   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
```

```
0.00   3.49   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 15  16   8.24   1   1.45   0.28   0.00   0.04   0.12   0.00   0.68
0.00   3.49   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 16   1   8.41   1   1.18   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.47   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 16   2   8.41   1   1.18   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.47   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 16   3   8.41   1   1.18   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.47   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 16   4   8.41   1   1.18   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 16   5   8.41   1   1.18   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 16   6   8.41   1   1.18   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 16   7   8.41   1   1.18   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 16   8   8.41   1   1.18   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.48   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 16   9   8.41   1   1.18   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.47   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 16  10   8.41   1   1.18   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.47   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 16  11   8.41   1   1.18   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.47   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 17   1   8.41   1   0.74   0.27   0.00   0.07   0.12   0.00   0.65
0.00   3.45   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 17   2   8.41   1   0.30   0.27   0.00   0.07   0.12   0.00   0.62
0.00   3.32   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 17   3   8.41   1   0.30   0.27   0.00   0.07   0.12   0.00   0.60
0.00   3.21   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 17   4   8.41   1   0.30   0.27   0.00   0.07   0.12   0.00   0.59
0.00   3.15   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 17   5   8.41   1   0.30   0.27   0.00   0.07   0.12   0.00   0.58
0.00   3.12   0.00   0.00   0.00   0.00   0.00   0.00   0.00

         STREAM QUALITY SIMULATION
                                 OUTPUT PAGE NUMBER    11
         QUAL-2E STREAM QUALITY ROUTING MODEL
                         Version 3.22  --  May 1996
                                                ***** STEADY STATE
SIMULATION *****

                                                ** REACTION
COEFFICIENT SUMMARY **

RCH ELE      DO   K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3
 NH3    NO2   ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
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```
NUM NUM    SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY
SRCE  DECAY  DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
         MG/L      1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY
MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D

 17   6   8.41   1   0.30   0.27   0.00   0.07   0.12   0.00   0.59
0.00   3.17   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 17   7   8.41   1   0.30   0.27   0.00   0.07   0.12   0.00   0.58
0.00   3.12   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 17   8   8.41   1   0.30   0.27   0.00   0.07   0.12   0.00   0.58
0.00   3.10   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 17   9   8.41   1   0.30   0.27   0.00   0.07   0.12   0.00   0.58
0.00   3.09   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 18   1   8.58   1   0.27   0.26   0.00   0.06   0.11   0.00   0.53
0.00   2.92   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18   2   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.51
0.00   2.84   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18   3   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.51
0.00   2.79   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18   4   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.50
0.00   2.77   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18   5   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.50
0.00   2.75   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18   6   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.50
0.00   2.74   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18   7   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.49
0.00   2.74   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18   8   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.52
0.00   2.86   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18   9   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.50
0.00   2.79   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18  10   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.50
0.00   2.76   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18  11   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.50
0.00   2.76   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18  12   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.49
0.00   2.74   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 18  13   8.58   1   0.24   0.26   0.00   0.06   0.11   0.00   0.49
0.00   2.73   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 19   1   8.66   1   0.27   0.25   0.00   0.06   0.11   0.00   0.50
0.00   2.80   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 19   2   8.66   1   0.29   0.25   0.00   0.06   0.11   0.00   0.52
0.00   2.91   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 19   3   8.66   1   0.29   0.25   0.00   0.06   0.11   0.00   0.53
0.00   2.96   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 19   4   8.66   1   0.29   0.25   0.00   0.06   0.11   0.00   0.53
0.00   2.99   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 19   5   8.66   1   0.29   0.25   0.00   0.06   0.11   0.00   0.54
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```
0.00   3.01   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 20   1   8.46   1   0.50   0.27   0.00   0.11   0.12   0.00   0.59
0.00   3.20   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 20   2   8.46   1   0.15   0.27   0.00   0.11   0.12   0.00   0.57
0.00   3.05   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 20   3   8.46   1   0.15   0.27   0.00   0.11   0.12   0.00   0.54
0.00   2.88   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 21   1   8.27   1   0.24   0.28   0.00   0.12   0.12   0.00   0.62
0.00   3.20   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 21   2   8.27   1   0.33   0.28   0.00   0.12   0.12   0.00   0.66
0.00   3.43   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 21   3   8.27   1   0.33   0.28   0.00   0.12   0.12   0.00   0.68
0.00   3.50   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 21   4   8.27   1   0.33   0.28   0.00   0.12   0.12   0.00   0.68
0.00   3.53   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 21   5   8.27   1   0.33   0.28   0.00   0.12   0.12   0.00   0.68
0.00   3.54   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 22   1   8.27   1   0.33   0.28   0.00   0.12   0.12   0.00   0.68
0.00   3.54   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 22   2   8.27   1   0.33   0.28   0.00   0.12   0.12   0.00   0.69
0.00   3.55   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 22   3   8.27   1   0.33   0.28   0.00   0.12   0.12   0.00   0.69
0.00   3.55   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 22   4   8.27   1   0.33   0.28   0.00   0.12   0.12   0.00   0.69
0.00   3.55   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 22   5   8.27   1   0.33   0.28   0.00   0.12   0.12   0.00   0.69
0.00   3.55   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 22   6   8.27   1   0.33   0.28   0.00   0.12   0.12   0.00   0.69
0.00   3.55   0.00   0.00   0.00   0.00   0.00   0.00   0.00

         STREAM QUALITY SIMULATION
                                     OUTPUT PAGE NUMBER    12
         QUAL-2E STREAM QUALITY ROUTING MODEL
                          Version 3.22  --  May 1996
                                                 ***** STEADY STATE
SIMULATION *****

                                                 ** REACTION
COEFFICIENT SUMMARY **

RCH ELE     DO  K2  OXYGN    BOD    BOD    SOD   ORGN   ORGN    NH3
 NH3    NO2   ORGP   ORGP   DISP   COLI    ANC    ANC    ANC
NUM NUM    SAT OPT  REAIR  DECAY   SETT   RATE  DECAY   SETT  DECAY
SRCE  DECAY  DECAY   SETT   SRCE  DECAY  DECAY   SETT   SRCE
          MG/L      1/DAY  1/DAY  1/DAY  G/F2D  1/DAY  1/DAY  1/DAY
MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D  1/DAY  1/DAY  1/DAY MG/F2D
```

```
 22   7   8.27   1   0.33   0.28   0.00   0.12   0.12   0.00   0.69
0.00   3.55   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 23   1   8.14   1   0.73   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.74   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 23   2   8.14   1   1.12   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.73   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 23   3   8.14   1   1.12   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.73   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 23   4   8.14   1   1.12   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.72   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 23   5   8.14   1   1.12   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.72   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 23   6   8.14   1   1.12   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.72   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 23   7   8.14   1   1.12   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.72   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 23   8   8.14   1   1.12   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.72   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 23   9   8.14   1   1.12   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.72   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 23  10   8.14   1   1.12   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.72   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 24   1   8.14   1   0.90   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.71   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24   2   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.74
0.00   3.69   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24   3   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.73
0.00   3.67   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24   4   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.73
0.00   3.65   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24   5   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.72
0.00   3.64   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24   6   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.72
0.00   3.62   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24   7   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.72
0.00   3.63   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24   8   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.72
0.00   3.62   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24   9   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.72
0.00   3.61   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24  10   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.72
0.00   3.60   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24  11   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.72
0.00   3.60   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24  12   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.72
0.00   3.59   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24  13   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.71
```

```
0.00   3.59   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24  14   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.71
0.00   3.59   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24  15   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.71
0.00   3.58   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24  16   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.71
0.00   3.58   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 24  17   8.14   1   0.68   0.29   0.00   0.13   0.13   0.00   0.71
0.00   3.58   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 25   1   8.19   1   1.22   0.29   0.00   0.12   0.13   0.00   0.71
0.00   3.62   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 25   2   8.19   1   1.76   0.29   0.00   0.12   0.13   0.00   0.73
0.00   3.69   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 25   3   8.19   1   1.76   0.29   0.00   0.12   0.13   0.00   0.73
0.00   3.70   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 25   4   8.19   1   1.76   0.29   0.00   0.12   0.13   0.00   0.73
0.00   3.71   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 25   5   8.19   1   1.76   0.29   0.00   0.12   0.13   0.00   0.73
0.00   3.71   0.00   0.00   0.00   0.00   0.00   0.00   0.00


 26   1   8.04   1   2.63   0.30   0.00   0.13   0.13   0.00   0.79
0.00   3.90   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 26   2   8.04   1   3.45   0.30   0.00   0.13   0.13   0.00   0.80
0.00   3.90   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 26   3   8.04   1   3.45   0.30   0.00   0.13   0.13   0.00   0.80
0.00   3.90   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 26   4   8.04   1   3.45   0.30   0.00   0.13   0.13   0.00   0.80
0.00   3.90   0.00   0.00   0.00   0.00   0.00   0.00   0.00



         STREAM QUALITY SIMULATION
                                    OUTPUT PAGE NUMBER    13
         QUAL-2E STREAM QUALITY ROUTING MODEL
                         Version 3.22  --  May 1996
                                                 ***** STEADY STATE
SIMULATION *****

                                                    ** WATER QUALITY
VARIABLES **

RCH ELE              CM-1   CM-2   CM-3
                                                  ANC
NUM NUM       TEMP                         DO     BOD    ORGN   NH3N
NO2N   NO3N  SUM-N   ORGP  DIS-P  SUM-P   COLI           CHLA
             DEG-F                         MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L   MG/L   MG/L #/100ML          UG/L

  1   1      75.20   0.00   0.00   0.00   3.79   0.62   0.00   0.28
```

```
0.05   0.34   0.66   0.00   0.00   0.00.00E+00   0.00   0.00
  1   2      75.20   0.00   0.00   0.00   3.98   0.38   0.00   0.11
0.02   0.52   0.66   0.00   0.00   0.00.00E+00   0.00   0.00
  1   3      75.20   0.00   0.00   0.00   4.15   0.23   0.00   0.05
0.01   0.60   0.66   0.00   0.00   0.00.00E+00   0.00   0.00
  1   4      75.20   0.00   0.00   0.00   4.26   0.14   0.00   0.02
0.00   0.64   0.66   0.00   0.00   0.00.00E+00   0.00   0.00
  1   5      75.20   0.00   0.00   0.00   4.31   0.09   0.00   0.01
0.00   0.65   0.66   0.00   0.00   0.00.00E+00   0.00   0.00
  1   6      75.20   0.00   0.00   0.00   4.34   0.05   0.00   0.00
0.00   0.66   0.66   0.00   0.00   0.00.00E+00   0.00   0.00
  1   7      75.20   0.00   0.00   0.00   4.35   0.03   0.00   0.00
0.00   0.66   0.66   0.00   0.00   0.00.00E+00   0.00   0.00
  1   8      75.20   0.00   0.00   0.00   4.36   0.02   0.00   0.00
0.00   0.66   0.66   0.00   0.00   0.00.00E+00   0.00   0.00
  1   9      75.20   0.00   0.00   0.00   4.36   0.01   0.00   0.00
0.00   0.66   0.66   0.00   0.00   0.00.00E+00   0.00   0.00


  2   1      75.20   0.00   0.00   0.00   4.06   0.01   0.00   0.00
0.00   0.66   0.66   0.00   0.00   0.00.00E+00   0.00   0.00
  2   2      75.20   0.00   0.00   0.00   3.61   0.02   0.00   0.00
0.00   0.66   0.66   0.00   0.00   0.00.00E+00   0.00   0.00
  2   3      75.20   0.00   0.00   0.00   1.62  13.33   0.00   0.05
0.01   0.35   0.40   0.00   0.00   0.00.00E+00   0.00   0.00
  2   4      75.20   0.00   0.00   0.00   0.70  10.16   0.00   0.04
0.01   0.36   0.40   0.00   0.00   0.00.00E+00   0.00   0.00


  3   1      69.80   0.00   0.00   0.00   0.14   6.82   0.00   0.04
0.01   0.36   0.40   0.00   0.00   0.00.00E+00   0.00   0.00
  3   2      69.80   0.00   0.00   0.00   0.17   3.32   0.00   0.07
0.01   0.25   0.32   0.00   0.00   0.00.00E+00   0.00   0.00
  3   3      69.80   0.00   0.00   0.00   0.00   2.25   0.00   0.07
0.01   0.25   0.32   0.00   0.00   0.00.00E+00   0.00   0.00
  3   4      69.80   0.00   0.00   0.00   0.00   1.53   0.00   0.07
0.01   0.25   0.32   0.00   0.00   0.00.00E+00   0.00   0.00
  3   5      69.80   0.00   0.00   0.00   0.38   1.03   0.00   0.08
0.01   0.19   0.28   0.00   0.00   0.00.00E+00   0.00   0.00


  4   1      75.02   0.00   0.00   0.00   0.00   0.47   0.00   0.08
0.01   0.19   0.28   0.00   0.00   0.00.00E+00   0.00   0.00
  4   2      75.02   0.00   0.00   0.00   1.63   0.16   0.00   0.02
0.00   0.26   0.28   0.00   0.00   0.00.00E+00   0.00   0.00
  4   3      75.02   0.00   0.00   0.00   2.60   0.12   0.00   0.01
0.00   0.24   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
  4   4      75.02   0.00   0.00   0.00   2.67   0.05   0.00   0.00
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
  4   5      75.02   0.00   0.00   0.00   2.73   0.02   0.00   0.00
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
  4   6      75.02   0.00   0.00   0.00   2.76   0.01   0.00   0.00
```

```
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
  4   7      75.02   0.00   0.00   0.00   2.96   0.07   0.00   0.01
0.00   0.23   0.24   0.00   0.00   0.00.00E+00   0.00   0.00
  4   8      75.02   0.00   0.00   0.00   2.82   0.03   0.00   0.00
0.00   0.23   0.23   0.00   0.00   0.00.00E+00   0.00   0.00


  5   1      82.40   0.00   0.00   0.00   6.64   0.90   0.00   0.03
0.00   0.01   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  5   2      82.40   0.00   0.00   0.00   5.30   0.81   0.00   0.02
0.00   0.01   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  5   3      82.40   0.00   0.00   0.00   4.80   0.72   0.00   0.02
0.00   0.02   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  5   4      82.40   0.00   0.00   0.00   4.61   0.65   0.00   0.01
0.00   0.02   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  5   5      82.40   0.00   0.00   0.00   4.55   0.58   0.00   0.01
0.00   0.03   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  5   6      82.40   0.00   0.00   0.00   4.53   0.52   0.00   0.01
0.00   0.03   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  5   7      82.40   0.00   0.00   0.00   4.53   0.47   0.00   0.01
0.00   0.03   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  5   8      82.40   0.00   0.00   0.00   4.53   0.42   0.00   0.00
0.00   0.03   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  5   9      82.40   0.00   0.00   0.00   4.54   0.38   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  5  10      82.40   0.00   0.00   0.00   4.54   0.34   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  5  11      82.40   0.00   0.00   0.00   4.54   0.30   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  5  12      82.40   0.00   0.00   0.00   4.55   0.27   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00


         STREAM QUALITY SIMULATION
                                   OUTPUT PAGE NUMBER    14
         QUAL-2E STREAM QUALITY ROUTING MODEL
                          Version 3.22  --  May 1996
                                                     ***** STEADY STATE
SIMULATION *****

                                                        ** WATER QUALITY
VARIABLES **

RCH ELE              CM-1   CM-2   CM-3
                                                      ANC
NUM NUM       TEMP                              DO    BOD    ORGN   NH3N
NO2N   NO3N  SUM-N   ORGP  DIS-P  SUM-P   COLI           CHLA
              DEG-F                            MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L   MG/L   MG/L #/100ML          UG/L

  6   1      73.04   0.00   0.00   0.00   4.45   0.22   0.00   0.00
```

```
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  6   2      73.04   0.00   0.00   0.00   3.04   0.16   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  6   3      73.04   0.00   0.00   0.00   2.50   0.12   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  6   4      73.04   0.00   0.00   0.00   2.29   0.08   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  6   5      73.04   0.00   0.00   0.00   2.21   0.06   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  6   6      73.04   0.00   0.00   0.00   2.18   0.04   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  6   7      73.04   0.00   0.00   0.00   2.17   0.03   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  6   8      73.04   0.00   0.00   0.00   2.17   0.02   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  6   9      73.04   0.00   0.00   0.00   2.17   0.02   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  6  10      73.04   0.00   0.00   0.00   2.17   0.01   0.00   0.00
0.00   0.04   0.04   0.00   0.00   0.00.00E+00   0.00   0.00
  6  11      73.04   0.00   0.00   0.00   3.43   0.43   0.00   0.05
0.01   0.03   0.10   0.00   0.00   0.00.00E+00   0.00   0.00
  6  12      73.04   0.00   0.00   0.00   2.80   0.36   0.00   0.04
0.01   0.05   0.10   0.00   0.00   0.00.00E+00   0.00   0.00
  6  13      73.04   0.00   0.00   0.00   2.45   0.30   0.00   0.03
0.01   0.06   0.10   0.00   0.00   0.00.00E+00   0.00   0.00
  6  14      73.04   0.00   0.00   0.00   3.27   0.47   0.00   0.06
0.01   0.05   0.11   0.00   0.00   0.00.00E+00   0.00   0.00
  6  15      73.04   0.00   0.00   0.00   2.82   0.42   0.00   0.04
0.01   0.06   0.11   0.00   0.00   0.00.00E+00   0.00   0.00
  6  16      73.04   0.00   0.00   0.00   3.31   0.52   0.00   0.06
0.01   0.06   0.12   0.00   0.00   0.00.00E+00   0.00   0.00


  7   1      71.60   0.00   0.00   0.00   3.14   0.42   0.00   0.04
0.01   0.07   0.12   0.00   0.00   0.00.00E+00   0.00   0.00
  7   2      71.60   0.00   0.00   0.00   4.34   0.31   0.00   0.02
0.00   0.10   0.12   0.00   0.00   0.00.00E+00   0.00   0.00
  7   3      71.60   0.00   0.00   0.00   5.00   0.34   0.00   0.03
0.00   0.09   0.13   0.00   0.00   0.00.00E+00   0.00   0.00
  7   4      71.60   0.00   0.00   0.00   5.08   0.27   0.00   0.02
0.00   0.11   0.13   0.00   0.00   0.00.00E+00   0.00   0.00
  7   5      71.60   0.00   0.00   0.00   5.14   0.21   0.00   0.01
0.00   0.12   0.13   0.00   0.00   0.00.00E+00   0.00   0.00
  7   6      71.60   0.00   0.00   0.00   5.16   0.44   0.00   0.01
0.00   0.12   0.13   0.00   0.00   0.00.00E+00   0.00   0.00


  8   1      72.59   0.00   0.00   0.00   5.07   0.14   0.00   0.00
0.00   0.19   0.20   0.00   0.00   0.00.00E+00   0.00   0.00
  8   2      72.59   0.00   0.00   0.00   4.54   0.14   0.00   0.00
0.00   0.19   0.20   0.00   0.00   0.00.00E+00   0.00   0.00
  8   3      72.59   0.00   0.00   0.00   4.02   0.13   0.00   0.00
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0.00   0.19   0.20   0.00   0.00   0.00.00E+00   0.00   0.00
  8   4      72.59   0.00   0.00   0.00   3.96   0.24   0.00   0.02
0.00   0.17   0.19   0.00   0.00   0.00.00E+00   0.00   0.00
  8   5      72.59   0.00   0.00   0.00   3.52   0.23   0.00   0.02
0.00   0.17   0.19   0.00   0.00   0.00.00E+00   0.00   0.00
  8   6      72.59   0.00   0.00   0.00   3.10   0.22   0.00   0.02
0.00   0.17   0.19   0.00   0.00   0.00.00E+00   0.00   0.00
  8   7      72.59   0.00   0.00   0.00   2.70   0.22   0.00   0.02
0.00   0.17   0.19   0.00   0.00   0.00.00E+00   0.00   0.00
  8   8      72.59   0.00   0.00   0.00   2.31   0.21   0.00   0.02
0.00   0.17   0.19   0.00   0.00   0.00.00E+00   0.00   0.00
  8   9      72.59   0.00   0.00   0.00   2.49   0.29   0.00   0.03
0.00   0.15   0.19   0.00   0.00   0.00.00E+00   0.00   0.00
  8  10      72.59   0.00   0.00   0.00   2.15   0.29   0.00   0.03
0.00   0.15   0.19   0.00   0.00   0.00.00E+00   0.00   0.00
  8  11      72.59   0.00   0.00   0.00   1.82   0.28   0.00   0.03
0.00   0.15   0.19   0.00   0.00   0.00.00E+00   0.00   0.00
  8  12      72.59   0.00   0.00   0.00   1.50   0.27   0.00   0.03
0.00   0.15   0.19   0.00   0.00   0.00.00E+00   0.00   0.00
  8  13      72.59   0.00   0.00   0.00   1.19   0.27   0.00   0.03
0.00   0.16   0.19   0.00   0.00   0.00.00E+00   0.00   0.00
  8  14      72.59   0.00   0.00   0.00   0.90   0.26   0.00   0.03
0.00   0.16   0.19   0.00   0.00   0.00.00E+00   0.00   0.00


  9   1      71.96   0.00   0.00   0.00   1.01   0.25   0.00   0.03
0.00   0.15   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
  9   2      71.96   0.00   0.00   0.00   0.88   0.25   0.00   0.03
0.00   0.15   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
  9   3      71.96   0.00   0.00   0.00   0.74   0.24   0.00   0.03
0.00   0.15   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
  9   4      71.96   0.00   0.00   0.00   0.61   0.24   0.00   0.03
0.00   0.15   0.18   0.00   0.00   0.00.00E+00   0.00   0.00



         STREAM QUALITY SIMULATION
                                 OUTPUT PAGE NUMBER    15
         QUAL-2E STREAM QUALITY ROUTING MODEL
                         Version 3.22  --  May 1996
                                                    ***** STEADY STATE
SIMULATION *****

                                                       ** WATER QUALITY
VARIABLES **

RCH ELE              CM-1   CM-2   CM-3
                                                     ANC
NUM NUM       TEMP                               DO    BOD   ORGN   NH3N
NO2N   NO3N  SUM-N   ORGP  DIS-P  SUM-P   COLI          CHLA
             DEG-F                              MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L   MG/L   MG/L #/100ML         UG/L
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 10   1      72.50   0.00   0.00   0.00   2.44   0.19   0.00   0.02
0.00   0.16   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10   2      72.50   0.00   0.00   0.00   3.05   0.12   0.00   0.01
0.00   0.17   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10   3      72.50   0.00   0.00   0.00   3.39   0.06   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10   4      72.50   0.00   0.00   0.00   3.69   0.03   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10   5      72.50   0.00   0.00   0.00   3.95   0.01   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10   6      72.50   0.00   0.00   0.00   4.24   0.04   0.00   0.00
0.00   0.17   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10   7      72.50   0.00   0.00   0.00   4.34   0.02   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10   8      72.50   0.00   0.00   0.00   4.44   0.01   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10   9      72.50   0.00   0.00   0.00   4.53   0.01   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10  10      72.50   0.00   0.00   0.00   4.60   0.00   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10  11      72.50   0.00   0.00   0.00   4.65   0.00   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10  12      72.50   0.00   0.00   0.00   4.69   0.00   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10  13      72.50   0.00   0.00   0.00   4.73   0.00   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 10  14      72.50   0.00   0.00   0.00   4.75   0.00   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00


 11   1      73.33   0.00   0.00   0.00   4.61   0.04   0.00   0.00
0.00   0.17   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 11   2      73.33   0.00   0.00   0.00   4.09   0.03   0.00   0.00
0.00   0.17   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 11   3      73.33   0.00   0.00   0.00   3.62   0.02   0.00   0.00
0.00   0.17   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 11   4      73.33   0.00   0.00   0.00   3.21   0.01   0.00   0.00
0.00   0.17   0.18   0.00   0.00   0.00.00E+00   0.00   0.00


 12   1      70.16   0.00   0.00   0.00   1.09   0.48   0.00   0.11
0.02   0.12   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 12   2      70.16   0.00   0.00   0.00   1.19   0.23   0.00   0.05
0.01   0.19   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 12   3      70.16   0.00   0.00   0.00   1.40   0.11   0.00   0.02
0.00   0.22   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 12   4      70.16   0.00   0.00   0.00   1.57   0.05   0.00   0.01
0.00   0.24   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 12   5      70.16   0.00   0.00   0.00   1.68   0.03   0.00   0.00
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 12   6      70.16   0.00   0.00   0.00   1.75   0.01   0.00   0.00
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0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 12   7      70.16   0.00   0.00   0.00   1.79   0.01   0.00   0.00
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 12   8      70.16   0.00   0.00   0.00   1.81   0.00   0.00   0.00
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 12   9      70.16   0.00   0.00   0.00   1.82   0.00   0.00   0.00
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 12  10      70.16   0.00   0.00   0.00   1.83   0.00   0.00   0.00
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 12  11      70.16   0.00   0.00   0.00   1.83   0.00   0.00   0.00
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00


 13   1      70.70   0.00   0.00   0.00   1.59   0.00   0.00   0.00
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 13   2      70.70   0.00   0.00   0.00   2.14   0.00   0.00   0.00
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 13   3      70.70   0.00   0.00   0.00   2.35   0.00   0.00   0.00
0.00   0.25   0.25   0.00   0.00   0.00.00E+00   0.00   0.00
 13   4      70.70   0.00   0.00   0.00   3.34   0.26   0.00   0.03
0.00   0.17   0.20   0.00   0.00   0.00.00E+00   0.00   0.00
 13   5      70.70   0.00   0.00   0.00   2.79   0.14   0.00   0.01
0.00   0.19   0.20   0.00   0.00   0.00.00E+00   0.00   0.00
 13   6      70.70   0.00   0.00   0.00   2.57   0.07   0.00   0.00
0.00   0.20   0.20   0.00   0.00   0.00.00E+00   0.00   0.00
 13   7      70.70   0.00   0.00   0.00   3.25   0.24   0.00   0.02
0.00   0.16   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 13   8      70.70   0.00   0.00   0.00   2.84   0.15   0.00   0.01
0.00   0.17   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 13   9      70.70   0.00   0.00   0.00   2.63   0.09   0.00   0.01
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 13  10      70.70   0.00   0.00   0.00   2.53   0.06   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 13  11      70.70   0.00   0.00   0.00   2.48   0.04   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00

         STREAM QUALITY SIMULATION
                                 OUTPUT PAGE NUMBER    16
         QUAL-2E STREAM QUALITY ROUTING MODEL
                          Version 3.22  --  May 1996
                                                ***** STEADY STATE
SIMULATION *****

                                                   ** WATER QUALITY
VARIABLES **

RCH ELE              CM-1   CM-2   CM-3
                                                 ANC
NUM NUM       TEMP                                  DO    BOD   ORGN   NH3N
NO2N   NO3N  SUM-N   ORGP  DIS-P  SUM-P   COLI          CHLA
              DEG-F                               MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L   MG/L   MG/L #/100ML         UG/L
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 13  12       70.70   0.00   0.00   0.00   2.46   0.02   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 13  13       70.70   0.00   0.00   0.00   2.45   0.01   0.00   0.00
0.00   0.18   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 13  14       70.70   0.00   0.00   0.00   3.11   0.18   0.00   0.02
0.00   0.15   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 13  15       70.70   0.00   0.00   0.00   2.82   0.12   0.00   0.01
0.00   0.16   0.17   0.00   0.00   0.00.00E+00   0.00   0.00


 14   1       70.79   0.00   0.00   0.00   2.01   0.08   0.00   0.01
0.00   0.17   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 14   2       70.79   0.00   0.00   0.00   2.08   0.04   0.00   0.00
0.00   0.17   0.18   0.00   0.00   0.00.00E+00   0.00   0.00


 15   1       76.28   0.00   0.00   0.00   4.68   0.02   0.00   0.00
0.00   0.17   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 15   2       76.28   0.00   0.00   0.00   4.66   0.02   0.00   0.00
0.00   0.17   0.18   0.00   0.00   0.00.00E+00   0.00   0.00
 15   3       76.28   0.00   0.00   0.00   4.75   0.06   0.00   0.01
0.00   0.17   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15   4       76.28   0.00   0.00   0.00   4.74   0.06   0.00   0.01
0.00   0.17   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15   5       76.28   0.00   0.00   0.00   4.72   0.06   0.00   0.01
0.00   0.17   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15   6       76.28   0.00   0.00   0.00   4.81   0.10   0.00   0.01
0.00   0.16   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15   7       76.28   0.00   0.00   0.00   4.79   0.10   0.00   0.01
0.00   0.16   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15   8       76.28   0.00   0.00   0.00   4.77   0.10   0.00   0.01
0.00   0.16   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15   9       76.28   0.00   0.00   0.00   4.75   0.10   0.00   0.01
0.00   0.16   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15  10       76.28   0.00   0.00   0.00   4.83   0.14   0.00   0.02
0.00   0.15   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15  11       76.28   0.00   0.00   0.00   4.81   0.14   0.00   0.02
0.00   0.15   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15  12       76.28   0.00   0.00   0.00   4.79   0.14   0.00   0.02
0.00   0.15   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15  13       76.28   0.00   0.00   0.00   4.78   0.14   0.00   0.02
0.00   0.15   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15  14       76.28   0.00   0.00   0.00   4.76   0.13   0.00   0.02
0.00   0.15   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15  15       76.28   0.00   0.00   0.00   4.74   0.13   0.00   0.02
0.00   0.15   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 15  16       76.28   0.00   0.00   0.00   4.73   0.13   0.00   0.02
0.00   0.15   0.17   0.00   0.00   0.00.00E+00   0.00   0.00


 16   1       74.30   0.00   0.00   0.00   7.02   0.21   0.00   0.01
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0.00   0.12   0.14   0.00   0.00   0.00.00E+00   0.00   0.00
 16   2       74.30   0.00   0.00   0.00   7.12   0.05   0.00   0.00
0.00   0.14   0.14   0.00   0.00   0.00.00E+00   0.00   0.00
 16   3       74.30   0.00   0.00   0.00   7.14   0.01   0.00   0.00
0.00   0.14   0.14   0.00   0.00   0.00.00E+00   0.00   0.00
 16   4       74.30   0.00   0.00   0.00   7.14   0.00   0.00   0.00
0.00   0.14   0.14   0.00   0.00   0.00.00E+00   0.00   0.00
 16   5       74.30   0.00   0.00   0.00   7.14   0.00   0.00   0.00
0.00   0.14   0.14   0.00   0.00   0.00.00E+00   0.00   0.00
 16   6       74.30   0.00   0.00   0.00   7.14   0.00   0.00   0.00
0.00   0.14   0.14   0.00   0.00   0.00.00E+00   0.00   0.00
 16   7       74.30   0.00   0.00   0.00   7.14   0.00   0.00   0.00
0.00   0.14   0.14   0.00   0.00   0.00.00E+00   0.00   0.00
 16   8       74.30   0.00   0.00   0.00   7.14   0.00   0.00   0.00
0.00   0.14   0.14   0.00   0.00   0.00.00E+00   0.00   0.00
 16   9       74.30   0.00   0.00   0.00   7.05   0.18   0.00   0.01
0.00   0.13   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 16  10       74.30   0.00   0.00   0.00   7.04   0.20   0.00   0.01
0.00   0.13   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 16  11       74.30   0.00   0.00   0.00   7.09   0.09   0.00   0.00
0.00   0.14   0.15   0.00   0.00   0.00.00E+00   0.00   0.00


 17   1       74.30   0.00   0.00   0.00   6.54   0.04   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 17   2       74.30   0.00   0.00   0.00   4.76   0.02   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 17   3       74.30   0.00   0.00   0.00   4.03   0.01   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 17   4       74.30   0.00   0.00   0.00   3.72   0.00   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 17   5       74.30   0.00   0.00   0.00   3.59   0.00   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00

         STREAM QUALITY SIMULATION
                                 OUTPUT PAGE NUMBER    17
         QUAL-2E STREAM QUALITY ROUTING MODEL
                          Version 3.22  --  May 1996
                                                  ***** STEADY STATE
SIMULATION *****

                                                     ** WATER QUALITY
VARIABLES **

RCH ELE               CM-1   CM-2   CM-3
                                                   ANC
NUM NUM        TEMP                           DO    BOD   ORGN   NH3N
NO2N   NO3N   SUM-N   ORGP  DIS-P  SUM-P   COLI          CHLA
               DEG-F                          MG/L   MG/L   MG/L   MG/L
MG/L   MG/L    MG/L   MG/L   MG/L   MG/L #/100ML          UG/L

 17   6       74.30   0.00   0.00   0.00   3.82   0.13   0.00   0.01
```

```
0.00   0.13   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 17   7      74.30   0.00   0.00   0.00   3.60   0.07   0.00   0.00
0.00   0.14   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 17   8      74.30   0.00   0.00   0.00   3.52   0.04   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 17   9      74.30   0.00   0.00   0.00   3.49   0.02   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00


 18   1      72.32   0.00   0.00   0.00   3.44   0.01   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18   2      72.32   0.00   0.00   0.00   3.15   0.01   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18   3      72.32   0.00   0.00   0.00   2.99   0.00   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18   4      72.32   0.00   0.00   0.00   2.91   0.00   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18   5      72.32   0.00   0.00   0.00   2.86   0.00   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18   6      72.32   0.00   0.00   0.00   2.84   0.00   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18   7      72.32   0.00   0.00   0.00   2.83   0.00   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18   8      72.32   0.00   0.00   0.00   3.20   0.12   0.00   0.01
0.00   0.13   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18   9      72.32   0.00   0.00   0.00   2.98   0.07   0.00   0.01
0.00   0.14   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18  10      72.32   0.00   0.00   0.00   2.88   0.04   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18  11      72.32   0.00   0.00   0.00   2.89   0.07   0.00   0.00
0.00   0.14   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18  12      72.32   0.00   0.00   0.00   2.83   0.04   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 18  13      72.32   0.00   0.00   0.00   2.80   0.03   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00


 19   1      71.53   0.00   0.00   0.00   3.21   0.11   0.00   0.01
0.00   0.14   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 19   2      71.53   0.00   0.00   0.00   3.63   0.06   0.00   0.00
0.00   0.14   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 19   3      71.53   0.00   0.00   0.00   3.88   0.04   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 19   4      71.53   0.00   0.00   0.00   4.03   0.02   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00
 19   5      71.53   0.00   0.00   0.00   4.12   0.01   0.00   0.00
0.00   0.15   0.15   0.00   0.00   0.00.00E+00   0.00   0.00


 20   1      73.69   0.00   0.00   0.00   4.29   0.09   0.00   0.01
0.00   0.16   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 20   2      73.69   0.00   0.00   0.00   3.54   0.06   0.00   0.00
```

```
0.00   0.16   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 20   3      73.69   0.00   0.00   0.00   2.97   0.04   0.00   0.00
0.00   0.16   0.17   0.00   0.00   0.00.00E+00   0.00   0.00


 21   1      75.85   0.00   0.00   0.00   3.43   0.07   0.00   0.01
0.00   0.16   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 21   2      75.85   0.00   0.00   0.00   4.55   0.04   0.00   0.00
0.00   0.16   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 21   3      75.85   0.00   0.00   0.00   5.14   0.02   0.00   0.00
0.00   0.16   0.17   0.00   0.00   0.00.00E+00   0.00   0.00
 21   4      75.85   0.00   0.00   0.00   5.47   0.05   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 21   5      75.85   0.00   0.00   0.00   5.61   0.03   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00


 22   1      75.85   0.00   0.00   0.00   5.67   0.07   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 22   2      75.85   0.00   0.00   0.00   5.71   0.04   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 22   3      75.85   0.00   0.00   0.00   5.75   0.06   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 22   4      75.85   0.00   0.00   0.00   5.75   0.04   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 22   5      75.85   0.00   0.00   0.00   5.76   0.02   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 22   6      75.85   0.00   0.00   0.00   5.78   0.01   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00

         STREAM QUALITY SIMULATION
                                 OUTPUT PAGE NUMBER    18
         QUAL-2E STREAM QUALITY ROUTING MODEL
                          Version 3.22  --  May 1996
                                                ***** STEADY STATE
SIMULATION *****

                                                   ** WATER QUALITY
VARIABLES **

RCH ELE              CM-1   CM-2   CM-3
                                                 ANC
NUM NUM       TEMP                               DO     BOD    ORGN   NH3N
NO2N   NO3N  SUM-N   ORGP  DIS-P  SUM-P   COLI          CHLA
              DEG-F                       MG/L   MG/L   MG/L   MG/L
MG/L   MG/L   MG/L   MG/L   MG/L   MG/L #/100ML         UG/L

 22   7      75.85   0.00   0.00   0.00   5.79   0.01   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00


 23   1      77.47   0.00   0.00   0.00   6.34   0.01   0.00   0.00
```

```
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 23   2       77.47   0.00   0.00   0.00   6.22   0.01   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 23   3       77.47   0.00   0.00   0.00   6.14   0.00   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 23   4       77.47   0.00   0.00   0.00   6.10   0.00   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 23   5       77.47   0.00   0.00   0.00   6.08   0.00   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 23   6       77.47   0.00   0.00   0.00   6.06   0.00   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 23   7       77.47   0.00   0.00   0.00   6.05   0.00   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 23   8       77.47   0.00   0.00   0.00   6.05   0.00   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 23   9       77.47   0.00   0.00   0.00   6.05   0.00   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 23  10       77.47   0.00   0.00   0.00   6.09   0.11   0.00   0.01
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00


 24   1       77.47   0.00   0.00   0.00   5.94   0.18   0.00   0.02
0.00   0.14   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24   2       77.47   0.00   0.00   0.00   5.68   0.24   0.00   0.03
0.00   0.13   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24   3       77.47   0.00   0.00   0.00   5.41   0.21   0.00   0.02
0.00   0.14   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24   4       77.47   0.00   0.00   0.00   5.20   0.19   0.00   0.02
0.00   0.14   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24   5       77.47   0.00   0.00   0.00   5.05   0.17   0.00   0.01
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24   6       77.47   0.00   0.00   0.00   4.94   0.15   0.00   0.01
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24   7       77.47   0.00   0.00   0.00   4.99   0.20   0.00   0.02
0.00   0.14   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24   8       77.47   0.00   0.00   0.00   4.89   0.18   0.00   0.01
0.00   0.14   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24   9       77.47   0.00   0.00   0.00   4.82   0.17   0.00   0.01
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24  10       77.47   0.00   0.00   0.00   4.77   0.20   0.00   0.01
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24  11       77.47   0.00   0.00   0.00   4.72   0.18   0.00   0.01
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24  12       77.47   0.00   0.00   0.00   4.69   0.16   0.00   0.01
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24  13       77.47   0.00   0.00   0.00   4.66   0.14   0.00   0.00
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24  14       77.47   0.00   0.00   0.00   4.65   0.13   0.00   0.00
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24  15       77.47   0.00   0.00   0.00   4.64   0.12   0.00   0.00
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24  16       77.47   0.00   0.00   0.00   4.63   0.11   0.00   0.00
```

```
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 24  17       77.47   0.00   0.00   0.00   4.63   0.09   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00


 25   1       76.80   0.00   0.00   0.00   5.53   0.13   0.00   0.01
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 25   2       76.80   0.00   0.00   0.00   6.66   0.10   0.00   0.00
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 25   3       76.80   0.00   0.00   0.00   7.10   0.08   0.00   0.00
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 25   4       76.80   0.00   0.00   0.00   7.28   0.06   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 25   5       76.80   0.00   0.00   0.00   7.33   0.09   0.00   0.01
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00


 26   1       78.69   0.00   0.00   0.00   7.50   0.07   0.00   0.00
0.00   0.15   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 26   2       78.69   0.00   0.00   0.00   7.69   0.05   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 26   3       78.69   0.00   0.00   0.00   7.73   0.04   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00
 26   4       78.69   0.00   0.00   0.00   7.74   0.03   0.00   0.00
0.00   0.16   0.16   0.00   0.00   0.00.00E+00   0.00   0.00



         STREAM QUALITY SIMULATION
                                        OUTPUT PAGE NUMBER    19
         QUAL-2E STREAM QUALITY ROUTING MODEL
                                Version 3.22  --  May 1996
                                                   ***** STEADY STATE
SIMULATION *****

                                                       ** DISSOLVED
OXYGEN DATA **


COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE             DO             DO     DAM     NIT
ORD NUM NUM    TEMP     SAT      DO    DEF   INPUT   INHIB
F-FNCTN   OXYGN                      NET
              DEG-F    MG/L    MG/L    MG/L    MG/L    FACT
INPUT   REAIR   C-BOD     SOD     P-R   NH3-N   NO2-N

  1   1   1   75.20    8.33    3.79    4.54    0.00    0.90
1.81    6.75   -0.17   -5.39    0.00   -0.58   -0.17
  2   1   2   75.20    8.33    3.98    4.35    0.00    0.91
0.00    6.47   -0.10   -5.39    0.00   -0.25   -0.09
  3   1   3   75.20    8.33    4.15    4.17    0.00    0.92
0.00    6.20   -0.06   -5.39    0.00   -0.10   -0.04
```

```
  4   1   4   75.20    8.33    4.26    4.07    0.00    0.92
0.00    6.05   -0.04   -5.39    0.00   -0.04   -0.02
  5   1   5   75.20    8.33    4.31    4.02    0.00    0.92
0.00    5.97   -0.02   -5.39    0.00   -0.02   -0.01
  6   1   6   75.20    8.33    4.34    3.99    0.00    0.93
0.00    5.93   -0.02   -5.39    0.00   -0.01    0.00
  7   1   7   75.20    8.33    4.35    3.98    0.00    0.93
0.00    5.91   -0.01   -5.39    0.00    0.00    0.00
  8   1   8   75.20    8.33    4.36    3.97    0.00    0.93
0.00    5.90   -0.01   -5.39    0.00    0.00    0.00
  9   1   9   75.20    8.33    4.36    3.97    0.00    0.93
0.00    5.90    0.00   -5.39    0.00    0.00    0.00


 10   2   1   75.20    8.33    4.06    4.27    0.00    0.91
0.00    5.76    0.00   -5.39    0.00    0.00    0.00
 11   2   2   75.20    8.33    3.61    4.71    0.00    0.89
0.00    5.70    0.00   -5.39    0.00    0.00    0.00
 12   2   3   75.20    8.33    1.62    6.71    0.00    0.62
3.10    8.11   -3.69   -5.39    0.00   -0.07   -0.02
 13   2   4   75.20    8.33    0.70    7.63    0.00    0.34
0.00    9.23   -2.81   -5.39    0.00   -0.03   -0.01


 14   3   1   69.80    8.82    0.14    8.68    0.00    0.08
0.00    6.38   -1.64   -2.67    0.00   -0.01    0.00
 15   3   2   69.80    8.82    0.17    8.65    0.00    0.10
1.19    2.97   -0.80   -2.67    0.00   -0.01    0.00
 16   3   3   69.80    8.82    0.00    8.82    0.00    0.00
0.00    3.03   -0.54   -2.67    0.00    0.00    0.00
 17   3   4   69.80    8.82    0.00    8.82    0.00    0.00
0.00    3.03   -0.37   -2.67    0.00    0.00    0.00
 18   3   5   69.80    8.82    0.38    8.44    0.00    0.20
1.19    2.90   -0.25   -2.67    0.00   -0.03   -0.01


 19   4   1   75.02    8.34    0.00    8.34    0.00    0.00
0.00    2.91   -0.13   -1.71    0.00    0.00    0.00
 20   4   2   75.02    8.34    1.63    6.71    0.00    0.62
0.00    2.21   -0.04   -1.71    0.00   -0.03   -0.01
 21   4   3   75.02    8.34    2.60    5.74    0.00    0.79
0.24    1.89   -0.03   -1.71    0.00   -0.02   -0.01
 22   4   4   75.02    8.34    2.67    5.67    0.00    0.80
0.00    1.87   -0.01   -1.71    0.00    0.00    0.00
 23   4   5   75.02    8.34    2.73    5.61    0.00    0.81
0.00    1.85   -0.01   -1.71    0.00    0.00    0.00
 24   4   6   75.02    8.34    2.76    5.58    0.00    0.81
0.00    1.84    0.00   -1.71    0.00    0.00    0.00
 25   4   7   75.02    8.34    2.96    5.38    0.00    0.83
0.24    1.77   -0.02   -1.71    0.00   -0.01    0.00
 26   4   8   75.02    8.34    2.82    5.52    0.00    0.82
0.00    1.82   -0.01   -1.71    0.00    0.00    0.00
```

```
 27   5   1   82.40    7.74    6.64    1.10    0.00    0.98
29.67    5.25   -0.30  -13.72    0.00   -0.10   -0.02
 28   5   2   82.40    7.74    5.30    2.44    0.00    0.96
0.00   11.63   -0.27  -13.72    0.00   -0.07   -0.02
 29   5   3   82.40    7.74    4.80    2.95    0.00    0.94
0.00   14.02   -0.24  -13.72    0.00   -0.05   -0.02
 30   5   4   82.40    7.74    4.61    3.13    0.00    0.94
0.00   14.89   -0.22  -13.72    0.00   -0.04   -0.02
 31   5   5   82.40    7.74    4.55    3.19    0.00    0.93
0.00   15.19   -0.19  -13.72    0.00   -0.03   -0.01
 32   5   6   82.40    7.74    4.53    3.21    0.00    0.93
0.00   15.28   -0.17  -13.72    0.00   -0.02   -0.01
 33   5   7   82.40    7.74    4.53    3.22    0.00    0.93
0.00   15.30   -0.16  -13.72    0.00   -0.02   -0.01
 34   5   8   82.40    7.74    4.53    3.21    0.00    0.93
0.00   15.28   -0.14  -13.72    0.00   -0.01   -0.01
 35   5   9   82.40    7.74    4.54    3.21    0.00    0.93
0.00   15.26   -0.13  -13.72    0.00   -0.01    0.00
 36   5  10   82.40    7.74    4.54    3.20    0.00    0.93
0.00   15.24   -0.11  -13.72    0.00   -0.01    0.00
 37   5  11   82.40    7.74    4.54    3.20    0.00    0.93
0.00   15.22   -0.10  -13.72    0.00   -0.01    0.00
 38   5  12   82.40    7.74    4.55    3.20    0.00    0.93
0.00   15.20   -0.09  -13.72    0.00    0.00    0.00


         STREAM QUALITY SIMULATION
                                  OUTPUT PAGE NUMBER    20
         QUAL-2E STREAM QUALITY ROUTING MODEL
                           Version 3.22  --  May 1996
                                                  ***** STEADY STATE
SIMULATION *****

                                                      ** DISSOLVED
OXYGEN DATA **


COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE             DO              DO     DAM     NIT
ORD NUM NUM    TEMP     SAT      DO     DEF   INPUT   INHIB
F-FNCTN   OXYGN                     NET
              DEG-F    MG/L    MG/L    MG/L    MG/L    FACT
INPUT   REAIR   C-BOD     SOD     P-R   NH3-N   NO2-N

 39   6   1   73.04    8.52    4.45    4.07    0.00    0.93
0.00   10.68   -0.06   -6.24    0.00    0.00    0.00
 40   6   2   73.04    8.52    3.04    5.47    0.00    0.84
0.00    5.71   -0.04   -6.24    0.00    0.00    0.00
 41   6   3   73.04    8.52    2.50    6.02    0.00    0.78
```

0.00	6.28	-0.03	-6.24	0.00	0.00	0.00	
42	6	4	73.04	8.52	2.29	6.23	0.00	0.75
0.00	6.50	-0.02	-6.24	0.00	0.00	0.00	
43	6	5	73.04	8.52	2.21	6.31	0.00	0.73
0.00	6.58	-0.02	-6.24	0.00	0.00	0.00	
44	6	6	73.04	8.52	2.18	6.34	0.00	0.73
0.00	6.61	-0.01	-6.24	0.00	0.00	0.00	
45	6	7	73.04	8.52	2.17	6.35	0.00	0.73
0.00	6.62	-0.01	-6.24	0.00	0.00	0.00	
46	6	8	73.04	8.52	2.17	6.35	0.00	0.73
0.00	6.62	-0.01	-6.24	0.00	0.00	0.00	
47	6	9	73.04	8.52	2.17	6.35	0.00	0.73
0.00	6.62	0.00	-6.24	0.00	0.00	0.00	
48	6	10	73.04	8.52	2.17	6.35	0.00	0.73
0.00	6.62	0.00	-6.24	0.00	0.00	0.00	
49	6	11	73.04	8.52	3.43	5.09	0.00	0.87
4.82	5.31	-0.11	-6.24	0.00	-0.10	-0.02	
50	6	12	73.04	8.52	2.80	5.72	0.00	0.81
0.00	5.97	-0.09	-6.24	0.00	-0.07	-0.02	
51	6	13	73.04	8.52	2.45	6.06	0.00	0.77
0.00	6.33	-0.08	-6.24	0.00	-0.05	-0.02	
52	6	14	73.04	8.52	3.27	5.25	0.00	0.86
4.82	5.48	-0.12	-6.24	0.00	-0.10	-0.03	
53	6	15	73.04	8.52	2.82	5.70	0.00	0.82
0.00	5.95	-0.11	-6.24	0.00	-0.08	-0.02	
54	6	16	73.04	8.52	3.31	5.21	0.00	0.86
4.82	5.43	-0.14	-6.24	0.00	-0.11	-0.03	

55	7	1	71.60	8.65	3.14	5.51	0.00	0.85
0.00	5.71	-0.11	-3.36	0.00	-0.07	-0.02	
56	7	2	71.60	8.65	4.34	4.31	0.00	0.93
0.00	4.52	-0.08	-3.36	0.00	-0.04	-0.02	
57	7	3	71.60	8.65	5.00	3.65	0.00	0.95
1.20	3.83	-0.09	-3.36	0.00	-0.06	-0.02	
58	7	4	71.60	8.65	5.08	3.57	0.00	0.95
0.00	3.74	-0.07	-3.36	0.00	-0.03	-0.01	
59	7	5	71.60	8.65	5.14	3.51	0.00	0.95
0.00	3.68	-0.05	-3.36	0.00	-0.02	-0.01	
60	7	6	71.60	8.65	5.16	3.49	0.00	0.95
0.23	3.66	-0.11	-3.36	0.00	-0.02	-0.01	

61	8	1	72.59	8.56	5.07	3.49	0.00	0.95
0.00	1.80	-0.04	-5.10	0.00	-0.01	0.00	
62	8	2	72.59	8.56	4.54	4.02	0.00	0.93
0.00	1.37	-0.04	-5.10	0.00	-0.01	0.00	
63	8	3	72.59	8.56	4.02	4.54	0.00	0.91
0.00	1.54	-0.03	-5.10	0.00	0.00	0.00	
64	8	4	72.59	8.56	3.96	4.60	0.00	0.91
8.06	1.57	-0.06	-5.10	0.00	-0.04	0.00	
65	8	5	72.59	8.56	3.52	5.04	0.00	0.88

```
0.00     1.71   -0.06   -5.10    0.00   -0.04   -0.01
 66   8   6   72.59    8.56    3.10    5.46    0.00    0.84
0.00     1.86   -0.06   -5.10    0.00   -0.03   -0.01
 67   8   7   72.59    8.56    2.70    5.86    0.00    0.80
0.00     1.99   -0.06   -5.10    0.00   -0.03   -0.01
 68   8   8   72.59    8.56    2.31    6.25    0.00    0.75
0.00     2.12   -0.05   -5.10    0.00   -0.03   -0.01
 69   8   9   72.59    8.56    2.49    6.07    0.00    0.78
8.06     2.06   -0.08   -5.10    0.00   -0.05   -0.01
 70   8  10   72.59    8.56    2.15    6.41    0.00    0.73
0.00     2.18   -0.07   -5.10    0.00   -0.04   -0.01
 71   8  11   72.59    8.56    1.82    6.74    0.00    0.66
0.00     2.29   -0.07   -5.10    0.00   -0.04   -0.01
 72   8  12   72.59    8.56    1.50    7.06    0.00    0.59
0.00     2.40   -0.07   -5.10    0.00   -0.03   -0.01
 73   8  13   72.59    8.56    1.19    7.36    0.00    0.51
0.00     2.50   -0.07   -5.10    0.00   -0.03   -0.01
 74   8  14   72.59    8.56    0.90    7.66    0.00    0.42
0.00     2.60   -0.07   -5.10    0.00   -0.02   -0.01


 75   9   1   71.96    8.62    1.01    7.61    0.00    0.45
6.02     2.56   -0.06   -6.42    0.00   -0.03   -0.01
 76   9   2   71.96    8.62    0.88    7.74    0.00    0.41
0.00     2.61   -0.06   -6.42    0.00   -0.02   -0.01
 77   9   3   71.96    8.62    0.74    7.88    0.00    0.36
0.00     2.66   -0.06   -6.42    0.00   -0.02   -0.01
 78   9   4   71.96    8.62    0.61    8.01    0.00    0.31
0.00     2.70   -0.06   -6.42    0.00   -0.02    0.00


         STREAM QUALITY SIMULATION
                         OUTPUT PAGE NUMBER    21
         QUAL-2E STREAM QUALITY ROUTING MODEL
                          Version 3.22  --  May 1996
                                                  ***** STEADY STATE
SIMULATION *****

                                                      ** DISSOLVED
OXYGEN DATA **


COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE              DO              DO     DAM     NIT
ORD NUM NUM    TEMP     SAT       DO     DEF   INPUT   INHIB
F-FNCTN   OXYGN                       NET
               DEG-F    MG/L    MG/L    MG/L    MG/L    FACT
INPUT   REAIR   C-BOD     SOD     P-R   NH3-N   NO2-N

 79  10   1   72.50    8.57    2.44    6.13    0.00    0.77
0.12     1.27   -0.05   -0.24    0.00   -0.03   -0.01
```

80	10	2	72.50	8.57	3.05	5.51	0.00	0.84	
0.12	0.41	-0.03	-0.24	0.00	-0.02	-0.01			
81	10	3	72.50	8.57	3.39	5.18	0.00	0.87	
0.00	0.38	-0.01	-0.24	0.00	-0.01	0.00			
82	10	4	72.50	8.57	3.69	4.88	0.00	0.89	
0.00	0.36	-0.01	-0.24	0.00	0.00	0.00			
83	10	5	72.50	8.57	3.95	4.62	0.00	0.91	
0.00	0.34	0.00	-0.24	0.00	0.00	0.00			
84	10	6	72.50	8.57	4.24	4.33	0.00	0.92	
0.12	0.32	-0.01	-0.24	0.00	-0.01	0.00			
85	10	7	72.50	8.57	4.34	4.22	0.00	0.93	
0.00	0.31	-0.01	-0.24	0.00	0.00	0.00			
86	10	8	72.50	8.57	4.44	4.12	0.00	0.93	
0.00	0.31	0.00	-0.24	0.00	0.00	0.00			
87	10	9	72.50	8.57	4.53	4.04	0.00	0.93	
0.00	0.30	0.00	-0.24	0.00	0.00	0.00			
88	10	10	72.50	8.57	4.60	3.97	0.00	0.94	
0.00	0.30	0.00	-0.24	0.00	0.00	0.00			
89	10	11	72.50	8.57	4.65	3.92	0.00	0.94	
0.00	0.29	0.00	-0.24	0.00	0.00	0.00			
90	10	12	72.50	8.57	4.69	3.87	0.00	0.94	
0.00	0.29	0.00	-0.24	0.00	0.00	0.00			
91	10	13	72.50	8.57	4.73	3.84	0.00	0.94	
0.00	0.29	0.00	-0.24	0.00	0.00	0.00			
92	10	14	72.50	8.57	4.75	3.82	0.00	0.94	
0.00	0.28	0.00	-0.24	0.00	0.00	0.00			

93	11	1	73.33	8.49	4.61	3.88	0.00	0.94	
0.27	0.25	-0.01	-0.50	0.00	-0.01	0.00			
94	11	2	73.33	8.49	4.09	4.40	0.00	0.91	
0.00	0.24	-0.01	-0.50	0.00	0.00	0.00			
95	11	3	73.33	8.49	3.62	4.87	0.00	0.89	
0.00	0.26	0.00	-0.50	0.00	0.00	0.00			
96	11	4	73.33	8.49	3.21	5.29	0.00	0.85	
0.00	0.28	0.00	-0.50	0.00	0.00	0.00			

97	12	1	70.16	8.79	1.09	7.70	0.00	0.48	
0.35	2.06	-0.12	-1.63	0.00	-0.10	-0.03			
98	12	2	70.16	8.79	1.19	7.59	0.00	0.51	
0.00	2.03	-0.06	-1.63	0.00	-0.05	-0.02			
99	12	3	70.16	8.79	1.40	7.39	0.00	0.57	
0.00	1.98	-0.03	-1.63	0.00	-0.02	-0.01			
100	12	4	70.16	8.79	1.57	7.22	0.00	0.61	
0.00	1.93	-0.01	-1.63	0.00	-0.01	0.00			
101	12	5	70.16	8.79	1.68	7.10	0.00	0.64	
0.00	1.90	-0.01	-1.63	0.00	0.00	0.00			
102	12	6	70.16	8.79	1.75	7.04	0.00	0.65	
0.00	1.88	0.00	-1.63	0.00	0.00	0.00			
103	12	7	70.16	8.79	1.79	7.00	0.00	0.66	
0.00	1.87	0.00	-1.63	0.00	0.00	0.00			

```
104  12   8   70.16    8.79    1.81    6.98    0.00    0.66
0.00    1.87    0.00   -1.63    0.00    0.00    0.00
105  12   9   70.16    8.79    1.82    6.97    0.00    0.66
0.00    1.86    0.00   -1.63    0.00    0.00    0.00
106  12  10   70.16    8.79    1.83    6.96    0.00    0.67
0.00    1.86    0.00   -1.63    0.00    0.00    0.00
107  12  11   70.16    8.79    1.83    6.96    0.00    0.67
0.00    1.86    0.00   -1.63    0.00    0.00    0.00


108  13   1   70.70    8.73    1.59    7.15    0.00    0.61
0.00    1.82    0.00   -1.32    0.00    0.00    0.00
109  13   2   70.70    8.73    2.14    6.59    0.00    0.72
0.00    1.58    0.00   -1.32    0.00    0.00    0.00
110  13   3   70.70    8.73    2.35    6.39    0.00    0.76
0.00    1.53    0.00   -1.32    0.00    0.00    0.00
111  13   4   70.70    8.73    3.34    5.39    0.00    0.87
0.96    1.29   -0.06   -1.32    0.00   -0.05   -0.01
112  13   5   70.70    8.73    2.79    5.94    0.00    0.81
0.00    1.42   -0.03   -1.32    0.00   -0.02   -0.01
113  13   6   70.70    8.73    2.57    6.16    0.00    0.79
0.00    1.48   -0.02   -1.32    0.00   -0.01    0.00
114  13   7   70.70    8.73    3.25    5.48    0.00    0.86
0.96    1.31   -0.06   -1.32    0.00   -0.04   -0.01
115  13   8   70.70    8.73    2.84    5.90    0.00    0.82
0.00    1.41   -0.04   -1.32    0.00   -0.02   -0.01
116  13   9   70.70    8.73    2.63    6.10    0.00    0.79
0.00    1.46   -0.02   -1.32    0.00   -0.01    0.00
117  13  10   70.70    8.73    2.53    6.21    0.00    0.78
0.00    1.49   -0.01   -1.32    0.00    0.00    0.00
118  13  11   70.70    8.73    2.48    6.26    0.00    0.77
0.00    1.50   -0.01   -1.32    0.00    0.00    0.00

         STREAM QUALITY SIMULATION
                                         OUTPUT PAGE NUMBER    22
         QUAL-2E STREAM QUALITY ROUTING MODEL
                         Version 3.22  --  May 1996
                                                 ***** STEADY STATE
SIMULATION *****

                                                     ** DISSOLVED
OXYGEN DATA **


COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE             DO              DO     DAM     NIT
ORD NUM NUM    TEMP     SAT      DO     DEF   INPUT   INHIB
F-FNCTN   OXYGN                     NET
              DEG-F    MG/L    MG/L    MG/L    MG/L    FACT
INPUT   REAIR   C-BOD     SOD     P-R   NH3-N   NO2-N

119  13  12   70.70    8.73    2.46    6.28    0.00    0.77
```

```
0.00    1.50   -0.01   -1.32    0.00    0.00    0.00
120  13  13   70.70    8.73    2.45    6.28    0.00    0.77
0.00    1.50    0.00   -1.32    0.00    0.00    0.00
121  13  14   70.70    8.73    3.11    5.63    0.00    0.85
0.96    1.35   -0.04   -1.32    0.00   -0.03   -0.01
122  13  15   70.70    8.73    2.82    5.91    0.00    0.82
0.00    1.41   -0.03   -1.32    0.00   -0.02   -0.01


123  14   1   70.79    8.73    2.01    6.72    0.00    0.70
0.00    1.61   -0.02   -1.44    0.00   -0.01    0.00
124  14   2   70.79    8.73    2.08    6.64    0.00    0.71
0.00    1.58   -0.01   -1.44    0.00    0.00    0.00


125  15   1   76.28    8.24    4.68    3.56    0.00    0.94
0.00    2.86    0.00   -5.49    0.00    0.00    0.00
126  15   2   76.28    8.24    4.66    3.57    0.00    0.94
0.00    5.18    0.00   -5.49    0.00    0.00    0.00
127  15   3   76.28    8.24    4.75    3.48    0.00    0.94
14.66    5.05   -0.02   -5.49    0.00   -0.02    0.00
128  15   4   76.28    8.24    4.74    3.50    0.00    0.94
0.00    5.07   -0.02   -5.49    0.00   -0.02    0.00
129  15   5   76.28    8.24    4.72    3.51    0.00    0.94
0.00    5.09   -0.02   -5.49    0.00   -0.02    0.00
130  15   6   76.28    8.24    4.81    3.43    0.00    0.94
14.66    4.97   -0.03   -5.49    0.00   -0.03    0.00
131  15   7   76.28    8.24    4.79    3.45    0.00    0.94
0.00    5.00   -0.03   -5.49    0.00   -0.03    0.00
132  15   8   76.28    8.24    4.77    3.47    0.00    0.94
0.00    5.03   -0.03   -5.49    0.00   -0.03    0.00
133  15   9   76.28    8.24    4.75    3.48    0.00    0.94
0.00    5.05   -0.03   -5.49    0.00   -0.03    0.00
134  15  10   76.28    8.24    4.83    3.41    0.00    0.94
14.66    4.94   -0.04   -5.49    0.00   -0.04    0.00
135  15  11   76.28    8.24    4.81    3.42    0.00    0.94
0.00    4.96   -0.04   -5.49    0.00   -0.04    0.00
136  15  12   76.28    8.24    4.79    3.44    0.00    0.94
0.00    4.99   -0.04   -5.49    0.00   -0.04   -0.01
137  15  13   76.28    8.24    4.78    3.46    0.00    0.94
0.00    5.02   -0.04   -5.49    0.00   -0.04   -0.01
138  15  14   76.28    8.24    4.76    3.48    0.00    0.94
0.00    5.04   -0.04   -5.49    0.00   -0.04   -0.01
139  15  15   76.28    8.24    4.74    3.49    0.00    0.94
0.00    5.06   -0.04   -5.49    0.00   -0.04   -0.01
140  15  16   76.28    8.24    4.73    3.51    0.00    0.94
0.00    5.09   -0.04   -5.49    0.00   -0.04   -0.01


141  16   1   74.30    8.41    7.02    1.39    0.00    0.99
0.50    1.64   -0.06   -1.38    0.00   -0.03   -0.01
142  16   2   74.30    8.41    7.12    1.29    0.00    0.99
```

```
0.00     1.52   -0.01   -1.38    0.00    0.00    0.00
143  16   3   74.30    8.41    7.14    1.27    0.00    0.99
0.00     1.50    0.00   -1.38    0.00    0.00    0.00
144  16   4   74.30    8.41    7.14    1.26    0.00    0.99
0.00     1.49    0.00   -1.38    0.00    0.00    0.00
145  16   5   74.30    8.41    7.14    1.26    0.00    0.99
0.00     1.49    0.00   -1.38    0.00    0.00    0.00
146  16   6   74.30    8.41    7.14    1.26    0.00    0.99
0.00     1.49    0.00   -1.38    0.00    0.00    0.00
147  16   7   74.30    8.41    7.14    1.26    0.00    0.99
0.00     1.49    0.00   -1.38    0.00    0.00    0.00
148  16   8   74.30    8.41    7.14    1.26    0.00    0.99
0.00     1.49    0.00   -1.38    0.00    0.00    0.00
149  16   9   74.30    8.41    7.05    1.35    0.00    0.99
0.52     1.60   -0.05   -1.38    0.00   -0.03   -0.01
150  16  10   74.30    8.41    7.04    1.37    0.00    0.99
0.52     1.62   -0.05   -1.38    0.00   -0.03   -0.01
151  16  11   74.30    8.41    7.09    1.31    0.00    0.99
0.00     1.55   -0.02   -1.38    0.00   -0.01    0.00


152  17   1   74.30    8.41    6.54    1.87    0.00    0.98
0.00     1.39   -0.01   -1.38    0.00    0.00    0.00
153  17   2   74.30    8.41    4.76    3.64    0.00    0.94
0.00     1.11   -0.01   -1.38    0.00    0.00    0.00
154  17   3   74.30    8.41    4.03    4.38    0.00    0.91
0.00     1.33    0.00   -1.38    0.00    0.00    0.00
155  17   4   74.30    8.41    3.72    4.69    0.00    0.89
0.00     1.43    0.00   -1.38    0.00    0.00    0.00
156  17   5   74.30    8.41    3.59    4.81    0.00    0.88
0.00     1.46    0.00   -1.38    0.00    0.00    0.00

         STREAM QUALITY SIMULATION
                                 OUTPUT PAGE NUMBER    23
         QUAL-2E STREAM QUALITY ROUTING MODEL
                          Version 3.22  --  May 1996
                                                  ***** STEADY STATE
SIMULATION *****

                                                      ** DISSOLVED
OXYGEN DATA **


COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE              DO              DO      DAM      NIT
ORD NUM NUM    TEMP     SAT       DO     DEF   INPUT   INHIB
F-FNCTN   OXYGN                     NET
              DEG-F    MG/L    MG/L    MG/L    MG/L    FACT
INPUT   REAIR   C-BOD     SOD     P-R   NH3-N   NO2-N

157  17   6   74.30    8.41    3.82    4.58    0.00    0.90
0.52     1.39   -0.04   -1.38    0.00   -0.03   -0.01
```

```
158  17   7   74.30    8.41    3.60    4.81    0.00    0.88
0.00    1.46   -0.02   -1.38    0.00   -0.01    0.00
159  17   8   74.30    8.41    3.52    4.89    0.00    0.88
0.00    1.49   -0.01   -1.38    0.00    0.00    0.00
160  17   9   74.30    8.41    3.49    4.91    0.00    0.88
0.00    1.49   -0.01   -1.38    0.00    0.00    0.00


161  18   1   72.32    8.58    3.44    5.15    0.00    0.87
0.00    1.39    0.00   -1.29    0.00    0.00    0.00
162  18   2   72.32    8.58    3.15    5.43    0.00    0.85
0.00    1.32    0.00   -1.29    0.00    0.00    0.00
163  18   3   72.32    8.58    2.99    5.59    0.00    0.83
0.00    1.36    0.00   -1.29    0.00    0.00    0.00
164  18   4   72.32    8.58    2.91    5.67    0.00    0.83
0.00    1.38    0.00   -1.29    0.00    0.00    0.00
165  18   5   72.32    8.58    2.86    5.72    0.00    0.82
0.00    1.39    0.00   -1.29    0.00    0.00    0.00
166  18   6   72.32    8.58    2.84    5.74    0.00    0.82
0.00    1.39    0.00   -1.29    0.00    0.00    0.00
167  18   7   72.32    8.58    2.83    5.76    0.00    0.82
0.00    1.40    0.00   -1.29    0.00    0.00    0.00
168  18   8   72.32    8.58    3.20    5.38    0.00    0.85
0.52    1.30   -0.03   -1.29    0.00   -0.02   -0.01
169  18   9   72.32    8.58    2.98    5.60    0.00    0.83
0.00    1.36   -0.02   -1.29    0.00   -0.01    0.00
170  18  10   72.32    8.58    2.88    5.70    0.00    0.82
0.00    1.38   -0.01   -1.29    0.00    0.00    0.00
171  18  11   72.32    8.58    2.89    5.69    0.00    0.82
0.10    1.38   -0.02   -1.29    0.00   -0.01    0.00
172  18  12   72.32    8.58    2.83    5.76    0.00    0.82
0.00    1.40   -0.01   -1.29    0.00    0.00    0.00
173  18  13   72.32    8.58    2.80    5.78    0.00    0.81
0.00    1.40   -0.01   -1.29    0.00    0.00    0.00


174  19   1   71.53    8.66    3.21    5.45    0.00    0.85
0.38    1.45   -0.03   -1.22    0.00   -0.02   -0.01
175  19   2   71.53    8.66    3.63    5.03    0.00    0.89
0.00    1.47   -0.02   -1.22    0.00   -0.01    0.00
176  19   3   71.53    8.66    3.88    4.77    0.00    0.90
0.00    1.40   -0.01   -1.22    0.00    0.00    0.00
177  19   4   71.53    8.66    4.03    4.63    0.00    0.91
0.00    1.36   -0.01   -1.22    0.00    0.00    0.00
178  19   5   71.53    8.66    4.12    4.54    0.00    0.92
0.00    1.33    0.00   -1.22    0.00    0.00    0.00


179  20   1   73.69    8.46    4.29    4.17    0.00    0.92
0.00    2.08   -0.02   -1.01    0.00   -0.02   -0.01
180  20   2   73.69    8.46    3.54    4.92    0.00    0.88
0.00    0.72   -0.02   -1.01    0.00   -0.01    0.00
```

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181  20   3   73.69    8.46    2.97    5.49    0.00    0.83
0.00    0.81   -0.01   -1.01    0.00    0.00    0.00


182  21   1   75.85    8.27    3.43    4.84    0.00    0.87
0.19    1.17   -0.02   -0.71    0.00   -0.01    0.00
183  21   2   75.85    8.27    4.55    3.73    0.00    0.93
0.00    1.24   -0.01   -0.71    0.00    0.00    0.00
184  21   3   75.85    8.27    5.14    3.13    0.00    0.95
0.00    1.04   -0.01   -0.71    0.00    0.00    0.00
185  21   4   75.85    8.27    5.47    2.80    0.00    0.96
0.19    0.93   -0.01   -0.71    0.00   -0.01    0.00
186  21   5   75.85    8.27    5.61    2.67    0.00    0.97
0.00    0.89   -0.01   -0.71    0.00    0.00    0.00


187  22   1   75.85    8.27    5.67    2.61    0.00    0.97
0.04    0.87   -0.02   -0.71    0.00    0.00    0.00
188  22   2   75.85    8.27    5.71    2.57    0.00    0.97
0.00    0.85   -0.01   -0.71    0.00    0.00    0.00
189  22   3   75.85    8.27    5.75    2.52    0.00    0.97
0.19    0.84   -0.02   -0.71    0.00   -0.01    0.00
190  22   4   75.85    8.27    5.75    2.52    0.00    0.97
0.00    0.84   -0.01   -0.71    0.00    0.00    0.00
191  22   5   75.85    8.27    5.76    2.51    0.00    0.97
0.00    0.83   -0.01   -0.71    0.00    0.00    0.00
192  22   6   75.85    8.27    5.78    2.50    0.00    0.97
0.00    0.83    0.00   -0.71    0.00    0.00    0.00

         STREAM QUALITY SIMULATION
                                  OUTPUT PAGE NUMBER    24
         QUAL-2E STREAM QUALITY ROUTING MODEL
                          Version 3.22  --  May 1996
                                                ***** STEADY STATE
SIMULATION *****

                                                    ** DISSOLVED
OXYGEN DATA **


COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)
ELE RCH ELE              DO              DO     DAM     NIT
ORD NUM NUM    TEMP     SAT      DO     DEF   INPUT   INHIB
F-FNCTN   OXYGN                      NET
             DEG-F    MG/L    MG/L    MG/L    MG/L    FACT
INPUT   REAIR   C-BOD     SOD     P-R   NH3-N   NO2-N

193  22   7   75.85    8.27    5.79    2.48    0.00    0.97
0.00    0.83    0.00   -0.71    0.00    0.00    0.00


194  23   1   77.47    8.14    6.34    1.80    0.00    0.98
```

```
0.01     1.31    0.00    -2.20    0.00    0.00    0.00
195  23   2   77.47    8.14    6.22    1.92    0.00    0.98
0.00     2.15    0.00    -2.20    0.00    0.00    0.00
196  23   3   77.47    8.14    6.14    1.99    0.00    0.97
0.00     2.23    0.00    -2.20    0.00    0.00    0.00
197  23   4   77.47    8.14    6.10    2.03    0.00    0.97
0.00     2.28    0.00    -2.20    0.00    0.00    0.00
198  23   5   77.47    8.14    6.08    2.06    0.00    0.97
0.00     2.31    0.00    -2.20    0.00    0.00    0.00
199  23   6   77.47    8.14    6.06    2.07    0.00    0.97
0.00     2.32    0.00    -2.20    0.00    0.00    0.00
200  23   7   77.47    8.14    6.05    2.08    0.00    0.97
0.00     2.33    0.00    -2.20    0.00    0.00    0.00
201  23   8   77.47    8.14    6.05    2.09    0.00    0.97
0.00     2.34    0.00    -2.20    0.00    0.00    0.00
202  23   9   77.47    8.14    6.05    2.09    0.00    0.97
0.00     2.34    0.00    -2.20    0.00    0.00    0.00
203  23  10   77.47    8.14    6.09    2.05    0.00    0.97
1.65     2.29   -0.03    -2.20    0.00   -0.03   -0.01


204  24   1   77.47    8.14    5.94    2.19    0.00    0.97
1.65     1.97   -0.05    -2.20    0.00   -0.05   -0.01
205  24   2   77.47    8.14    5.68    2.45    0.00    0.97
1.65     1.67   -0.07    -2.20    0.00   -0.07   -0.02
206  24   3   77.47    8.14    5.41    2.73    0.00    0.96
0.02     1.85   -0.06    -2.20    0.00   -0.05   -0.02
207  24   4   77.47    8.14    5.20    2.93    0.00    0.96
0.00     1.99   -0.06    -2.20    0.00   -0.04   -0.01
208  24   5   77.47    8.14    5.05    3.09    0.00    0.95
0.00     2.10   -0.05    -2.20    0.00   -0.03   -0.01
209  24   6   77.47    8.14    4.94    3.20    0.00    0.95
0.02     2.17   -0.04    -2.20    0.00   -0.02   -0.01
210  24   7   77.47    8.14    4.99    3.14    0.00    0.95
1.65     2.14   -0.06    -2.20    0.00   -0.04   -0.01
211  24   8   77.47    8.14    4.89    3.25    0.00    0.95
0.00     2.21   -0.05    -2.20    0.00   -0.03   -0.01
212  24   9   77.47    8.14    4.82    3.32    0.00    0.94
0.01     2.26   -0.05    -2.20    0.00   -0.03   -0.01
213  24  10   77.47    8.14    4.77    3.36    0.00    0.94
0.20     2.29   -0.06    -2.20    0.00   -0.02   -0.01
214  24  11   77.47    8.14    4.72    3.41    0.00    0.94
0.00     2.32   -0.05    -2.20    0.00   -0.02   -0.01
215  24  12   77.47    8.14    4.69    3.45    0.00    0.94
0.00     2.34   -0.05    -2.20    0.00   -0.01   -0.01
216  24  13   77.47    8.14    4.66    3.47    0.00    0.94
0.00     2.36   -0.04    -2.20    0.00   -0.01    0.00
217  24  14   77.47    8.14    4.65    3.49    0.00    0.94
0.00     2.37   -0.04    -2.20    0.00   -0.01    0.00
218  24  15   77.47    8.14    4.64    3.50    0.00    0.94
0.00     2.38   -0.03    -2.20    0.00   -0.01    0.00
219  24  16   77.47    8.14    4.63    3.50    0.00    0.94
```

0.00		2.38	-0.03	-2.20	0.00	-0.01	0.00	
220	24	17	77.47	8.14	4.63	3.50	0.00	0.94
0.00		2.38	-0.03	-2.20	0.00	0.00	0.00	
221	25	1	76.80	8.19	5.53	2.66	0.00	0.96
0.47		3.24	-0.04	-1.27	0.00	-0.02	0.00	
222	25	2	76.80	8.19	6.66	1.53	0.00	0.98
0.00		2.69	-0.03	-1.27	0.00	-0.01	0.00	
223	25	3	76.80	8.19	7.10	1.09	0.00	0.99
0.00		1.91	-0.02	-1.27	0.00	-0.01	0.00	
224	25	4	76.80	8.19	7.28	0.91	0.00	0.99
0.00		1.60	-0.02	-1.27	0.00	0.00	0.00	
225	25	5	76.80	8.19	7.33	0.86	0.00	0.99
0.47		1.51	-0.03	-1.27	0.00	-0.02	0.00	
226	26	1	78.69	8.04	7.50	0.54	0.00	0.99
0.00		1.41	-0.02	-0.90	0.00	-0.01	0.00	
227	26	2	78.69	8.04	7.69	0.34	0.00	0.99
0.00		1.19	-0.02	-0.90	0.00	0.00	0.00	
228	26	3	78.69	8.04	7.73	0.31	0.00	0.99
0.00		1.05	-0.01	-0.90	0.00	0.00	0.00	
229	26	4	78.69	8.04	7.74	0.30	0.00	0.99
0.00		1.02	-0.01	-0.90	0.00	0.00	0.00	

Attachment 2

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Data for Manganese Load Duration Curve			Observed Data				
Skillet Fork IL_CA-03 (cfs)	% of Time Exceeded	Manganese load (lbs/day)	Date	Skillet Fork IL_CA-03 (cfs)	Concentration (ug/l)	Percentile	Manganese load (lbs/day)
0.1	99.993%	0.54	1/4/1994	246.8	870	35.0%	1,158
0.4	98.446%	2.16	2/17/1994	201.5	640	38.3%	696
0.7	97.706%	3.78	4/11/1994	19474.2	530	0.4%	55,671
0.8	96.966%	4.32	5/25/1994	45.3	810	62.0%	198
1.1	96.226%	5.93	6/20/1994	14.3	700	76.8%	54
1.5	95.486%	8.09	8/10/1994	6.8	1400	84.5%	51
1.8	94.747%	9.71	9/20/1994	0.1	1200	100.0%	1
2.1	94.007%	11.33	11/2/1994	1	580	96.8%	3
2.3	93.267%	12.41	12/14/1994	45.3	260	62.0%	64
2.7	92.527%	14.56	2/2/1995	317	240	31.1%	410
2.9	91.787%	15.64	3/2/1995	622.7	280	22.1%	940
3.2	91.047%	17.26	4/13/1995	135.9	790	45.0%	579
3.6	90.307%	19.42	5/24/1995	634	78	22.0%	267
3.8	89.567%	20.50	6/22/1995	104.2	1300	49.4%	731
4.3	88.827%	23.19	8/16/1995	40.8	620	63.3%	136
4.8	88.087%	25.89	9/21/1995	0.5	900	98.2%	2
5	87.347%	26.97	11/14/1995	1.8	490	94.9%	5
5.4	86.607%	29.13	12/8/1995	1.5	380	95.6%	3
5.9	85.868%	31.82	1/25/1996	4800.6	560	6.0%	14,500
6.3	85.128%	33.98	2/20/1996	61.1	570	57.5%	188
6.8	84.388%	36.68	4/11/1996	142.7	360	44.1%	277
7.5	83.648%	40.45	5/29/1996	3894.8	650	7.4%	13,655
7.9	82.908%	42.61	7/3/1996	12	1700	79.0%	110
8.6	82.168%	46.39	8/7/1996	3.2	1200	91.5%	21
9.3	81.428%	50.16	9/4/1996	3.2	1000	91.5%	17
10.2	80.688%	55.02	10/9/1996	5.7	640	86.5%	20
10.9	79.948%	58.79	12/4/1996	217.4	250	37.1%	293
11.5	79.208%	62.03	1/28/1997	9261.6	240	2.2%	11,989
12.5	78.468%	67.42	2/27/1997	8423.7	1700	2.5%	77,240
12.9	77.728%	69.58	4/17/1997	160.8	420	42.0%	364
13.8	76.989%	74.43	5/15/1997	101.9	600	49.8%	330
14.7	76.249%	79.29	6/19/1997	4823.3	220	6.0%	5,723
15.4	75.509%	83.06	7/28/1997	36.2	450	65.0%	88
16.1	74.769%	86.84	9/11/1997	8.4	930	82.6%	42
17	74.029%	91.69	10/9/1997	0.4	840	98.6%	2
18.1	73.289%	97.63	12/22/1997	22.4	410	70.8%	50
19	72.549%	102.48	1/22/1998	144.9	290	43.8%	227
20.4	71.809%	110.03	3/5/1998	380.4	200	28.6%	410
21.5	71.069%	115.97	4/1/1998	2921.1	200	9.2%	3,151
22.6	70.329%	121.90	6/3/1998	77	690	54.3%	287
24.9	69.589%	134.31	7/9/1998	4732.7	1200	6.1%	30,633
27.2	68.849%	146.71	8/13/1998	1302.1	130	15.2%	913
27.2	68.110%	146.71	9/30/1998	58.9	410	58.0%	130
29.4	67.370%	158.58	11/12/1998	966.9	460	17.7%	2,399
31.7	66.630%	170.98	12/16/1998	61.1	320	57.5%	105
31.7	65.890%	170.98	2/4/1999	5366.7	140	5.3%	4,053
34	65.150%	183.39	3/18/1999	477.8	170	25.4%	438
36.2	64.410%	195.25	4/22/1999	303.4	530	31.8%	867
38.5	63.670%	207.66	5/24/1999	72.5	710	55.0%	278
40.8	62.930%	220.07	6/21/1999	36.2	630	65.0%	123
43	62.190%	231.93	7/21/1999	47.6	920	61.1%	236
45.3	61.450%	244.34	9/29/1999	0.7	680	97.8%	3
47.6	60.710%	256.74	11/9/1999	0.7	840	97.8%	3
49.8	59.970%	268.61	12/9/1999	1	570	96.8%	3
54.3	59.230%	292.88	1/11/2000	18.1	280	73.3%	27
56.6	58.491%	305.29	3/8/2000	129.1	470	45.9%	327
58.9	57.751%	317.69	4/18/2000	371.4	390	28.9%	781
61.1	57.011%	329.56	5/25/2000	40.8	320	63.3%	70
65.7	56.271%	354.37	6/28/2000	8876.6	220	2.4%	10,533
67.9	55.531%	366.24	8/1/2000	803.9	380	19.4%	1,648
72.5	54.791%	391.05	9/18/2000	15.2	670	75.9%	55
77	54.051%	415.32	11/21/2000	83.8	180	53.0%	81
81.5	53.311%	439.59	1/25/2001	294.4	200	32.3%	318
83.8	52.571%	452.00	3/13/2001	156.2	490	42.6%	413
88.3	51.831%	476.27	4/2/2001	156.2	440	42.6%	371
92.8	51.091%	500.54	7/5/2001	142.7	590	44.1%	454
97.4	50.351%	525.35	8/13/2001	3.8	780	90.0%	16
101.9	49.612%	549.63	9/12/2001	4.1	480	89.4%	11
106.4	48.872%	573.90	10/24/2001	156.2	200	42.6%	169
113.2	48.132%	610.58	11/19/2001	34	530	65.8%	97
115.5	47.392%	622.98	1/29/2002	192.5	260	38.9%	270

Data for Manganese Load Duration Curve

Skillet Fork IL_CA-03 (cfs)	% of Time Exceeded	Manganese load (lbs/day)
122.3	46.652%	659.66
129.1	45.912%	696.34
133.6	45.172%	720.61
138.1	44.432%	744.88
144.9	43.692%	781.56
151.7	42.952%	818.24
158.5	42.212%	854.91
165.3	41.472%	891.59
172.1	40.733%	928.27
181.2	39.993%	977.35
187.9	39.253%	1013.49
197	38.513%	1062.57
206.1	37.773%	1111.66
217.4	37.033%	1172.61
226.4	36.293%	1221.15
237.8	35.553%	1282.64
249.1	34.813%	1343.59
260.4	34.073%	1404.54
271.7	33.333%	1465.49
285.3	32.593%	1538.84
301.2	31.853%	1624.61
317	31.114%	1709.83
332.9	30.374%	1795.59
351	29.634%	1893.22
371.4	28.894%	2003.25
389.5	28.154%	2100.88
409.9	27.414%	2210.91
430.2	26.674%	2320.40
452.9	25.934%	2442.84
482.3	25.194%	2601.42
514	24.454%	2772.40
545.7	23.714%	2943.38
575.2	22.974%	3102.50
618.2	22.235%	3334.43
665.7	21.495%	3590.64
706.5	20.755%	3810.70
758.6	20.015%	4091.72
817.5	19.275%	4409.41
883.1	18.535%	4763.24
960.1	17.795%	5178.56
1048.4	17.055%	5654.83
1132.2	16.315%	6106.83
1245.4	15.575%	6717.41
1358.7	14.835%	7328.52
1505.9	14.095%	8122.49
1662.1	13.356%	8964.99
1820.6	12.616%	9819.91
2024.4	11.876%	10919.16
2230.5	11.136%	12030.82
2445.6	10.396%	13191.02
2717.3	9.656%	14656.51
3057	8.916%	16488.77
3464.6	8.176%	18687.28
3872.2	7.436%	20885.78
4370.4	6.696%	23572.96
4845.9	5.956%	26137.70
5434.7	5.216%	29313.55
6136.6	4.477%	33099.44
6861.3	3.737%	37008.31
7699.1	2.997%	41527.22
9057.8	2.257%	48855.74
11005.2	1.517%	59359.58
15488.8	0.777%	83543.11
54346.6	0.037%	293133.38

Observed Data

Date	Skillet Fork IL_CA-03 (cfs)	Concentration (ug/l)	Percentile	Manganese load (lbs/day)
3/5/2002	1025.8	280	17.2%	1,549
4/15/2002	4098.6	350	7.1%	7,737
5/22/2002	226.4	78	36.5%	95
6/12/2002	113.2	1200	48.1%	733
8/14/2002	2.7	1200	92.7%	17
9/26/2002	2.5	770	93.2%	10
11/4/2002	13.6	230	77.4%	17
12/19/2002	1487.7	1300	14.2%	10,432
1/13/2003	45.3	320	62.0%	78
2/13/2003	36.2	470	65.0%	92
4/9/2003	353.3	300	29.5%	572
9/1/2005	15.9	300	75.2%	26
9/1/2005	15.9	260	75.2%	22
9/1/2005	15.9	260	75.2%	22

Data for Manganese Load Duration Curve			Observed Data				
Skillet Fork IL_CA-05 (cfs)	% of Time Exceeded	Manganese load (lbs/day)	Date	Skillet Fork IL_CA-05 (cfs)	Concentration (ug/l)	Percentile	Manganese load (lbs/day)
0.10	100%	0.08	9/1/2005	8.8	600	75%	28
0.20	98%	0.16	1/26/1994	3133.1	390	5%	6,591
0.40	98%	0.32	3/7/1994	157.9	470	33%	400
0.40	97%	0.32	4/19/1994	335.9	310	22%	562
0.60	96%	0.49	5/16/1994	154.1	360	33%	299
0.80	95%	0.65	6/20/1994	7.9	770	77%	33
1.00	95%	0.81	7/20/1994	8.5	650	76%	30
1.20	94%	0.97	8/29/1994	2.1	1300	90%	15
1.30	93%	1.05	10/5/1994	0.4	1200	98%	3
1.50	93%	1.21	11/28/1994	377.2	560	21%	1,139
1.60	92%	1.29	1/11/1995	60.2	440	49%	143
1.80	91%	1.46	2/22/1995	81.5	380	44%	167
2.00	90%	1.62	3/27/1995	323.3	440	23%	767
2.10	90%	1.70	5/30/1995	3421.3	160	4%	2,953
2.40	89%	1.94	6/28/1995	80.2	390	44%	169
2.60	88%	2.10	7/26/1995	82.7	840	43%	375
2.80	87%	2.27	9/20/1995	0.3	1600	98%	3
3.00	87%	2.43	11/8/1995	0.2	1000	99%	1
3.30	86%	2.67	12/6/1995	0.3	530	98%	1
3.50	85%	2.83	1/22/1996	211.8	300	28%	343
3.80	84%	3.07	2/26/1996	37.6	700	56%	142
4.10	84%	3.32	4/3/1996	2857.4	270	6%	4,161
4.40	83%	3.56	5/13/1996	1190.6	300	11%	1,927
4.80	82%	3.88	6/10/1996	8384.1	250	1%	11,305
5.10	81%	4.13	7/22/1996	3.8	880	85%	18
5.60	81%	4.53	9/18/1996	22.6	380	63%	46
6.00	80%	4.85	11/6/1996	2.6	1100	88%	15
6.40	79%	5.18	12/9/1996	134.1	170	35%	123
6.90	78%	5.58	2/3/1997	750.7	210	15%	850
7.10	78%	5.74	3/3/1997	3935.2	240	3%	5,094
7.60	77%	6.15	4/14/1997	198	300	29%	320
8.10	76%	6.55	5/21/1997	32.6	1000	58%	176
8.50	76%	6.88	6/11/1997	164.2	430	32%	381
8.90	75%	7.20	7/21/1997	16.3	620	68%	55
9.40	74%	7.61	9/8/1997	5.5	860	81%	26
10.00	73%	8.09	10/20/1997	1.4	980	93%	7
10.50	73%	8.50	12/1/1997	4.8	830	82%	21
11.30	72%	9.14	1/26/1998	263.2	320	25%	454
11.90	71%	9.63	3/18/1998	3020.3	600	5%	9,774
12.50	70%	10.11	4/20/1998	723.1	280	15%	1,092
13.80	70%	11.17	6/1/1998	99	400	40%	214
15.00	69%	12.14	7/13/1998	1169.3	240	12%	1,514
15.00	68%	12.14	8/3/1998	195.5	190	30%	200
16.30	67%	13.19	9/21/1998	42.6	710	54%	163
17.50	67%	14.16	11/9/1998	31.3	330	59%	56
17.50	66%	14.16	12/7/1998	60.2	610	49%	198
18.80	65%	15.21	1/19/1999	3860	370	4%	7,703
20.10	64%	16.26	3/18/1999	264.4	240	25%	342
21.30	64%	17.23	4/12/1999	303.3	270	24%	442
22.60	63%	18.28	5/17/1999	89	320	42%	154
23.80	62%	19.26	6/14/1999	508.8	660	18%	1,811
25.10	61%	20.31	9/1/1999	5	550	82%	15
26.30	61%	21.28	10/12/1999	0.4	600	98%	1
27.60	60%	22.33	11/15/1999	0.4	970	98%	2
30.10	59%	24.35	1/12/2000	8.6	150	75%	7
31.30	58%	25.32	2/14/2000	102.8	290	40%	161
32.60	58%	26.38	3/27/2000	178	380	31%	365
33.80	57%	27.35	4/24/2000	82.7	440	43%	196
36.30	56%	29.37	5/30/2000	436.1	190	20%	447
37.60	56%	30.42	8/8/2000	2519	320	6%	4,348
40.10	55%	32.44	10/17/2000	13.8	460	70%	34
42.60	54%	34.47	12/5/2000	81.5	280	44%	123
45.10	53%	36.49	1/23/2001	264.4	230	25%	328
46.40	53%	37.54	2/27/2001	3007.8	97	5%	1,574
48.90	52%	39.56	4/10/2001	101.5	450	40%	246
51.40	51%	41.59	6/12/2001	46.4	300	53%	75
53.90	50%	43.61	9/11/2001	2.6	920	88%	13
56.40	50%	45.63	10/23/2001	27.6	240	60%	36
58.90	49%	47.65	11/27/2001	73.9	300	45%	120
62.70	48%	50.73	1/29/2002	106.5	250	39%	144
63.90	47%	51.70	2/20/2002	2832.3	420	6%	6,416

Data for Manganese Load Duration Curve

Skillet Fork IL_CA-05 (cfs)	% of Time Exceeded	Manganese load (lbs/day)
67.70	47%	54.77
71.40	46%	57.77
73.90	45%	59.79
76.40	44%	61.81
80.20	44%	64.89
84.00	43%	67.96
87.70	42%	70.96
91.50	41%	74.03
95.20	41%	77.02
100.30	40%	81.15
104.00	39%	84.14
109.00	39%	88.19
114.00	38%	92.23
120.30	37%	97.33
125.30	36%	101.38
131.60	36%	106.47
137.90	35%	111.57
144.10	34%	116.59
150.40	33%	121.68
157.90	33%	127.75
166.70	32%	134.87
175.50	31%	141.99
184.20	30%	149.03
194.30	30%	157.20
205.50	29%	166.26
215.60	28%	174.43
226.80	27%	183.50
238.10	27%	192.64
250.60	26%	202.75
266.90	25%	215.94
284.50	24%	230.18
302.00	24%	244.34
318.30	23%	257.53
342.10	22%	276.78
368.50	21%	298.14
391.00	21%	316.34
419.80	20%	339.65
452.40	19%	366.02
488.80	19%	395.47
531.40	18%	429.94
580.20	17%	469.42
626.60	16%	506.96
689.30	16%	557.69
751.90	15%	608.34
833.40	14%	674.28
919.90	13%	744.26
1,007.60	13%	815.22
1,120.40	12%	906.48
1,234.40	11%	998.71
1,353.50	10%	1,095.07
1,503.90	10%	1,216.75
1,691.90	9%	1,368.86
1,917.40	8%	1,551.30
2,143.00	7%	1,733.83
2,418.70	7%	1,956.89
2,681.90	6%	2,169.84
3,007.80	5%	2,433.51
3,396.30	4%	2,747.83
3,797.30	4%	3,072.27
4,261.00	3%	3,447.43
5,012.90	2%	4,055.77
6,090.70	2%	4,927.78
8,572.10	1%	6,935.40
30,077.60	0%	24,334.77

Observed Data

Date	Skillet Fork IL_CA-05 (cfs)	Concentration (ug/l)	Percentile	Manganese load (lbs/day)
4/8/2002	471.2	290	19%	737
5/14/2002	8810.2	160	1%	7,603
6/17/2002	73.9	440	45%	175
8/7/2002	0.9	820	95%	4
9/17/2002	0.1	1400	100%	1
10/22/2002	0.7	800	96%	3
12/10/2002	2.1	760	90%	9
1/30/2003	7	820	78%	31
3/19/2003	387.2	270	21%	564
4/15/2003	65.2	460	47%	162
6/17/2003	347.1	200	22%	374

Data for Manganese Load Duration Curve			Observed Data				
Skillet Fork IL_CA-06 (cfs)	% of Time Exceeded	Manganese load (lbs/day)	Date	Skillet Fork IL_CA-06 (cfs)	Concentration (ug/l)	Percentile	Manganese load (lbs/day)
0.1	100%	0.5	9/1/2005	3.9	600	75%	13
0.1	98%	0.5	9/1/2005	3.9	690	75%	15
0.2	98%	1.1	1/27/1994	2141.3	230	2%	2,656
0.2	97%	1.1	3/8/1994	62.8	430	34%	146
0.3	96%	1.6	4/20/1994	104.3	330	27%	186
0.4	95%	2.2	5/17/1994	48.2	340	39%	88
0.4	95%	2.2	6/21/1994	3.3	1400	78%	25
0.5	94%	2.7	7/21/1994	3	1200	79%	19
0.6	93%	3.2	8/30/1994	0.4	890	96%	2
0.7	93%	3.8	10/6/1994	0.1	560	100%	0
0.7	92%	3.8	11/29/1994	92.5	220	29%	110
0.8	91%	4.3	1/12/1995	191.2	360	20%	371
0.9	90%	4.9	2/23/1995	32.5	330	46%	58
1	90%	5.4	3/28/1995	455.2	320	12%	786
1.1	89%	5.9	5/31/1995	964.2	410	7%	2,132
1.2	88%	6.5	6/29/1995	29.7	540	47%	87
1.2	87%	6.5	7/27/1995	22.4	400	52%	48
1.3	87%	7.0	9/21/1995	0.1	800	100%	0
1.5	86%	8.1	11/9/1995	0.1	2700	100%	1
1.6	85%	8.6	12/7/1995	0.2	370	98%	0
1.7	84%	9.2	1/23/1996	545.4	240	11%	706
1.8	84%	9.7	2/27/1996	17.9	410	55%	40
2	83%	10.8	4/4/1996	444	230	13%	551
2.1	82%	11.3	5/14/1996	223.7	300	18%	362
2.3	81%	12.4	6/11/1996	6278.3	140	0%	4,741
2.5	81%	13.5	7/23/1996	1.7	660	85%	6
2.7	80%	14.6	9/19/1996	3.7	280	76%	6
2.9	79%	15.6	11/7/1996	13.5	5300	59%	386
3.1	78%	16.7	12/10/1996	33.6	96	45%	17
3.2	78%	17.3	2/4/1997	1065.1	630	7%	3,619
3.4	77%	18.3	3/4/1997	616.6	210	10%	698
3.6	76%	19.4	4/15/1997	63.9	270	34%	93
3.8	76%	20.5	5/22/1997	13.5	870	59%	63
4	75%	21.6	6/12/1997	49.3	640	38%	170
4.2	74%	22.7	7/22/1997	639	660	10%	2,275
4.5	73%	24.3	9/9/1997	2.1	640	83%	7
4.7	73%	25.4	10/21/1997	0.3	1300	97%	2
5	72%	27.0	12/2/1997	2.3	310	82%	4
5.3	71%	28.6	1/27/1998	123.9	280	25%	187
5.6	70%	30.2	3/19/1998	1519.1	300	4%	2,458
6.2	70%	33.4	4/21/1998	137.3	250	24%	185
6.7	69%	36.1	6/2/1998	24.7	380	50%	51
6.7	68%	36.1	7/14/1998	117.7	260	25%	165
7.3	67%	39.4	8/4/1998	1715.3	220	4%	2,035
7.8	67%	42.1	9/22/1998	13.5	480	59%	35
7.8	66%	42.1	11/10/1998	19.1	300	54%	31
8.4	65%	45.3	12/8/1998	32	370	46%	64
9	64%	48.5	1/20/1999	1777	200	3%	1,917
9.5	64%	51.2	3/18/1999	118.3	300	25%	191
10.1	63%	54.5	4/13/1999	93.1	260	29%	131
10.7	62%	57.7	5/18/1999	66.1	400	34%	143
11.2	61%	60.4	6/15/1999	77.9	280	31%	118
11.8	61%	63.6	8/31/1999	2.4	980	81%	13
12.3	60%	66.3	10/13/1999	0.2	1500	98%	2
13.5	59%	72.8	11/16/1999	0.2	7000	98%	8
14	58%	75.5	1/13/2000	4.4	99	74%	2
14.6	58%	78.7	2/15/2000	75.7	260	32%	106
15.1	57%	81.4	3/28/2000	86.9	300	30%	141
16.3	56%	87.9	4/25/2000	77.9	330	31%	139
16.8	56%	90.6	5/31/2000	61.7	280	35%	93
17.9	55%	96.5	8/7/2000	176.6	270	21%	257
19.1	54%	103.0	10/16/2000	5.5	280	71%	8
20.2	53%	109.0	12/4/2000	38.7	300	43%	63
20.7	53%	111.7	1/22/2001	133.4	230	24%	165
21.9	52%	118.1	2/26/2001	1552.8	240	4%	2,010
23	51%	124.1	4/10/2001	45.4	430	40%	105
24.1	50%	130.0	5/15/2001	6.2	890	70%	30
25.2	50%	135.9	9/11/2001	1.2	280	88%	2
26.3	49%	141.9	10/23/2001	12.3	230	60%	15

Data for Manganese Load Duration Curve

Skillet Fork IL_CA-06 (cfs)	% of Time Exceeded	Manganese load (lbs/day)
28	48%	151.0
28.6	47%	154.3
30.3	47%	163.4
32	46%	172.6
33.1	45%	178.5
34.2	44%	184.5
35.9	44%	193.6
37.6	43%	202.8
39.2	42%	211.4
40.9	41%	220.6
42.6	41%	229.8
44.8	40%	241.6
46.5	39%	250.8
48.8	39%	263.2
51	38%	275.1
53.8	37%	290.2
56.1	36%	302.6
58.9	36%	317.7
61.7	35%	332.8
64.5	34%	347.9
67.3	33%	363.0
70.6	33%	380.8
74.6	32%	402.4
78.5	31%	423.4
82.4	30%	444.4
86.9	30%	468.7
91.9	29%	495.7
96.4	28%	520.0
101.5	27%	547.5
106.5	27%	574.4
112.1	26%	604.6
119.4	25%	644.0
127.2	24%	686.1
135.1	24%	728.7
142.4	23%	768.1
153	22%	825.2
164.8	21%	888.9
174.9	21%	943.4
187.8	20%	1,013.0
202.4	19%	1,091.7
218.6	19%	1,179.1
237.7	18%	1,282.1
259.5	17%	1,399.7
280.3	16%	1,511.9
308.3	16%	1,662.9
336.3	15%	1,813.9
372.8	14%	2,010.8
411.5	13%	2,219.5
450.7	13%	2,431.0
501.1	12%	2,702.8
552.2	11%	2,978.4
605.4	10%	3,265.4
672.7	10%	3,628.4
756.8	9%	4,082.0
857.7	8%	4,626.2
958.6	7%	5,170.5
1081.9	7%	5,835.5
1199.6	6%	6,470.4
1345.3	5%	7,256.2
1519.1	4%	8,193.7
1698.5	4%	9,161.3
1905.9	3%	10,280.0
2242.2	2%	12,093.9
2724.3	2%	14,694.3
3834.2	1%	20,680.8
13453.4	0%	72,564.6

Observed Data

Date	Skillet Fork IL_CA-06 (cfs)	Concentration (ug/l)	Percentile	Manganese load (lbs/day)
11/27/2001	33.1	210	45%	37
1/29/2002	47.6	240	39%	62
2/20/2002	1266.9	430	6%	2,938
4/8/2002	210.8	320	19%	364
5/14/2002	3940.7	220	1%	4,676
6/17/2002	33.1	290	45%	52
8/7/2002	0.4	1000	96%	2
9/17/2002	0.1	1200	100%	1
10/22/2002	0.3	380	97%	1
12/10/2002	1	250	90%	1
1/30/2003	3.1	620	79%	10
3/18/2003	130.6	220	24%	155
4/15/2003	29.1	380	47%	60

Data for Manganese Load Duration Curve

Brush Creek IL_CAR-01 (cfs)	% of Time Exceeded	Manganese load (lbs/day)
0.1	100%	0.54
0.1	98%	0.54
0.1	98%	0.54
0.1	97%	0.54
0.1	96%	0.54
0.1	95%	0.54
0.1	95%	0.54
0.1	94%	0.54
0.1	93%	0.54
0.1	93%	0.54
0.2	92%	1.08
0.2	91%	1.08
0.2	90%	1.08
0.2	90%	1.08
0.2	89%	1.08
0.3	88%	1.62
0.3	87%	1.62
0.3	87%	1.62
0.3	86%	1.62
0.3	85%	1.62
0.4	84%	2.16
0.4	84%	2.16
0.4	83%	2.16
0.5	82%	2.70
0.5	81%	2.70
0.5	81%	2.70
0.6	80%	3.24
0.6	79%	3.24
0.7	78%	3.78
0.7	78%	3.78
0.7	77%	3.78
0.8	76%	4.32
0.8	76%	4.32
0.9	75%	4.85
0.9	74%	4.85
1	73%	5.39
1	73%	5.39
1.1	72%	5.93
1.1	71%	5.93
1.2	70%	6.47
1.3	70%	7.01
1.4	69%	7.55
1.4	68%	7.55
1.6	67%	8.63
1.7	67%	9.17
1.7	66%	9.17
1.8	65%	9.71
1.9	64%	10.25
2.1	64%	11.33
2.2	63%	11.87
2.3	62%	12.41
2.4	61%	12.95
2.5	61%	13.48
2.7	60%	14.56
2.9	59%	15.64
3	58%	16.18
3.1	58%	16.72
3.3	57%	17.80
3.5	56%	18.88
3.6	56%	19.42
3.9	55%	21.04
4.1	54%	22.11
4.3	53%	23.19
4.5	53%	24.27
4.7	52%	25.35
4.9	51%	26.43
5.2	50%	28.05
5.4	50%	29.13
5.7	49%	30.74
6	48%	32.36

Observed Data

Date	Brush Creek IL_CAR-01 (cfs)	Concentration (ug/l)	Percentile	Manganese load (lbs/day)
9/1/2005	0.8	1200	76.8%	5.2
9/1/2005	0.8	2300	76.8%	9.9
9/11/2001	0.3	1600	88.1%	2.6
7/24/2001	1.7	1600	66.8%	14.7
5/30/2001	1.2	1000	71.0%	6.5
3/22/1999	11.9	290	36.6%	18.6
7/16/1998	6.9	260	45.9%	9.7

Data for Manganese Load Duration Curve

Brush Creek IL_CAR-01 (cfs)	% of Time Exceeded	Manganese load (lbs/day)
6.2	47%	33.44
6.5	47%	35.06
6.9	46%	37.22
7.1	45%	38.30
7.4	44%	39.91
7.7	44%	41.53
8.1	43%	43.69
8.4	42%	45.31
8.8	41%	47.47
9.2	41%	49.62
9.7	40%	52.32
10	39%	53.94
10.5	39%	56.63
11	38%	59.33
11.6	37%	62.57
12.1	36%	65.26
12.7	36%	68.50
13.3	35%	71.74
13.9	34%	74.97
14.5	33%	78.21
15.2	33%	81.99
16.1	32%	86.84
16.9	31%	91.15
17.7	30%	95.47
18.7	30%	100.86
19.8	29%	106.80
20.8	28%	112.19
21.8	27%	117.58
22.9	27%	123.52
24.1	26%	129.99
25.7	25%	138.62
27.4	24%	147.79
29.1	24%	156.96
30.7	23%	165.59
32.9	22%	177.46
35.5	21%	191.48
37.7	21%	203.35
40.4	20%	217.91
43.6	19%	235.17
47.1	19%	254.05
51.2	18%	276.16
55.9	17%	301.51
60.3	16%	325.24
66.4	16%	358.15
72.4	15%	390.51
80.3	14%	433.12
88.6	13%	477.89
97	13%	523.20
107.9	12%	581.99
118.9	11%	641.32
130.3	10%	702.81
144.8	10%	781.02
162.9	9%	878.65
184.7	8%	996.23
206.4	7%	1,113.28
232.9	7%	1,256.21
258.3	6%	1,393.21
289.7	5%	1,562.58
327.1	4%	1,764.30
365.7	4%	1,972.50
410.3	3%	2,213.07
482.8	2%	2,604.11
586.6	2%	3,163.99
825.5	1%	4,452.56
2896.6	0%	15,623.61

Data for Manganese Load Duration Curve

Horse Creek IL_CAN-01 (cfs)	% of Time Exceeded	Manganese load (lbs/day)
0.1	100%	0.54
0.1	98%	0.54
0.1	97%	0.54
0.1	96%	0.54
0.1	95%	0.54
0.2	95%	1.08
0.2	94%	1.08
0.2	93%	1.08
0.3	93%	1.62
0.3	92%	1.62
0.3	91%	1.62
0.3	90%	1.62
0.4	90%	2.16
0.4	89%	2.16
0.5	88%	2.70
0.5	87%	2.70
0.5	87%	2.70
0.6	86%	3.24
0.6	85%	3.24
0.6	84%	3.24
0.7	84%	3.78
0.8	83%	4.32
0.8	82%	4.32
0.9	81%	4.85
1.0	81%	5.39
1.0	80%	5.39
1.1	79%	5.93
1.2	78%	6.47
1.2	78%	6.47
1.3	77%	7.01
1.4	76%	7.55
1.5	76%	8.09
1.5	75%	8.09
1.6	74%	8.63
1.7	73%	9.17
1.8	73%	9.71
1.9	72%	10.25
2.0	71%	10.79
2.2	70%	11.87
2.4	70%	12.95
2.6	69%	14.02
2.6	68%	14.02
2.8	67%	15.10
3.0	67%	16.18
3.0	66%	16.18
3.2	65%	17.26
3.5	64%	18.88
3.7	64%	19.96
3.9	63%	21.04
4.1	62%	22.11
4.3	61%	23.19
4.5	61%	24.27
4.7	60%	25.35
5.2	59%	28.05
5.4	58%	29.13
5.6	58%	30.21
5.8	57%	31.28
6.3	56%	33.98
6.5	56%	35.06
6.9	55%	37.22
7.3	54%	39.37
7.8	53%	42.07
8.0	53%	43.15
8.4	52%	45.31
8.8	51%	47.47
9.3	50%	50.16
9.7	50%	52.32
10.1	49%	54.48
10.8	48%	58.25
11.0	47%	59.33
11.6	47%	62.57
12.3	46%	66.34

Observed Data

Date	Horse Creek IL_CAN-01 (cfs)	Concentration (ug/l)	Percentile	Manganese load (lbs/day)
9/1/05	1.5	1,200	76%	9.71
9/1/05	1.5	980	76%	7.93
9/1/05	1.5	580	76%	4.69
9/1/05	1.5	610	76%	4.94
9/11/01	0.5	1,500	88%	4.05
7/24/01	3	270	67%	4.37
5/30/01	2.2	420	71%	4.98
3/22/99	21.4	230	37%	26.55
7/16/98	12.3	340	46%	22.56

Data for Manganese Load Duration Curve

Horse Creek IL_CAN-01 (cfs)	% of Time Exceeded	Manganese load (lbs/day)
12.7	45%	68.50
13.2	44%	71.20
13.8	44%	74.43
14.5	43%	78.21
15.1	42%	81.45
15.7	41%	84.68
16.4	41%	88.46
17.3	40%	93.31
17.9	39%	96.55
18.8	39%	101.40
19.6	38%	105.72
20.7	37%	111.65
21.6	36%	116.51
22.7	36%	122.44
23.7	35%	127.83
24.8	34%	133.77
25.9	33%	139.70
27.2	33%	146.71
28.7	32%	154.80
30.2	31%	162.89
31.7	30%	170.98
33.4	30%	180.15
35.4	29%	190.94
37.1	28%	200.11
39.0	27%	210.36
41.0	27%	221.14
43.1	26%	232.47
46.0	25%	248.11
49.0	24%	264.30
52.0	24%	280.48
54.8	23%	295.58
58.9	22%	317.69
63.4	21%	341.97
67.3	21%	363.00
72.3	20%	389.97
77.9	19%	420.18
84.1	19%	453.62
91.5	18%	493.53
99.9	17%	538.84
107.9	16%	581.99
118.7	16%	640.24
129.4	15%	697.95
143.5	14%	774.01
158.3	13%	853.83
173.4	13%	935.28
192.9	12%	1040.46
212.5	11%	1146.18
233.0	10%	1256.75
258.9	10%	1396.45
291.2	9%	1570.67
330.1	8%	1780.49
368.9	7%	1989.76
416.4	7%	2245.97
461.7	6%	2490.31
517.8	5%	2792.90
584.6	4%	3153.20
653.7	4%	3525.91
733.5	3%	3956.33
862.9	2%	4654.29
1048.5	2%	5655.37
1475.6	1%	7959.06
5177.6	0%	27926.81

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Attachment 3

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Data for Fecal Coliform Load Duration Curve

Skillet Fork IL_CA-05 (cfs)	% of Time Exceeded	Fecal load (cfu/day)
0.00	100.00	0.0E+00
0.00	99.99	0.0E+00
0.00	99.05	0.0E+00
0.10	98.75	4.9E+08
0.10	98.44	4.9E+08
0.11	98.13	5.4E+08
0.20	97.83	9.8E+08
0.20	97.52	9.8E+08
0.30	97.22	1.5E+09
0.30	96.91	1.5E+09
0.30	96.60	1.5E+09
0.39	96.30	1.9E+09
0.40	95.99	2.0E+09
0.50	95.69	2.4E+09
0.50	95.38	2.4E+09
0.60	95.07	2.9E+09
0.60	94.77	2.9E+09
0.70	94.46	3.4E+09
0.70	94.16	3.4E+09
0.80	93.85	3.9E+09
0.80	93.54	3.9E+09
0.88	93.24	4.3E+09
0.90	92.93	4.4E+09
1.00	92.63	4.9E+09
1.00	92.32	4.9E+09
1.00	92.01	4.9E+09
1.10	91.71	5.4E+09
1.20	91.40	5.9E+09
1.20	91.10	5.9E+09
1.20	90.79	5.9E+09
1.30	90.48	6.4E+09
1.40	90.18	6.9E+09
1.40	89.87	6.9E+09
1.50	89.57	7.3E+09
1.50	89.26	7.3E+09
1.60	88.95	7.8E+09
1.70	88.65	8.3E+09
1.70	88.34	8.3E+09
1.80	88.04	8.8E+09
1.90	87.73	9.3E+09
1.90	87.42	9.3E+09
2.00	87.12	9.8E+09
2.00	86.81	9.8E+09
2.10	86.51	1.0E+10
2.20	86.20	1.1E+10
2.20	85.89	1.1E+10
2.30	85.59	1.1E+10
2.40	85.28	1.2E+10
2.50	84.98	1.2E+10
2.50	84.67	1.2E+10
2.60	84.36	1.3E+10
2.70	84.06	1.3E+10
2.80	83.75	1.4E+10
2.80	83.45	1.4E+10
2.90	83.14	1.4E+10
3.00	82.83	1.5E+10
3.00	82.53	1.5E+10
3.20	82.22	1.6E+10
3.20	81.92	1.6E+10
3.30	81.61	1.6E+10
3.50	81.30	1.7E+10
3.50	81.00	1.7E+10
3.70	80.69	1.8E+10
3.80	80.39	1.9E+10
3.90	80.08	1.9E+10
4.00	79.77	2.0E+10
4.10	79.47	2.0E+10

Observed Data

Date	Skillet Fork IL_CA-05 (cfs)	Concentration (cfu/100 ml)	Percentile	Fecal load (cfu/day)
5/16/1994	123.0	1900	31.00	5.72E+12
6/20/1994	6.3	50	74.22	7.71E+09
7/20/1994	6.8	30	73.30	4.99E+09
8/29/1994	1.7	580	88.16	2.41E+10
5/30/1995	2730.0	580	4.20	3.87E+13
7/26/1995	66.0	2000	40.08	3.23E+12
9/20/1995	0.2	210	97.35	1.03E+09
5/13/1996	950.0	400	11.00	9.30E+12
6/10/1996	6690.0	5700	0.60	9.33E+14
7/22/1996	3.0	520	82.44	3.82E+10
9/18/1996	18.0	5900	59.97	2.60E+12
5/21/1997	26.0	10	54.81	6.36E+09
6/11/1997	131.0	520	30.17	1.67E+12
7/21/1997	13.0	38	64.23	1.21E+10
9/8/1997	4.4	22	78.61	2.37E+09
10/20/1997	1.1	56	91.46	1.51E+09
6/1/1998	79.0	380	37.46	7.35E+11
7/13/1998	933.0	210	11.14	4.79E+12
8/3/1998	156.0	72	27.78	2.75E+11
9/21/1998	34.0	172	50.67	1.43E+11
10/23/2001	22.0	88	57.05	4.74E+10
5/14/2002	7030.0	3400	0.52	5.85E+14
8/7/2002	0.7	4	94.07	6.95E+07
9/17/2002	0.0	8	99.05	1.96E+06
10/22/2002	0.5	16	95.21	2.07E+08
5/13/2003	2290.0	65	5.41	3.64E+12
6/17/2003	277.0	155	21.14	1.05E+12
8/5/2003	5.0	460	76.93	5.63E+10
9/2/2003	1.6	80	88.76	3.13E+09
10/20/2003	0.8	400	93.93	7.63E+09
5/20/2004	70.0	380	39.21	6.51E+11
6/24/2004	37.0	70	49.38	6.34E+10
5/30/2000	348.0	140	18.96	1.19E+12
8/8/2000	2010.0	2360	6.25	1.16E+14
8/29/2000	69.0	560	39.48	9.45E+11
10/17/2000	11.0	120	66.54	3.23E+10
5/15/2001	11.0	18	66.54	4.84E+09
6/12/2001	37.0	105	49.38	9.51E+10
8/7/2001	4.6	27	78.17	3.04E+09
9/11/2001	2.1	46	86.25	2.36E+09
8/10/2004	6.7	20	73.44	3.28E+09
9/8/2004	28.0	150	53.57	1.03E+11
5/5/2005	91.0	110	35.26	2.45E+11

Data for Fecal Coliform Load Duration Curve

Skillet Fork IL_CA-05 (cfs)	% of Time Exceeded	Fecal load (cfu/day)
4.20	79.16	2.1E+10
4.30	78.86	2.1E+10
4.50	78.55	2.2E+10
4.60	78.24	2.3E+10
4.70	77.94	2.3E+10
4.90	77.63	2.4E+10
5.00	77.33	2.4E+10
5.00	77.02	2.4E+10
5.20	76.72	2.5E+10
5.30	76.41	2.6E+10
5.50	76.10	2.7E+10
5.60	75.80	2.7E+10
5.70	75.49	2.8E+10
5.80	75.19	2.8E+10
6.00	74.88	2.9E+10
6.20	74.57	3.0E+10
6.30	74.27	3.1E+10
6.50	73.96	3.2E+10
6.70	73.66	3.3E+10
6.80	73.35	3.3E+10
7.00	73.04	3.4E+10
7.00	72.74	3.4E+10
7.10	72.43	3.5E+10
7.30	72.13	3.6E+10
7.50	71.82	3.7E+10
7.70	71.51	3.8E+10
8.00	71.21	3.9E+10
8.00	70.90	3.9E+10
8.20	70.60	4.0E+10
8.60	70.29	4.2E+10
8.70	69.98	4.3E+10
9.00	69.68	4.4E+10
9.20	69.37	4.5E+10
9.40	69.07	4.6E+10
9.50	68.76	4.6E+10
9.90	68.45	4.8E+10
10.00	68.15	4.9E+10
10.00	67.84	4.9E+10
11.00	67.54	5.4E+10
11.00	67.23	5.4E+10
11.00	66.92	5.4E+10
11.00	66.62	5.4E+10
12.00	66.31	5.9E+10
73.00	38.74	3.6E+11
74.00	38.44	3.6E+11
76.00	38.13	3.7E+11
77.00	37.83	3.8E+11
79.00	37.52	3.9E+11
80.00	37.21	3.9E+11
82.00	36.91	4.0E+11
84.00	36.60	4.1E+11
86.00	36.30	4.2E+11
88.00	35.99	4.3E+11
90.00	35.68	4.4E+11
91.00	35.38	4.5E+11
93.00	35.07	4.6E+11
95.00	34.77	4.6E+11
97.00	34.46	4.7E+11
99.00	34.15	4.8E+11
100.00	33.85	4.9E+11
103.00	33.54	5.0E+11
105.00	33.24	5.1E+11
107.00	32.93	5.2E+11
110.00	32.62	5.4E+11
112.00	32.32	5.5E+11
115.00	32.01	5.6E+11
117.00	31.71	5.7E+11
120.00	31.40	5.9E+11

Data for Fecal Coliform Load Duration Curve

Skillet Fork IL_CA-05 (cfs)	% of Time Exceeded	Fecal load (cfu/day)
122.00	31.09	6.0E+11
125.00	30.79	6.1E+11
128.00	30.48	6.3E+11
131.00	30.18	6.4E+11
134.00	29.87	6.6E+11
137.00	29.56	6.7E+11
140.00	29.26	6.9E+11
144.00	28.95	7.0E+11
147.00	28.65	7.2E+11
150.00	28.34	7.3E+11
153.00	28.03	7.5E+11
157.00	27.73	7.7E+11
161.00	27.42	7.9E+11
165.00	27.12	8.1E+11
170.00	26.81	8.3E+11
173.00	26.50	8.5E+11
177.00	26.20	8.7E+11
182.00	25.89	8.9E+11
187.00	25.59	9.2E+11
191.00	25.28	9.3E+11
197.00	24.97	9.6E+11
202.00	24.67	9.9E+11
207.00	24.36	1.0E+12
212.00	24.06	1.0E+12
218.00	23.75	1.1E+12
226.00	23.44	1.1E+12
232.00	23.14	1.1E+12
238.00	22.83	1.2E+12
245.00	22.53	1.2E+12
250.00	22.22	1.2E+12
259.00	21.91	1.3E+12
267.00	21.61	1.3E+12
274.00	21.30	1.3E+12
282.00	21.00	1.4E+12
292.00	20.69	1.4E+12
300.00	20.38	1.5E+12
309.00	20.08	1.5E+12
320.00	19.77	1.6E+12
332.00	19.47	1.6E+12
342.00	19.16	1.7E+12
351.00	18.85	1.7E+12
364.00	18.55	1.8E+12
376.00	18.24	1.8E+12
389.00	17.94	1.9E+12
400.00	17.63	2.0E+12
414.00	17.32	2.0E+12
431.00	17.02	2.1E+12
448.00	16.71	2.2E+12
467.00	16.41	2.3E+12
486.00	16.10	2.4E+12
500.00	15.79	2.4E+12
523.00	15.49	2.6E+12
545.00	15.18	2.7E+12
564.00	14.88	2.8E+12
586.00	14.57	2.9E+12
610.00	14.26	3.0E+12
633.00	13.96	3.1E+12
660.00	13.65	3.2E+12
687.00	13.35	3.4E+12
716.00	13.04	3.5E+12
748.00	12.73	3.7E+12
781.00	12.43	3.8E+12
805.00	12.12	3.9E+12
843.00	11.82	4.1E+12
884.00	11.51	4.3E+12
923.00	11.20	4.5E+12
969.00	10.90	4.7E+12
1000.00	10.59	4.9E+12

Data for Fecal Coliform Load Duration Curve

Skillet Fork IL_CA-05 (cfs)	% of Time Exceeded	Fecal load (cfu/day)
1050.00	10.29	5.1E+12
1110.00	9.98	5.4E+12
1160.00	9.68	5.7E+12
1210.00	9.37	5.9E+12
1280.00	9.06	6.3E+12
1350.00	8.76	6.6E+12
1420.00	8.45	6.9E+12
1490.00	8.15	7.3E+12
1570.00	7.84	7.7E+12
1650.00	7.53	8.1E+12
1720.00	7.23	8.4E+12
1800.00	6.92	8.8E+12
1900.00	6.62	9.3E+12
2000.00	6.31	9.8E+12
2090.00	6.00	1.0E+13
2190.00	5.70	1.1E+13
2300.00	5.39	1.1E+13
2420.00	5.09	1.2E+13
2530.00	4.78	1.2E+13
2630.00	4.47	1.3E+13
2740.00	4.17	1.3E+13
2860.00	3.86	1.4E+13
3000.00	3.56	1.5E+13
3160.00	3.25	1.5E+13
3290.00	2.94	1.6E+13
3470.00	2.64	1.7E+13
3670.00	2.33	1.8E+13
3950.00	2.03	1.9E+13
4210.00	1.72	2.1E+13
4590.00	1.41	2.2E+13
5100.00	1.11	2.5E+13
5850.00	0.80	2.9E+13
7100.00	0.50	3.5E+13
10500.00	0.19	5.1E+13

Data for Fecal Coliform Load Duration Curve

Skillet Fork IL_CA-06 (cfs)	% of Time Exceeded	Fecal load (cfu/day)
0.00	100.00	0.E+00
0.00	99.99	0.E+00
0.04	98.75	2.E+08
0.04	98.44	2.E+08
0.05	98.13	2.E+08
0.09	97.83	4.E+08
0.09	97.52	4.E+08
0.13	96.91	7.E+08
0.13	96.60	7.E+08
0.17	96.30	9.E+08
0.18	95.99	9.E+08
0.22	95.69	1.E+09
0.22	95.38	1.E+09
0.27	95.07	1.E+09
0.27	94.77	1.E+09
0.31	94.46	2.E+09
0.31	94.16	2.E+09
0.36	93.85	2.E+09
0.36	93.54	2.E+09
0.39	93.24	2.E+09
0.40	92.93	2.E+09
0.45	92.63	2.E+09
0.45	92.32	2.E+09
0.45	92.01	2.E+09
0.49	91.71	2.E+09
0.54	91.40	3.E+09
0.54	91.10	3.E+09
0.54	90.79	3.E+09
0.58	90.48	3.E+09
0.63	90.18	3.E+09
0.63	89.87	3.E+09
0.67	89.57	3.E+09
0.67	89.26	3.E+09
0.72	88.95	4.E+09
0.76	88.65	4.E+09
0.76	88.34	4.E+09
0.81	88.04	4.E+09
0.85	87.73	4.E+09
0.85	87.42	4.E+09
0.90	87.12	4.E+09
0.90	86.81	4.E+09
0.94	86.51	5.E+09
0.99	86.20	5.E+09
0.99	85.89	5.E+09
1.03	85.59	5.E+09
1.08	85.28	5.E+09
1.12	84.98	5.E+09
1.12	84.67	5.E+09
1.17	84.36	6.E+09
1.21	84.06	6.E+09
1.26	83.75	6.E+09
1.26	83.45	6.E+09
1.30	83.14	6.E+09
1.34	82.83	7.E+09
1.34	82.53	7.E+09
1.43	82.22	7.E+09
1.43	81.92	7.E+09
1.48	81.61	7.E+09
1.57	81.30	8.E+09
1.57	81.00	8.E+09
1.66	80.69	8.E+09
1.70	80.39	8.E+09
1.75	80.08	9.E+09
1.79	79.77	9.E+09
1.84	79.47	9.E+09
1.88	79.16	9.E+09
1.93	78.86	9.E+09

Observed Data

Date	Skillet Fork IL_CA-06 (cfs)	Concentration (cfu/100 ml)	Percentile	Fecal load (cfu/day)
5/17/1994	38.6	175	36.17	1.65E+11
6/21/1994	2.6	48	75.18	3.05E+09
7/21/1994	2.4	62	76.18	3.67E+09
8/30/1994	0.3	220	94.59	1.57E+09
10/6/1994	0.0	4	98.93	3.51E+06
5/31/1995	771.0	270	7.19	5.09E+12
6/29/1995	23.8	3300	43.59	1.92E+12
7/27/1995	17.9	970	48.11	4.26E+11
9/21/1995	0.1	70	97.35	1.54E+08
5/14/1996	178.9	165	17.72	7.22E+11
6/11/1996	5020.7	3400	0.17	4.18E+14
7/23/1996	1.3	360	82.44	1.18E+10
9/19/1996	3.0	2100	73.78	1.52E+11
5/22/1997	10.8	50	55.87	1.32E+10
6/12/1997	39.4	690	35.85	6.66E+11
7/22/1997	511.0	30800	9.78	3.85E+14
9/9/1997	1.7	230	80.31	9.59E+09
10/21/1997	0.2	17	95.86	8.39E+07
6/2/1998	19.7	110	46.54	5.31E+10
7/14/1998	94.1	200	24.16	4.61E+11
8/4/1998	1371.7	6060	3.45	2.03E+14
9/22/1998	10.8	650	55.87	1.71E+11
10/23/2001	9.9	52	57.05	1.25E+10
5/14/2002	3151.4	2000	0.52	1.54E+14
8/7/2002	0.3	26	94.07	2.02E+08
9/17/2002	0.0	11	99.05	1.21E+06
10/22/2002	0.2	153	95.21	8.89E+08
5/31/2000	49.3	160	32.55	1.93E+11
8/7/2000	141.2	480	19.90	1.66E+12
8/28/2000	49.8	440	32.36	5.36E+11
10/16/2000	4.4	300	68.43	3.26E+10
5/15/2001	4.9	94	66.54	1.13E+10
6/12/2001	16.6	135	49.38	5.48E+10
8/7/2001	2.1	131	78.17	6.61E+09
9/11/2001	0.9	102	86.25	2.35E+09
5/25/2004	88.3	380	24.97	8.21E+11
6/22/2004	41.7	240	34.98	2.45E+11
8/3/2004	5.8	80	64.23	1.14E+10
9/14/2004	7.6	490	60.86	9.14E+10
5/5/2005	40.8	80	35.26	7.99E+10
6/21/2005	1.6	160	80.90	6.14E+09

Data for Fecal Coliform Load Duration Curve

Skillet Fork IL_CA-06 (cfs)	% of Time Exceeded	Fecal load (cfu/day)
2.02	78.55	1.E+10
2.06	78.24	1.E+10
2.11	77.94	1.E+10
2.20	77.63	1.E+10
2.24	77.33	1.E+10
2.24	77.02	1.E+10
2.33	76.72	1.E+10
2.38	76.41	1.E+10
2.47	76.10	1.E+10
2.51	75.80	1.E+10
2.56	75.49	1.E+10
2.60	75.19	1.E+10
2.69	74.88	1.E+10
2.78	74.57	1.E+10
2.82	74.27	1.E+10
2.91	73.96	1.E+10
3.00	73.66	1.E+10
3.05	73.35	1.E+10
3.14	73.04	2.E+10
3.14	72.74	2.E+10
3.18	72.43	2.E+10
3.27	72.13	2.E+10
3.36	71.82	2.E+10
3.45	71.51	2.E+10
3.59	71.21	2.E+10
3.59	70.90	2.E+10
3.68	70.60	2.E+10
3.86	70.29	2.E+10
3.90	69.98	2.E+10
4.03	69.68	2.E+10
4.12	69.37	2.E+10
4.21	69.07	2.E+10
4.26	68.76	2.E+10
4.44	68.45	2.E+10
4.48	68.15	2.E+10
4.48	67.84	2.E+10
4.93	67.54	2.E+10
4.93	67.23	2.E+10
4.93	66.92	2.E+10
4.93	66.62	2.E+10
5.38	66.31	3.E+10
32.72	38.74	2.E+11
33.17	38.44	2.E+11
34.07	38.13	2.E+11
34.52	37.83	2.E+11
35.41	37.52	2.E+11
35.86	37.21	2.E+11
36.76	36.91	2.E+11
37.66	36.60	2.E+11
38.55	36.30	2.E+11
39.45	35.99	2.E+11
40.34	35.68	2.E+11
40.79	35.38	2.E+11
41.69	35.07	2.E+11
42.59	34.77	2.E+11
43.48	34.46	2.E+11
44.38	34.15	2.E+11
44.83	33.85	2.E+11
46.17	33.54	2.E+11
47.07	33.24	2.E+11
47.97	32.93	2.E+11
49.31	32.62	2.E+11
50.21	32.32	2.E+11
51.55	32.01	3.E+11
52.45	31.71	3.E+11
53.79	31.40	3.E+11
54.69	31.09	3.E+11
56.03	30.79	3.E+11

Data for Fecal Coliform Load Duration Curve

Skillet Fork IL_CA-06 (cfs)	% of Time Exceeded	Fecal load (cfu/day)
57.38	30.48	3.E+11
58.72	30.18	3.E+11
60.07	29.87	3.E+11
61.41	29.56	3.E+11
62.76	29.26	3.E+11
64.55	28.95	3.E+11
65.90	28.65	3.E+11
67.24	28.34	3.E+11
68.59	28.03	3.E+11
70.38	27.73	3.E+11
72.17	27.42	4.E+11
73.97	27.12	4.E+11
76.21	26.81	4.E+11
77.55	26.50	4.E+11
79.34	26.20	4.E+11
81.59	25.89	4.E+11
83.83	25.59	4.E+11
85.62	25.28	4.E+11
88.31	24.97	4.E+11
90.55	24.67	4.E+11
92.79	24.36	5.E+11
95.03	24.06	5.E+11
97.72	23.75	5.E+11
101.31	23.44	5.E+11
104.00	23.14	5.E+11
106.69	22.83	5.E+11
109.83	22.53	5.E+11
112.07	22.22	5.E+11
116.10	21.91	6.E+11
119.69	21.61	6.E+11
122.83	21.30	6.E+11
126.41	21.00	6.E+11
130.90	20.69	6.E+11
134.48	20.38	7.E+11
138.52	20.08	7.E+11
143.45	19.77	7.E+11
148.83	19.47	7.E+11
153.31	19.16	8.E+11
157.34	18.85	8.E+11
163.17	18.55	8.E+11
168.55	18.24	8.E+11
174.38	17.94	9.E+11
179.31	17.63	9.E+11
185.59	17.32	9.E+11
193.21	17.02	9.E+11
200.83	16.71	1.E+12
209.34	16.41	1.E+12
217.86	16.10	1.E+12
224.14	15.79	1.E+12
234.45	15.49	1.E+12
244.31	15.18	1.E+12
252.83	14.88	1.E+12
262.69	14.57	1.E+12
273.45	14.26	1.E+12
283.76	13.96	1.E+12
295.86	13.65	1.E+12
307.97	13.35	2.E+12
320.97	13.04	2.E+12
335.31	12.73	2.E+12
350.10	12.43	2.E+12
360.86	12.12	2.E+12
377.90	11.82	2.E+12
396.28	11.51	2.E+12
413.76	11.20	2.E+12
434.38	10.90	2.E+12
448.28	10.59	2.E+12
470.69	10.29	2.E+12
497.59	9.98	2.E+12

Data for Fecal Coliform Load Duration Curve

Skillet Fork IL_CA-06 (cfs)	% of Time Exceeded	Fecal load (cfu/day)
520.00	9.68	3.E+12
542.41	9.37	3.E+12
573.79	9.06	3.E+12
605.17	8.76	3.E+12
636.55	8.45	3.E+12
667.93	8.15	3.E+12
703.79	7.84	3.E+12
739.66	7.53	4.E+12
771.03	7.23	4.E+12
806.90	6.92	4.E+12
851.72	6.62	4.E+12
896.55	6.31	4.E+12
936.90	6.00	5.E+12
981.72	5.70	5.E+12
1031.03	5.39	5.E+12
1084.83	5.09	5.E+12
1134.14	4.78	6.E+12
1178.97	4.47	6.E+12
1228.28	4.17	6.E+12
1282.07	3.86	6.E+12
1344.83	3.56	7.E+12
1416.55	3.25	7.E+12
1474.83	2.94	7.E+12
1555.52	2.64	8.E+12
1645.17	2.33	8.E+12
1770.69	2.03	9.E+12
1887.24	1.72	9.E+12
2057.59	1.41	1.E+13
2286.21	1.11	1.E+13
2622.41	0.80	1.E+13
3182.76	0.50	2.E+13
4706.90	0.19	2.E+13

Attachment 4

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Attachment 5: Responsiveness Summary

This responsiveness summary responds to substantive questions and comments received during the public comment period from June 21, 2007 through August 18, 2007 postmarked, including those from the July 19, 2007 public meeting discussed below.

What is a TMDL?

A Total Maximum Daily Load (TMDL) is the sum of the allowable amount of a pollutant that a water body can receive from all contributing sources and still meet water quality standards or designated uses. This TMDL is for the Skillet Fork Watershed and includes Brush Creek, Dums Creek, Horse Creek and Skillet Fork. This report details the watershed characteristics, impairment, sources, load and wasteload allocations, and reductions for each segment. The Illinois EPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act and regulations there under.

Background

Skillet Fork is a tributary to the Little Wabash River. Portions of the watershed lie in Clay, Marion, Wayne, Jefferson, White and Hamilton counties. The watershed is 672,425 acres (1,051 square miles) in size. Land use in the watershed id 65 percent agriculture, 16 percent forest, 12 percent grassland and five percent wetland. Skillet Fork is impaired for aquatic life use due to manganese, pH, and low dissolved oxygen. Skillet Creek is also impaired for primary contact (swimming) use due to fecal coliform bacteria. Brush Creek and Horse Creek are impaired for aquatic life use due to manganese and low dissolved oxygen. Dums Creek is impaired for aquatic life use due to low dissolved oxygen. The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) List.

Public Meetings

Public meetings were held in Wayne City on March 14, 2005 and July 19, 2007. The Illinois EPA provided public notice for all meetings by placing display ads in local newspapers in the watershed; the Carmi Times, the Centralia Morning Sentinel, the Mt. Vernon Register News, the Salem Times Commoner and the Wayne City Press. These notices gave the date, time, location, and purpose of the meetings. It also provided references to obtain additional information about this specific site, the TMDL Program and other related issues. Individuals and organizations were also sent the public notice by first class mail. The draft TMDL Report was available for review on the Agency's web page at http://www.epa.state.il.us/water/tmdl .

The public meeting on March 14, 2005 started at 6:00 p.m. Approximately fourteen people attended the first meeting. The public meeting on July 19, 2007, started at 6:00 p.m. It was attended by approximately two people and concluded at 7:30 p.m. with the meeting record remaining open until midnight, August 18, 2007.

Questions and Comments

1. There are issues with mining in this watershed. Brine water is withdrawn during the oil extraction process and we have reason to believe that people are dumping this brine water into the nearest ditch, which may be lowering the pH and causing impairment.

   Response
   Figure 3 of the Stage 1 Report has a map with the locations of the oil wells. Page 13 of the report discusses problems that may be occurring due to the oil wells. Illinois Department of Natural Resources, Office of Mines and Minerals should be contacted for mining issues. This group has inspectors that can visit the site in question and issue a violation if brine is dumped into the local streams. Their contact number is 217-782-4970 (ask for the Oil and Gas Division).

2. There are possibilities for implementation in TMDL watersheds. For example, in Casey Fork watershed, the local stakeholders have taken the TMDL and received CRP funding for implementation in about two-thirds of the watershed. How can we get a watershed group going? Is this too big of a watershed to have a group?

   Response
   Thank you for your comment. It is possible for implementation projects to take place if there are interested people in the watershed. Illinois EPA can regulate point sources that directly discharge into a stream using the permit process, but has no authority to regulate nonpoint sources. Local stakeholders in the watershed should decide what their priorities are and how they want to direct efforts to control nonpoint source pollutants. There are watershed groups that vary in size throughout the state of Illinois. You may need to start with a subwatershed if you have people only interested in a smaller area.