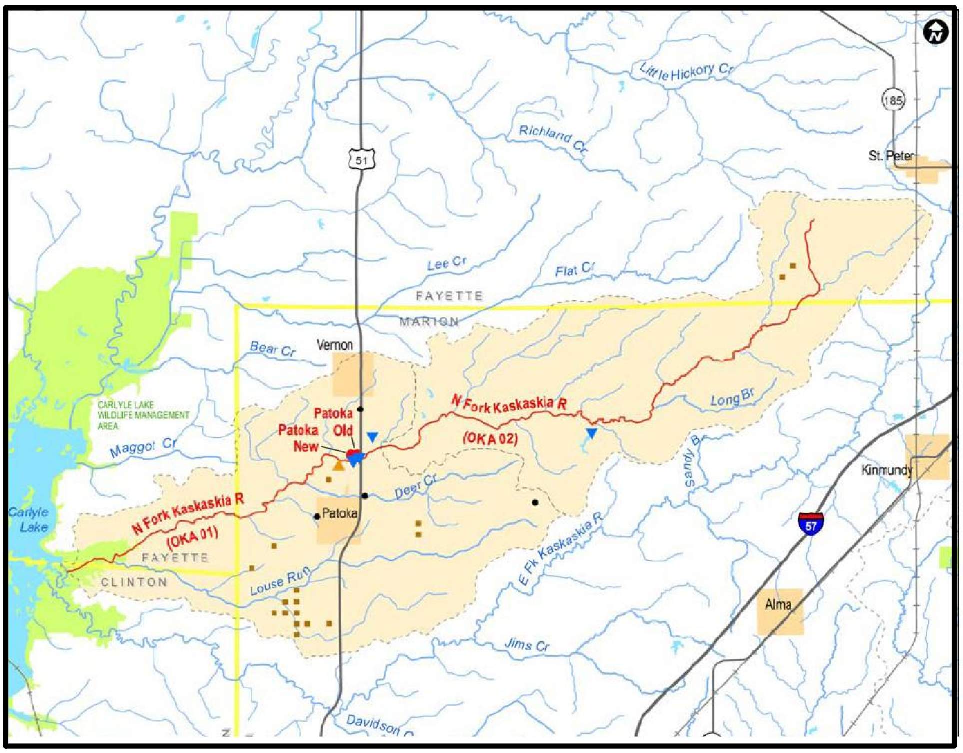
Illinois
Environmental
Protection Agency

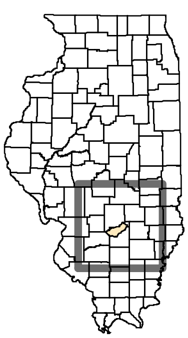
Bureau of Water
P.O. Box 19276
Springfield, IL 62794-9276

August 2007

IEPA/BOW/07-012

NORTH FORK KASKASKIA WATERSHED TMDL REPORT





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Final Report

Prepared for Illinois Environmental Protection Agency

August 2007

North Fork Kaskaskia River Watershed

North Fork Kaskaskia River (OKA 01, OKA 02),

Patoka Old Reservoir (SOI), and Patoka New Reservoir (SOJ)

Includes:

Final Stage 1 Report

Final Stage 2 Report

Final Approved TMDL

TMDL Implementation Plan

Limno-Tech, Inc.

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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

RECEIVED
SEP 25 2006
Watershed Management Section
BUREAU OF WATER

SEP 19 2006

Ms. Marcia T. Willhite
IEPA Bureau of Water
1021 North Grand Avenue East
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) submittal for the North Kaskaskia River Watershed, including supporting documentation and follow up information. IEPA's TMDLs address two stream segments IL OKA 01 and IL OKA 02, impaired for aquatic life use and primary contact recreational use. Based on this review, U.S. EPA has determined that Illinois' TMDLs for pH, manganese, iron, and fecal coliform meets the requirements of Section 303(d) of the Clean Water Act (CWA) and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves Illinois' seven TMDLs for the North Fork Kaskaskia River Watershed. The statutory and regulatory requirements, and U.S. EPA's review of Illinois' compliance with each requirement, are described in the enclosed decision document. The segments are also impaired by phosphorus and low dissolved oxygen but these causes are not addressed at this time.

We wish to acknowledge Illinois' effort in these submitted TMDLs, 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

Enclosure
cc: Trevor Sample

Final Stage 1 Progress Report

Prepared for Illinois Environmental Protection Agency

April 2005

North Fork Kaskaskia River Watershed

North Fork Kaskaskia River (OKA 01, OKA 02),

Patoka Old Reservoir (SOI), and Patoka New Reservoir (SOJ)

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First Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

August 2004

North Fork Kaskaskia River Watershed

North Fork Kaskaskia River (OKA 01, OKA 02),
Patoka Old Reservoir (SOI), and Patoka New Reservoir (SOJ)

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EXECUTIVE SUMMARY

This is the first in a series of quarterly status reports documenting work completed on the North Fork Kaskaskia River 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 work completed to date, the project team has concluded that TMDLs are warranted for all of the impaired waterbodies in this targeted watershed. Specifically:

- For **Segment OKA 01 of the North Fork Kaskaskia River**, data are sufficient to support the causes listed on the draft 2004 303(d) list, and manganese, iron, dissolved oxygen, and pH TMDLs are warranted.

  Potential sources of manganese and iron are watershed and streambank erosion of soils naturally enriched in manganese and iron. Naturally elevated concentrations in groundwater and release from bottom sediments under anoxic conditions are also potential sources of iron and manganese. Brine from oil wells is a potential minor source of manganese. Finally, a NPDES permitted discharger with a permit to discharge iron may also be contributing iron to this river segment; however, it should be noted that this discharger is located downstream of the sampling station used to list this segment for iron. Because the manganese and iron concentrations reflect natural background conditions, the public water supply and general use criteria for manganese and iron may be difficult to attain.

  Potential sources of pH include the naturally acidic watershed soils and four NPDES permitted dischargers with a permit requirement to monitor pH. Potential sources of low dissolved oxygen include runoff of nutrients from lawns and agricultural lands (cropland and livestock), sewage from failing septic systems and straight pipes and two NPDES permitted dischargers with a permit to discharge biochemical oxygen demand (BOD).

- For **Segment OKA 02 of the North Fork Kaskaskia River,** data collected for segment OKA 01 are sufficient to support the causes listed on the draft 2004 303(d) list, and manganese, iron, dissolved oxygen and pH.

  Potential sources of manganese and iron are watershed and streambank erosion of soils naturally enriched in manganese and iron. Naturally elevated concentrations in groundwater and release from bottom sediments under anoxic conditions are also potential sources of iron and manganese. Brine from oil wells is a potential minor source of manganese. Because the manganese and iron concentrations reflect natural background conditions, the public water supply and general use criteria for manganese and iron may be difficult to attain.

  A potential source of pH is the naturally acidic watershed soils. Potential sources of low dissolved oxygen include runoff of nutrients from lawns and agricultural lands (cropland and livestock), and sewage from failing septic systems and straight pipes.

- For **Patoka Old Reservoir (SOI),** data are sufficient to support the listing of this reservoir for manganese on the draft 2004 303(d) list. The watershed soils that are naturally enriched in manganese may contribute to elevated manganese concentrations in groundwater. Manganese may also be transported through runoff as well as watershed and streambank erosion. Manganese may also be entering the lake from the bottom sediments during anoxic conditions; however, there are insufficient data to verify this is occurring. A potential minor source may also be brine from oil wells.

- For **Patoka New Reservoir (SOJ),** data are sufficient to support the listing of this reservoir for manganese on the draft 2004 303(d) list. The watershed soils that are naturally enriched in manganese may contribute to elevated manganese concentrations in groundwater. Manganese may also be transported through runoff as well as watershed and streambank erosion. Manganese may also be entering the lake from the bottom sediments during anoxic conditions; however, there are insufficient data to verify this is occurring. A potential minor source may also be brine from oil wells.

INTRODUCTION

This Stage 1 report describes initial activities related to the development of TMDLs for the North Fork Kaskaskia River 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 the North Fork Kaskaskia River 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 2004a), 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).

Identified Watershed Impairment

The impaired waterbody segments included in the project watershed are listed in Table 1 below, along with the cause of the listing. These impairments were identified in the draft 2004 303(d) list (IEPA, 2004). TMDLs are currently only being developed for pollutants that have numerical water quality standards. Sources that are listed for pollutants that exceed statistical guidelines are not subject to TMDL development at this time (IEPA, 2004). Those impairments that have numerical water quality criteria are the focus of this report, and are shown in bold font in Table 1.

The Patoka Old and Patoka New Reservoirs are both partially supportive of the public water supply use, due to manganese. The two segments of the North Fork Kaskaskia River (OKA 01 and OKA 02) are listed as being partially supportive of the aquatic life use due to manganese, low dissolved oxygen and total phosphorus, and partially supportive of the public water supply use due to iron. Segment OKA 01 is also fully supportive of the fish consumption and primary contact (swimming) uses.

According to IEPA (2004a), the listing of segment OKA 02 is based on an evaluated assessment. Monitored assessments are based on current waterbody-specific monitoring data believed to accurately represent existing resource conditions. Evaluated assessments are resource-quality determinations not based primarily on such information (IEPA, 2004a). For the assessment of OKA 02, biological/habitat data were extrapolated from the downstream segment (OKA 01).

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 waterbody in the project watershed

Waterbody segment	Waterbody name	Size	Year Listed	Listed for[1]	Use support[2]
OKA 01	North Fork Kaskaskia River	10.25 mi	1994	**Iron, manganese, pH, dissolved oxygen**, total phosphorus (statistical guideline)	Aquatic life (P), Public water supply (P), Primary contact (swimming) (F), Fish consumption (F)
OKA 02[3]	North Fork Kaskaskia River	15.31 mi	2002[3]	**Iron, manganese, pH, dissolved oxygen**, total phosphorus (statistical guideline)	Aquatic life (P), Public water supply (P)
SOJ	Patoka New Reservoir	6 acres	2004	**Manganese**	Public water supply (P)
SOI	Patoka Old Reservoir	6 acres	2004	**Manganese**	Public water supply (P)

Source: IEPA, 2004

[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 support, P=partial support, N=nonsupport
[3] Evaluated using chemical data and biological/habitat data extrapolated from downstream waterbody (OKA 01)

WATERSHED CHARACTERIZATION

The purpose of watershed characterization was to obtain information describing the watershed to support the identification of sources contributing to manganese, iron, pH and dissolved oxygen impairments. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including soils and topography, climate, land cover, urbanization and growth and point sources and water withdrawals. Active watershed organizations were also identified. 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, numerous calls were placed to local agencies to obtain information on crops, pesticide and fertilizer application practices, tillage practices and best management practices employed. Calls were also placed to local watershed organizations. Additionally, on December 11, 2003 a meeting was held with Regional and State-level EPA staff and a site visit was conducted later the same day. A second site visit was completed on June 24, 2004. The GIS data obtained, calls placed, meeting and site visit are described below.

The first step in watershed characterization was to delineate the watershed boundary for the impaired waterbodies (Table 1) in GIS using topographic and stream network (hydrography) information. 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 waterbodies.

To better describe the watershed and obtain information related to active local watershed groups, data collection efforts, agricultural practices, and septic systems, numerous calls were placed to county-level officials, including those listed below:

- Clinton, Fayette and Marion County Health Departments
- Clinton, Fayette and Marion County NRCS District Conservationists
- Clinton, Fayette and Marion County SWCD Resource Conservationist
- Village of Patoka Water Department

A call was also placed to the State Water Quality Specialist with the NRCS to obtain information on manganese sources. Calls were also placed to the Carlyle Lake

Ecosystem Partnership and the United States Army Corps of Engineers to obtain information on local activities in the watershed. Several calls were also made to inquire about the public water intakes on Shell Pond and the Conservation Club 100 Lake. Site visits were completed on December 11, 2003 and June 24, 2004 to familiarize the project team with the watershed, and gain a better understanding of land uses and potential sources in the watershed. Lists of data sources and calls made are included in Appendix A. Some photos of the watershed are included in Appendix B.

Other information compiled for this task related to climate, population growth and urbanization. These data were obtained from State and Federal sources, including the Illinois State Climatologist, the U.S. Census Bureau and the State of Illinois. A summary of the North Fork Kaskaskia River watershed follows.

North Fork Kaskaskia River Watershed Characterization

The impaired waterbodies addressed in this report are all located within the North Fork Kaskaskia River watershed. The North Fork Kaskaskia River watershed is located in southern Illinois, approximately 75 miles southeast of Springfield, Illinois, and 60 miles east of St. Louis, Missouri. This project study area is part of the larger, Middle Kaskaskia River Watershed and includes portions of three counties (Fayette, Marion and Clinton). The two segments of the North Fork Kaskaskia River discussed in this report (OKA 01 and OKA 02) are about 26 miles in combined length and drain a 77.3 square mile watershed. Elevations in this watershed range from about 445 feet above mean sea level (AMSL) at Carlyle Lake to a maximum of about 595 feet AMSL, roughly three miles west of St. Peter. Tributaries to the North Fork Kaskaskia River include Louse Run, Deer Creek and Long Branch. The headwaters of the North Fork Kaskaskia River originate in Fayette County, Illinois, and this is the origin of segment OKA 02. Segment OKA 02 flows westward through Marion County, ending about 0.5 miles upstream of the US Route 51 overpass, where this segment flows into segment OKA 01. Segment OKA 01 flows westward from just east of the US Route 51 overpass, through Clinton County, to its terminus at Carlyle Lake. Water is pumped from the North Fork Kaskaskia River into the two Patoka reservoirs discussed below, to provide the village of Patoka with drinking water.

The Patoka Old and Patoka New Reservoirs are located within the watershed draining to the North Fork Kaskaskia River. These lakes were constructed in 1953 and 1982, respectively and are each 6 acres in size. Water is usually pumped from the North Fork Kaskaskia River into Patoka Old Reservoir, which serves as a settling pond. Water from Patoka Old Reservoir is then pumped into Patoka New, which serves as a water supply for the village of Patoka. When water levels in Patoka New Reservoir get low, Patoka Old Reservoir also serves as a secondary water supply source. According to the Village of Patoka Water Department, this rarely happens. The Water Department also indicated that they do not pump when during or several days after a rainfall event.

Figure 1 shows a map of the watershed, and includes some key features such as waterways, the 303(d) listed segments, the public water intakes, roads and other key features. The map also shows the location of the four facilities that have a permit to discharge under the National Pollutant Discharge Elimination System (NPDES).

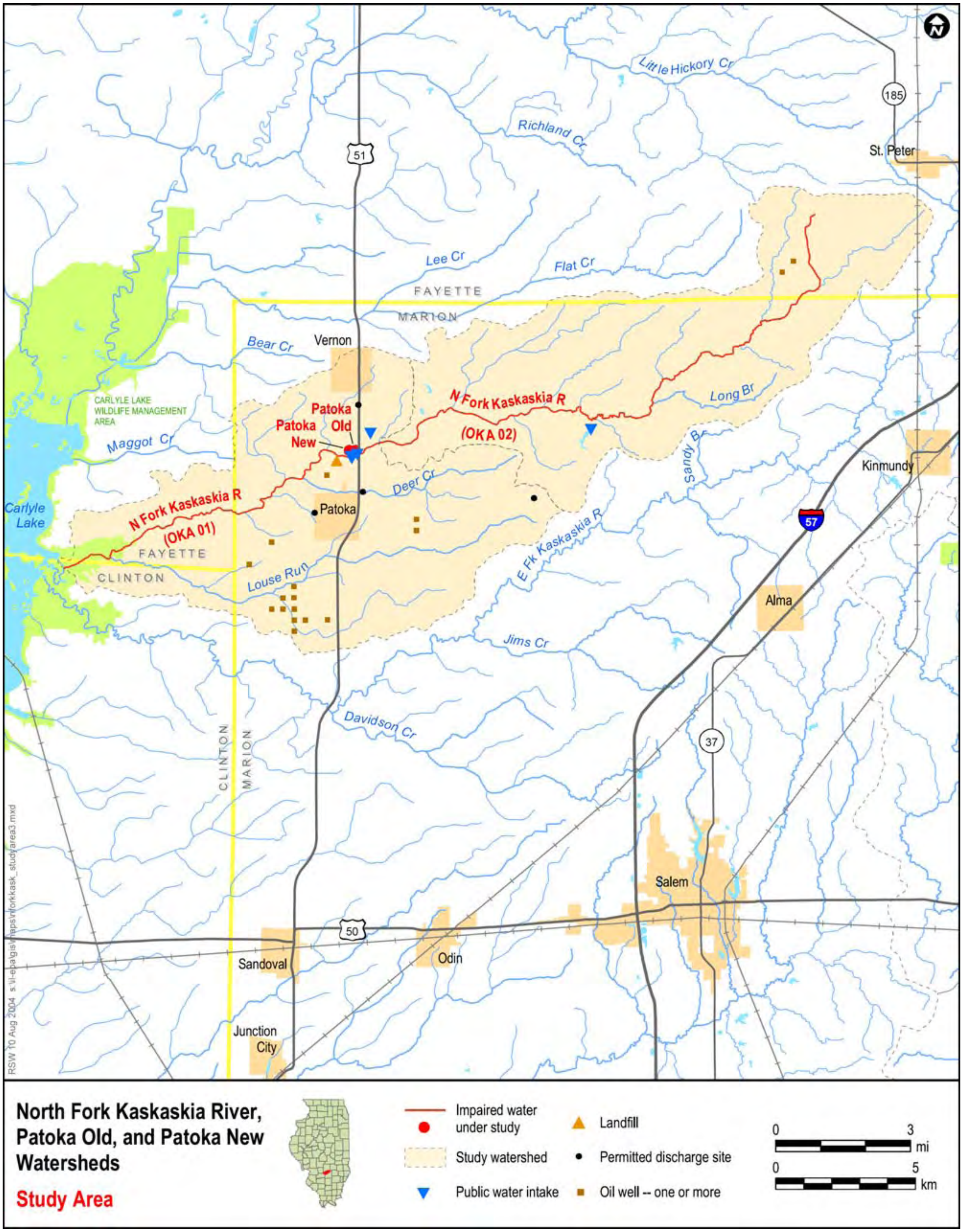

Figure 1. Study area map

The following sections provide a broad overview of the characteristics of the North Fork Kaskaskia River watershed.

Soils and topography

Information on soils and geology was compiled in order to understand whether the soils are a potential source of manganese, iron and phosphorus. Printed copies of the county soil surveys were obtained from the County NRCS District Conservationists for Clinton, Marion and Fayette Counties. The electronic STATSGO soils were also obtained. The STATSGO soils information was used to identify the predominant soil associations in the North Fork Kaskaskia River watershed and the Marion County soil survey (Miles, 1996) was then used to describe these soils. STATSGO soils for the North Fork Kaskaskia River watershed are shown in Figure 2 and summarized in Table 2. As discussed below, many of the soils in the North Fork Kaskaskia River 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. Furthermore, some of the soils described below (e.g., Hoyleton, Darmstadt, Bluford and Hickory) also are found on the short side slopes along drainageways, thus facilitating the transport of the manganese into waterbodies through streambank or lake shore erosion. The acidic nature of the soils may contribute to the low pH observed in the North Fork Kaskaskia River.

Fifty-five percent of the North Fork Kaskaskia River watershed is underlain by the Cisne-Hoyleton-Darmstadt association. 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.

Forty-five percent of the North Fork Kaskaskia River watershed is underlain by the Bluford-Ava-Hickory association. 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.

Information on soil phosphorus content not readily available, but according to the Fayette and Marion County SWCD Resource Conservationists, phosphorus levels in Fayette County were characterized as higher, and soils in Marion County were not characterized as being nutrient rich.

Table 2. Watershed soils (Source: STATSGO)

Soil Map Units (MUID)	Acres	Percentage
Cisne-Hoyleton-Darmstadt (IL006)	27,421	55%
Bluford-Ava-Hickory (IL038)	22,035	45%

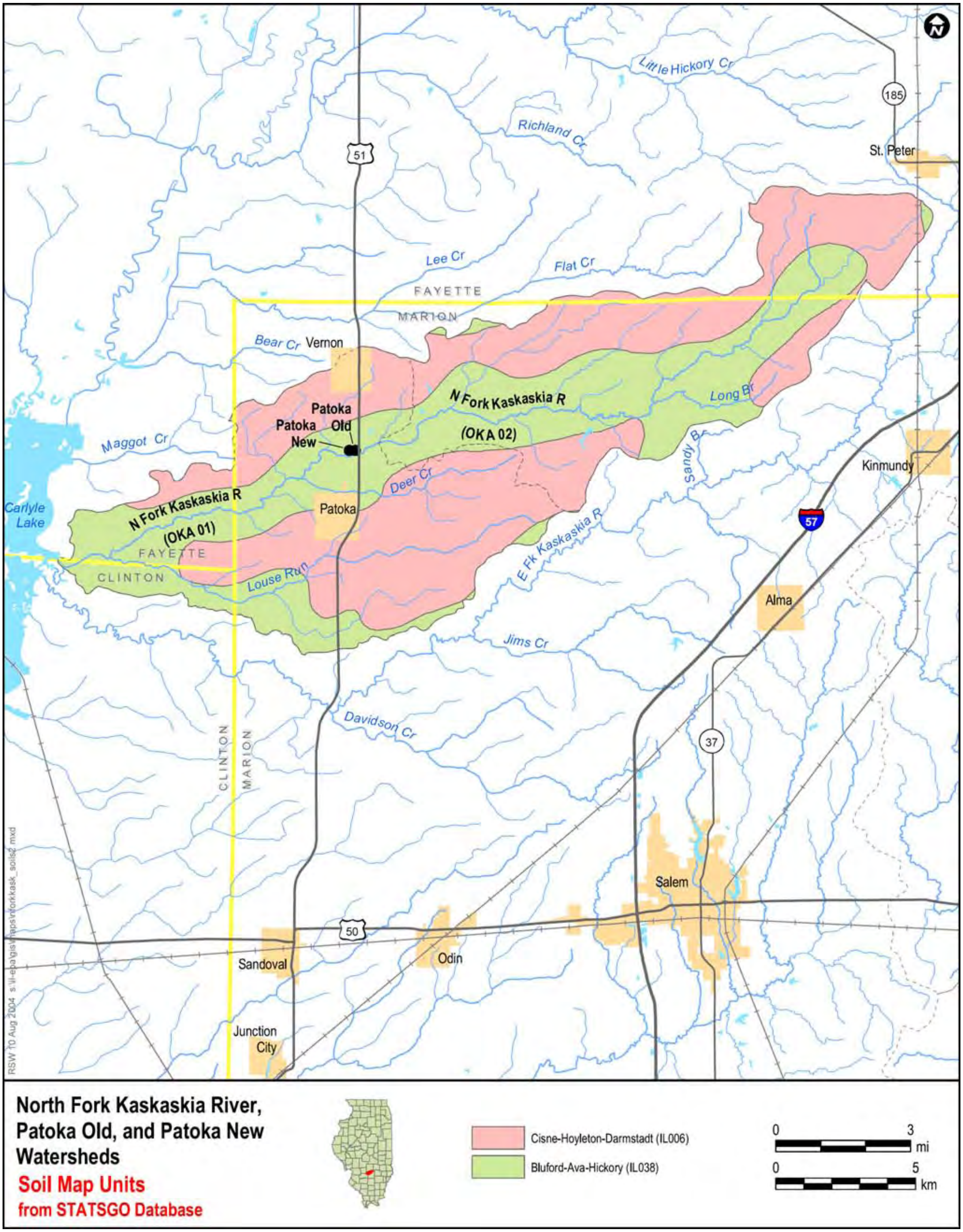

Figure 2. North Fork Kaskaskia River Watershed Soil Map

Climate

Climate information was obtained and summarized to support the watershed characterization and gain an understanding of runoff characteristics for this study area. Climate summaries were available on the web page of the Illinois State Climatologist Office, Illinois State Water Survey. Summaries of climate data were obtained for a station at Carlyle Reservoir for the period 1971-2000. This site belongs to the National Weather Service (NWS) Cooperative Observer Program (COOP).

The North Fork Kaskaskia River watershed has a temperate climate with cold, snowy winters and hot summers. The average long-term precipitation recorded at Carlyle Reservoir (Station 111290) is 40.64 inches. The maximum annual precipitation is 53.95 inches (1993) and the minimum annual precipitation is 22.36 inches (1976). On average there are 105 days with precipitation of at least 0.01 inches and 10 days with precipitation greater than 1 inch. Average snowfall is approximately 9.4 inches per year.

Average minimum and maximum temperatures recorded at Carlyle Reservoir (Station 111290) are 18.8 ^{o}F and 36.3 ^{o}F, in January and 66.6 ^{o}F and 87.7 ^{o}F in July. The average temperature recorded in January is 27.6 ^{o}F and the average temperature recorded in July is 77.2 ^{o}F.

Land Cover

Runoff from the land surface contributes pollutants to nearby receiving waters. In order to understand sources contributing to the waterbody impairments, it was necessary to characterize land cover in the watershed. Land cover in the watershed is shown in Figure 3, and listed in Table 3. Land cover is described in more detail in the sections that follow.

Table 3. Land cover distribution within the North Fork Kaskaskia River watershed

Land cover type	Area (acres)	Percent of total
Agriculture[1]	36,578	74.0%
Forest	4,448	9.0%
Grassland	3,823	7.7%
Wetland	3,689	7.5%
Urban	773	1.6%
Water	81	0.2%
Barren	43	0.1%

Source: Illinois Department of Agriculture, 1999-2000 land cover

[1]The primary agricultural crops are corn (52%), soybeans (29%) and winter wheat, other small grains and hay (18%)

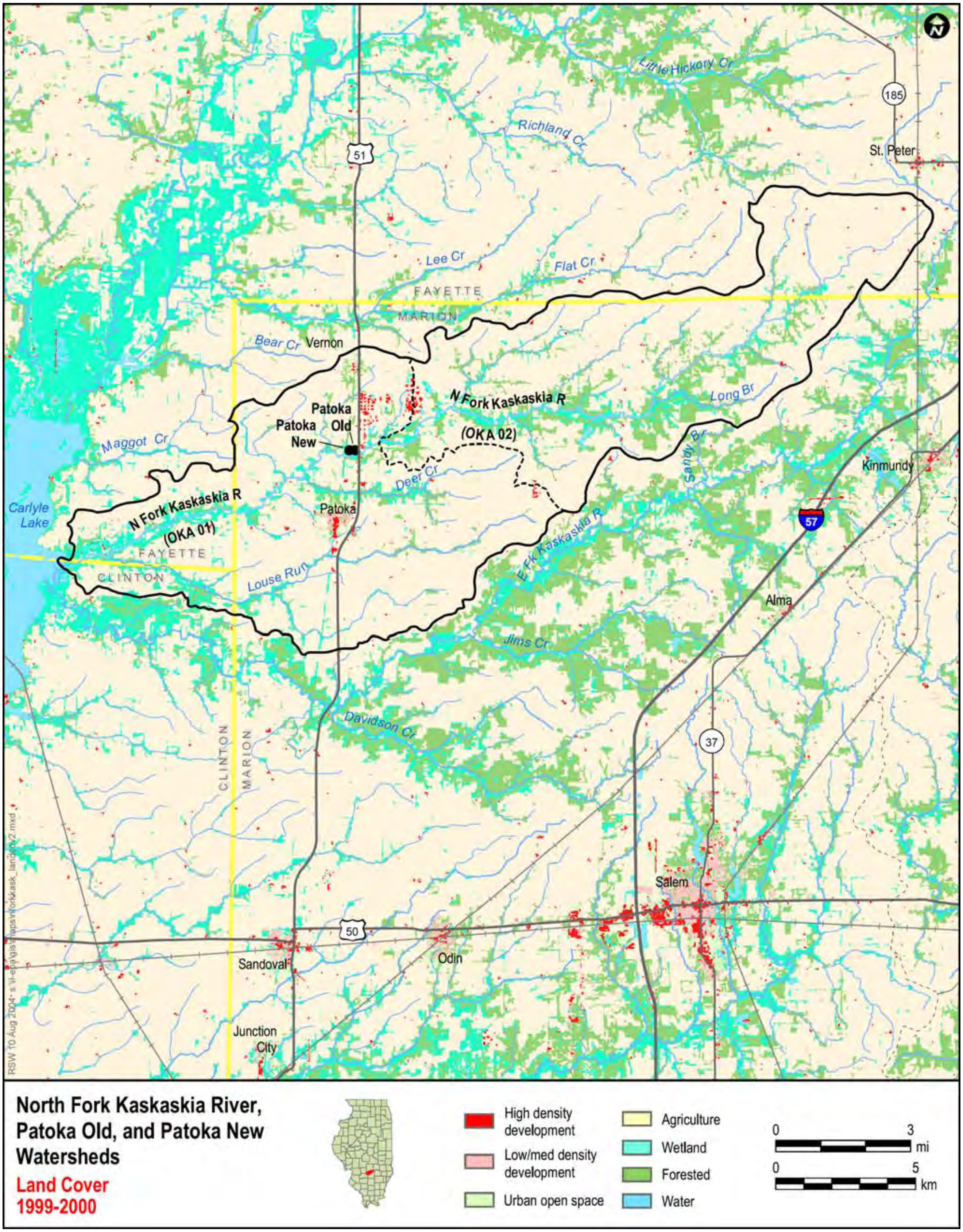

Figure 3. Current land cover (1999-2000) in the project watershed

Agriculture

The predominant land cover in the watershed is agriculture, comprising 74% of the watershed. Agriculture is shown in yellow in Figure 3. According to the Marion, Fayette and Clinton County NRCS District Conservationists, primary crops in the watershed are soybeans (40-45%), corn (40%) and wheat (10-15%). Between 45% and 60% of the soybeans are no-till, with the rest tilled using mulch tillage methods which leave about 20-30% residue. Most of the corn is conventional till in Marion County, with about 10% of the residue left on the fields. In Clinton County, many farmers practice no till and strip till farming, with little conventional farming being done. Residues are over 30% at a minimum (Clinton SWCD Resource Conservationist). The primary tillage practice for wheat is mulch till (20-30% residue) and no-till.

A summary of tillage information from a recent transect survey is presented for Marion, Fayette and Clinton Counties in Tables 4, 5 and 6 (Illinois Department of Agriculture, 2002).

Table 4. Percent of fields, by crop, with indicated tillage system – Marion County

	Tillage system			
	Conventional Till[1]	Reduced-Till[2]	Mulch-Till[3]	No-Till[3]
Corn	77	2	2	19
Soybean	32	6	9	53
Small grain	42	0	3	55

Source: Illinois Department of Agriculture (2002)
[1] Residue level 0 – 15%
[2] Residue level 16-30%
[3] Residue level > 30%

Table 5. Percent of fields, by crop, with indicated tillage system – Fayette County

	Tillage system			
	Conventional Till[1]	Reduced-Till[2]	Mulch-Till[3]	No-Till[3]
Corn	81	6	6	7
Soybean	25	9	24	42
Small grain	38	21	26	15

Source: Illinois Department of Agriculture (2002)
[1] Residue level 0 – 15%
[2] Residue level 16-30%
[3] Residue level > 30%

Table 6. Percent of fields, by crop, with indicated tillage system – Clinton County

	Tillage system			
	Conventional Till[1]	Reduced-Till[2]	Mulch-Till[3]	No-Till[3]
Corn	73	2	17	8
Soybean	21	1	14	64
Small grain	100	0	0	0

Source: Illinois Department of Agriculture (2002)
[1] Residue level 0 – 15%
[2] Residue level 16-30%
[3] Residue level > 30%

Tile drains are not widely used in the watershed due to the clay soils and most drainage is achieved using surface ditches (personal communication Marion County SWCD, and Fayette and Clinton County NRCS).

BMPs

There is a fairly large amount of land in the North Fork Kaskaskia River watershed in the conservation reserve program. In Marion County, there are approximately 35,000 acres (personal communication, Marion County NRCS), with over 1000 acres of land in the CRP in Clinton County (personal communication, Clinton County NRCS). In both counties, much of the bottomland is in the CRP or has been converted to filter strips due the marginal value of this land for farming. According to the Fayette County SWCD and NRCS Conservationists, there are over 30,000 acres in the CRP in Fayette County and also a lot of participation in other programs such as implementing filter strips (typical filter strip width is 70 feet), soil testing to prevent the over-application of fertilizers, grade stabilization structures and placement of ponds to capture runoff. In upland areas of Marion County, filter strips along waterways are common (personal communication, Marion County NRCS). The strips are between 66 and 120 feet wide (personal communication, Marion County SWCD). Nutrient management programs are also becoming more prevalent in Marion County (estimated 20% of farmers have plans in the watershed), due to the 303(d) listing of several waterbodies in the county (personal communication, Marion County SWCD).

Fertilizer and pesticide use

According to the Clinton county NRCS District Conservationist and SWCD Resource Conservationist, soil testing is fairly universal for farmers in the watershed, with most of the farmers just applying maintenance loads of fertilizer on the fields. Application rates follow University of Illinois extension recommendations. If disposal is needed, manure is spread on fields between crop cycles and is usually disked in. The Marion County NRCS District Conservationist stated that soil testing isn't conducted as frequently in Marion County, with an estimated 33% of the farmers testing the soil. Fertilizers are primarily applied in the spring and that commercial fertilizers are most commonly used (phosphorus and potassium), with some supplement of manure from livestock operations. In Fayette County, soil testing is fairly common, but not all farmers test (Fayette County

SWCD District Conservationist). Fertilization practices range from blanket application at the same rate every year, to using GIS and soil tests to place fertilizer as needed.

Pesticides are commonly applied in the spring, with different herbicides applied before and after crop emergence. Atrazine is the primary herbicide for corn and milo, due to its low cost. It is typically applied pre-planting in the spring. The majority of the soybeans are Roundup Ready and are sprayed post-emergent. Most application is conducted using tank spraying (personal communication, Marion, Fayette and Clinton County NRCS).

Animal feeding operations

There are several small beef operations in the North Fork Kaskaskia River watershed, with several located in Marion County. Between 25 and 33% of the cattle in Marion County are fenced off from local waterways. According to the Clinton County NRCS and SWCD Conservationists, there are between five and twelve operations in Clinton County (40-90 head of cattle per operation). Exact locations of the beef operations were not provided, but in Clinton County, it was noted that the livestock operations are located away from the bottomlands (due to the propensity of the lake high water levels to flood these areas) and the majority of the cattle are fenced away from streams. A winter feed station program has been implemented in the portion of the watershed in Clinton County, which involves setting up a feed station away from streams to allow farmers to collect waste more easily and reduce the impact of the cattle on the streams. In Fayette County, there are some small dairy and beef operations (Fayette County SWCD Resource Conservationist).

Forest and urban areas

The green areas on Figure 3 show forested lands (approximately 9%), which are both upland and partial canopy/Savannah upland. Also shown on the map (in red) are areas of low/medium and high density development. These areas indicate the locations of the towns and residential communities in the watershed as well as several tank farms. The developed lands comprise approximately two percent of the total land area within the watershed. Patoka and Vernon are the only towns located in the watershed.

Hydrology

There are no flow gages located in the project watershed. However, a USGS gage was identified on the East Fork Kaskaskia River (USGS gage 05592900), which has daily flow records available from October 1979 to present.

Urbanization and growth

The North Fork Kaskaskia River watershed encompasses portions of three rural counties and two small communities. The majority of the watershed is located in Marion County (77%), with lesser portions in Clinton (3%) and Fayette Counties (19%). The two communities in this watershed are Patoka and Vernon. The village of Patoka is the largest urbanized area in the watershed, with a population of 633 residents; Vernon has a population of 178 (Census 2000 website, http://factfinder.census.gov/home/saff/main.html?_lang=en).

Table 7 indicates that population growth in Fayette and Clinton Counties has been around 5% between 1990 and 2000 (US Census Bureau), with the Clinton County population projected to increase by approximately 10% between 2000 and 2020 (State of Illinois, 1997). The population in Marion County increased by only 0.3% between 1990 and 2000 (US Census Bureau) and is projected to decrease by 8% by 2020 (State of Illinois, 1997). Similarly, the Fayette County population is projected to decrease by 13% between 2000 and 2020 (State of Illinois, 1997).

Table 7. Clinton, Marion and Fayette County population

County	1990[1]	2000[1]	2010[2]	2020[2]
Clinton	33,944	35,535	37,253	39,134
Marion	41,561	41,691	39,328	38,261
Fayette	20,893	21,802	19,562	18,860

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

Point sources and septic systems

There are four NPDES-permitted dischargers located within the North Fork Kaskaskia River watershed. Two are sewage treatment plant outfalls (Table 8). There are also seventeen locations in the watershed where there are one or more oil wells. Between the 1920s and 1950s, brine from oil drilling operations used to be routinely dumped in lagoons and allowed to evaporate or drain to surface waters. The environmental effects of mixing brine water with fresh water are now better understood and the brine can be reinjected into the ground to help push oil to the pump (Personal communication, Marion County SWCD).

One landfill (Patoka Municipal, 1218100001) was also identified within the watershed. This landfill is closed and there is no monitoring requirement. The location of the NPDES-permitted dischargers, oil wells and the landfill are shown on Figure 1.

Based on calls to local agencies, it is believed that only Patoka has municipal sewer service and that the rest of the watershed is served by septic systems (personal communication with Clinton, Marion and Fayette Health Departments). All three health departments acknowledged that there may be straight pipe connections in the watershed. According to the Clinton County Heath Department, there are not many homes in the Clinton County portion of the watershed. Most of the soils in this watershed are not very good for septic systems and it is suspected that a "decent proportion are not doing very well." The Marion County Health Department described the condition of septic systems in the county as fair. In Fayette County, it was estimated that as many as 25% of the septic systems in the area could be failing (personal communication, Fayette County Health Department).

Table 8. NPDES-permitted discharges in the North Fork Kaskaskia River watershed

Facility Name	NPDES ID	Pipe Description	Average Design Flow (MGD)	Permitted to Discharge	Permit expiration date
Patoka STP	ILG58022	Sewage treatment plant outfall	0.072	BOD_5, $CBOD_5$, Flow, pH, Total suspended solids	12-31-07
Patoka Community Unit School	IL0024376	Sewage treatment plant outfall	0.006	BOD_5, $CBOD_5$, Flow, Total ammonia nitrogen, pH, Total suspended solids	6-30-06
Mobile Pipeline-Patoka Station	IL0071218	Hydrostatic test effluent	0.5	Flow, Dissolved iron, Total iron, pH, Total suspended solids	12-31-05
Ameren Energy – Kinmundy Power Plant	IL0075001	Miscellaneous equipment and floor drain wastewater	0.041	Flow, pH	4-30-06

Water withdrawals

There are five public water intakes in the watershed. One water intake is located on the North Fork Kaskaskia River. Water withdrawn at this location is pumped to the Patoka Old reservoir, which is used as a settling basin for water that is then pumped to the Patoka New reservoir. Water from the Patoka New reservoir is withdrawn for public water supply. During dry periods, the Patoka Old reservoir may also be used for water supply. The other two public water intakes are listed for Shell Recreation Lake and Conservation Club-100 Lake (also known as Patoka Club Lake). According to a Shell representative, "Shell Pond" was built for fire protection for the tank farm north of Patoka and the only water withdrawals would be for fire protection. The local fire department also has permission to fill their fire truck there when needed. The Conservation Club 100 Lake also has an intake that can be used for fire suppression. According to the treasurer of the Conservation Club, this private club owns the 27-29 acre Conservation Club 100 Lake, which is used for fishing and no-wake boating. The Patoka fire department recently received permission to withdraw water from the lake in the event of an emergency.

Watershed organizations

Active watershed organizations are good sources of watershed and water quality information and will be important partners for successful implementation of this TMDL. The Carlyle Lake Ecosystem Partnership and the Kaskaskia Watershed Association were two organizations identified that are active in or near the project watershed.

The following description of the Carlyle Lake Association and current projects was obtained from their website,
http://dnr.state.il.us/orep/c2000/ecosystem/partnerships/carlyle/carlyle1.htm

> "Concerned about the future of Carlyle Lake, a group of residents and other lake users formed the Carlyle Lake Association (CLA) in 1995. They created a representative board composed of farmers; landowners; businesses; fish and wildlife enthusiasts; boating, sailing, and camping users; and marina operators. In 1996, CLA joined forces with the Mid-Kaskaskia River Basin Coalition, Soil and Water Conservation Districts in the 6-county watershed area, and other interested organizations to form the Carlyle Lake Ecosystem Partnership."
>
> According to Jon Phillips, the group is active throughout the Kaskaskia River watershed. Some projects he mentioned are: USACE grants to improve wildlife areas in Carlyle Lake, a pilot project in strip till nutrient management, purchasing easements with C2000 grants in Fayette County and pursuing grants to obtain GPS units to assist technicians in helping to delineate wetlands and computers for GIS mapping. Another study is a river bank erosion study from Carlyle Lake to Shelbyville and some tree planting to reduce erosion.
>
> Current projects listed on the Carlyle Lake website include:
>
> - Marion County reforestation, with over 120,000 tree seedlings planted.
> - Various streambank stabilization projects.
> - Boulder Flats wetland restoration and reforestation.
> - Development of Southern Till Plain Prairie Preserve in Fayette and Marion Counties
> - A no-till drill purchased for use by landowners in Fayette County
> - Vandalia and Farina School Outdoor Classrooms
> - Educational center for K-12 classes, community members, and organizations at the Ramsey Community Unit District Site."

The Kaskaskia Watershed Association (KWA) was created to represent the entire watershed while recognizing the uniqueness within each of its four characteristic reaches: Upper Kaskaskia Reach, Carlyle Reach, Kaskaskia/Shoal Reach and the Lower Kaskaskia Reach. The Southwestern Illinois RC&D, Inc., U.S. Army Corps of Engineers and the Illinois Department of Natural Resources are leaders in the KWA (SIRC&D, 2002). The report, Kaskaskia River Watershed: An Ecosystem Approach to Issues and Opportunities, jointly commissioned by the Illinois Department of Natural Resources and the US Army Corps of Engineers, has recently been developed (summer 2002) to fully document the current issues involved within the watershed. The Southwestern Illinois

RC&D recently prepared a watershed action plan that recognizes the need to address water quality impairments (SWIRCD, 2002).

North Fork Kaskaskia River (OKA 01)

Segment OKA 01 of the North Fork Kaskaskia River is 10.25 miles in length. This segment begins about a half mile east of the Route 51 bridge crossing and ends at Carlyle Lake. Because this segment is the downstream segment on this river (the upstream segment OKA 02 is discussed in the following section of this report), watershed characterization for this segment includes the entire North Fork Kaskaskia River watershed downstream to Carlyle Lake.

The North Fork Kaskaskia River flows westward from its point of origin (west of St. Peter, IL) to its confluence with Carlyle Lake. This river is approximately 25.6 miles long and its watershed is roughly 77 square miles in size. Its watershed encompasses portions of three counties (Fayette, Marion and Clinton) and two towns (Vernon and Patoka). This river flows through open agricultural (primarily corn, soybean and wheat fields) and forest lands. Tributaries include Louse Run, Deer Creek and Long Branch. There are several small reservoirs in the watershed, including the Patoka Old and Patoka New Reservoirs, Shell Recreation Lake and Conservation Club 100 Lake. The previous general discussion of the project study area applies to this segment of the North Fork Kaskaskia River. Land cover, population and point source information was provided previously in Table 3 (land cover), Table 7 (population) and Table 8 (point sources). Photos are provided in Appendix B.

North Fork Kaskaskia River (OKA 02)

Segment OKA 02 of the North Fork Kaskaskia River is 15.31 miles in length. This segment begins at the river's headwaters, just west of St. Peter and flows westward towards Patoka, where it empties into segment OKA 01 (described previously). There are numerous small tributaries to this river segment, but only one that was identified by name (Long Branch). The watershed for segment OKA 02 includes portions of Fayette and Marion Counties (23% and 77%, respectively) and no urbanized areas. The downstream boundary for this watershed is shown as a dashed line in Figure 1, which is located just east of route 51.

This watershed is underlain by two soil associations: the Cisne-Hoyleton-Darmstadt and Bluford-Ava-Hickory associations. As discussed previously (see general soil discussion), many of these soils 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. Furthermore, some of the soils described (e.g., Hoyleton, Darmstadt, Bluford and Hickory) also are found on the short side slopes along drainageways, thus facilitating the transport of the manganese into waterbodies through streambank or lake shore erosion. The acidic nature of the soils may also influence instream pH.

Land cover for this watershed is provided in Table 9. Approximately 73% of the land is used for agriculture and approximately 13% is forested. It is notable that 6% of this watershed is comprised of wetlands. Agricultural land is primarily planted with soybeans (50%), corn (33%) and lesser amounts of wheat, hay and other small grains. The developed land in this watershed is primarily a tank farm, located north of the river, near the downstream watershed boundary.

Agricultural cropland is typically fertilized using commercial fertilizers, although manure is also used on fields between crop cycles, when disposal is needed. Commercial fertilizers commonly used are phosphorus and potassium (personal communication, Marion County NRCS). In Marion County, it is estimated that only 33% of the farmers conduct soil testing (personal communication, Marion County NRCS); however, in Fayette County, soil testing is reported as being fairly common (personal communication, Fayette County SWCD). Agricultural BMPs in this watershed include filter strips, soil testing, grade stabilization structures and placement of ponds to capture runoff (personal communication, Fayette County NRCS and SWCD and Marion County SWCD). A large amount of land in Marion and Fayette Counties is in the conservation reserve program: 35,000 acres and over 30,000 acres, respectively (Personal communication, Marion and Fayette County NRCS).

There are several small dairy and beef operations in the watershed, with about 25%-33% of those in Marion County being fenced from local waterways (Personal communication, Marion County SWCD).

There are no NPDES-permitted discharges located within the segment OKA 02 watershed. There are two areas with one or more oil wells (Figure 1), which are located near the headwaters of this segment, in Fayette County. The only water intake is located in the Conservation Club 100 Lake which, as previously described, is an intake for the Patoka Fire Department to use in emergency situations.

Table 9. Land Cover in the North Fork Kaskaskia River Subwatershed (OKA 02)

Land Cover	Area (acres)	Percent of watershed
Agriculture	17,254	72.6%
Forest	3,089	13.0%
Grassland	1,845	7.8%
Wetland	1,435	6.0%
Urban/developed	113	0.5%
Water	31	0.1%
Barren	14	0.1%

Patoka Old Reservoir (SOI) and Patoka New Reservoir (SOJ)

The Patoka Old and Patoka New Reservoirs are located north of the North Fork Kaskaskia River, just west of Route 51. These reservoirs are each 6 acres in size and were constructed in 1953 (Patoka Old) and 1982 (Patoka New) to serve as a public water supply. Water is pumped from the North Fork Kaskaskia River into the Patoka Old

Reservoir, which serves as a settling pond. Water is then pumped into the Patoka New Reservoir, where it is withdrawn for use as public drinking water. During dry periods, water may also be withdrawn directly from the Patoka Old Reservoir for drinking water.

The drainage area for the two Patoka reservoirs (SOI and SOJ) is approximately the same as that for Segment OKA 02, previously described. This is because the source of the water for these lakes is an intake on the North Fork Kaskaskia River located near the Route 51 overpass.

According to the Village of Patoka Water Department, manganese is a known problem in these reservoirs, but there have been no citizen complaints about staining. Additionally, "the manganese hits are definitely associated with the big algae blooms, during which dissolved oxygen clearly drops." It was also noted that in Patoka Old, there is a large amount of sediment resuspension during spring turnover.

Please refer to the segment OKA 02 discussion above for watershed characterization information for these two reservoirs.

DATABASE DEVELOPMENT AND DATA ANALYSIS

All readily available water quality and NPDES effluent data were obtained from Illinois EPA, STORET and STORET-modern and compiled into a Microsoft Access database. Those data that were provided in printed format were entered into the database to facilitate analysis. Information on water quality criteria was also obtained for comparison to the collected data.

Once database development was completed, the data were analyzed. Analysis methods included computing summary statistics, evaluating trends and correlations and using graphical analysis, including profile plots, to discern relationships in the data.

Data sources

All readily available data to describe water quality in the North Fork Kaskaskia River watershed and the two Patoka reservoirs were obtained. Sources contacted for data include the Illinois Environmental Protection Agency (State and Regional offices) and the United States Geologic Survey USGS. No USGS data were identified for the project watershed, however, a flow gage previously discussed was identified in an adjacent watershed (East Fork Kaskaskia River). All readily available data describing effluent quality for the permitted dischargers in the watershed were obtained from the Illinois EPA and permit limits were obtained from the USEPA PCS database. All available and relevant data were 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.

A summary of readily available water quality data for this watershed is presented in Table 10. Sampling station locations for the data analyzed for this report are shown in Figure 4.

Table 10. Water quality data summary for the North Fork Kaskaskia River watershed

Waterbody segment	Parameter[1]	Sampling station	Period of record (#)	Minimum	Maximum	Average
OKA 01	Manganese (ug/l)	OKA 01	1/1990-4/2003 (129 samples)	78	4463	562
	Dissolved Iron (ug/l)	OKA 01	1/1990-4/2003 (101 samples)	52	3200	259
	pH	OKA 01	1/1990-4/2003 (94 samples)	6.2	8.5	7.2
	Dissolved oxygen (mg/l)	OKA 01	1/1990-4/2003 (129 samples)	0.4	13	6.4
OKA 02 [2,3]	Manganese (ug/l)	N/A	N/A	N/A	N/A	N/A
	Iron (ug/l)	N/A	N/A	N/A	N/A	N/A
	pH	N/A	N/A	N/A	N/A	N/A
	Dissolved oxygen (mg/l)	N/A	N/A	N/A	N/A	N/A
SOI	Manganese (ug/l)	SOI-1	5/2003-10/2003 (5 samples)	89	310	234
SOJ	Manganese (ug/l)	SOJ-1	5/2003-10/2003 (5 samples)	78	290	126

[1]Media is water
[2]Monitoring station OKA-01 is 0.5 miles downstream of the public water supply intake and data from this site was used to assess segment OKA_02 for Public Water Supply use. Biological/habitat data were extrapolated from the downstream segment for the aquatic life use assessment.
[3]No sampling stations were identified for segment OKA 02
N/A = not available

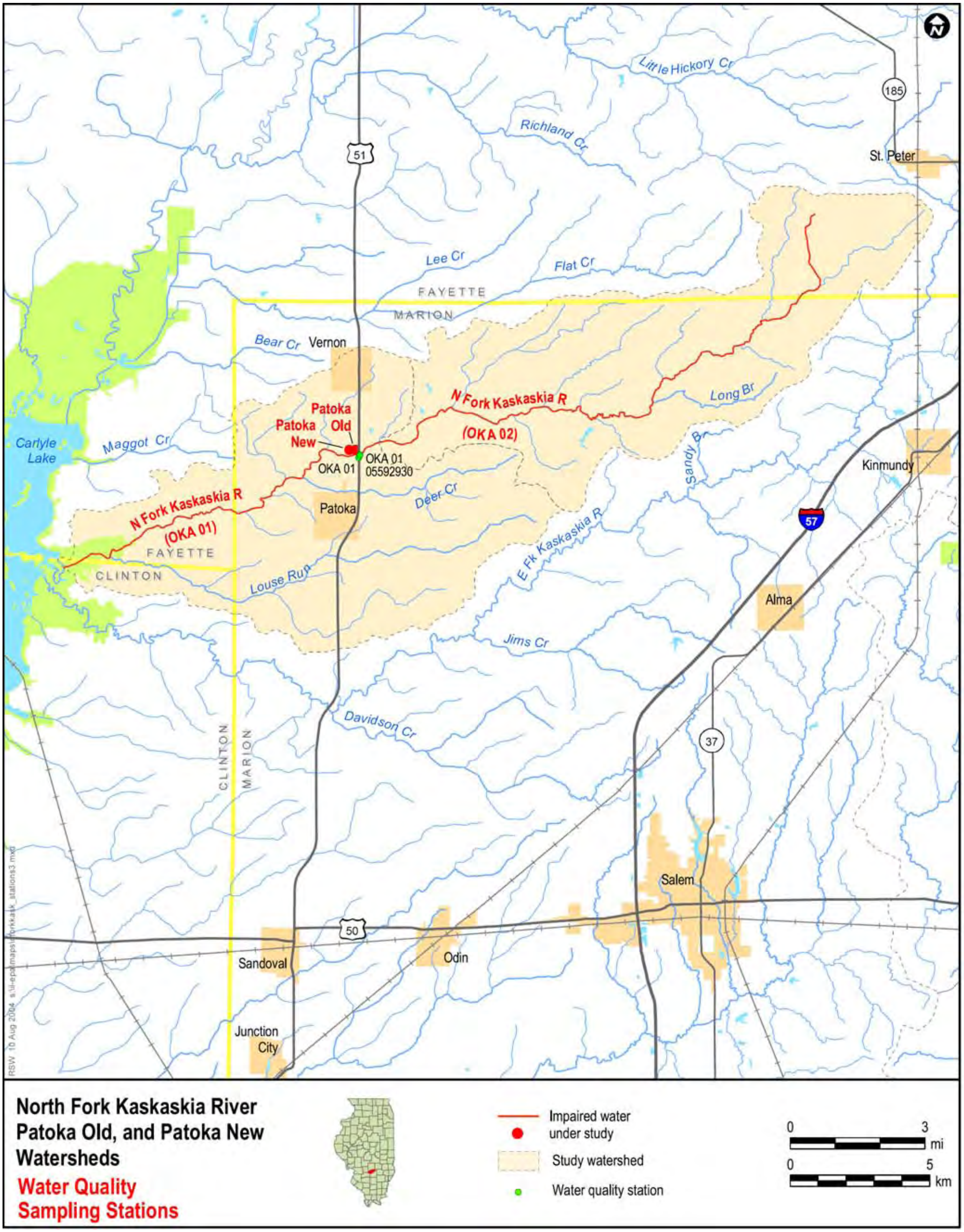

Figure 4. Sampling station locations in the North Fork Kaskaskia River watershed

Methods of data analysis

The water quality data were analyzed to confirm the cause of impairment for each waterbody and, in combination with the watershed characterization data, were assessed 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.

Analysis methods including computing summary statistics, comparing the data to water quality criteria, evaluating trends and correlations, and using graphical analysis to discern relationships in the data.

CONFIRMATION OF CAUSES AND SOURCES OF IMPAIRMENT

Water quality data were evaluated to confirm the cause of impairment for each waterbody in the North Fork Kaskaskia River 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 11 lists the impaired waterbodies, the applicable water quality criteria, and the number of samples exceeding the criteria. These data are discussed by waterbody in the following sections. This section presents an assessment of the sufficiency of the data to support the 303(d) listings and identifies suspected or known sources.

Table 11. Water quality impairments and endpoints for the North Fork Kaskaskia River watershed

Segment	Cause of impairment	Applicable Illinois WQS	Standard	Basis of Impairment
OKA 01	Iron (dissolved)	General Use	1000 ug/l	2 of 101 samples > general use criterion
		Public Water Supply	300 ug/l	10 of 43 samples collected between 1999-2003 > public water supply criterion
	Manganese	General Use	1000 ug/l	14 of 129 samples > general use criterion
		Public Water Supply	150 ug/l	40 of 48 samples collected between 1999-2003 > public water supply criterion
	Dissolved oxygen	General Use	5 mg/l minimum	50 of 129 samples < criterion
	pH	General Use	6.5 - 9	2 of 94 samples < 6.5 0 of 94 samples > 9.0
OKA 02	Iron (dissolved)	General Use	1000 ug/l	This segment was assessed as “evaluated” and data collected for segment OKA 01 were used for listing segment OKA 02
		Public Water Supply	300 ug/l	
	Manganese	General Use	1000 ug/l	
		Public Water Supply	150 ug/l	
	Dissolved oxygen	General Use	5 mg/l minimum	
	pH	General Use	6.5 – 9	
SOI	Manganese	General Use	1000 ug/l	0 of 5 samples > general use criterion
		Public Water Supply	150 ug/l	4 of 5 samples > public water supply criterion
SOJ	Manganese	General Use	1000 ug/l	0 of 5 samples > general use criterion
		Public Water Supply	150 ug/l	1 of 5 samples > public water supply criterion

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 12. These potential sources were supplemented with data reflecting point source discharges in the watershed, non-point pollution sources, and data and information collected as part of Stage 1 activities, as summarized in Table 13 and described in the following section.

Table 12. Waterbody impairment causes and sources (from IEPA, 2004)

Waterbody	Cause of impairments	Potential Sources (from 305(b) Report)
North Fork Kaskaskia River (OKA 01)		
	Manganese	Source unknown
	Iron (dissolved)	Source unknown, resource extraction
	pH	Resource extraction
	Dissolved Oxygen	Source unknown
North Fork Kaskaskia River (OKA 02)		
	Manganese	Source unknown
	Iron (dissolved)	Source unknown, resource extraction
	pH	Resource extraction
	Dissolved Oxygen	Source unknown
Patoka Old Lake (SOI)		
	Manganese	Source unknown
Patoka New Lake (SOJ)		
	Manganese	Source unknown

Table 13. Other impairment causes and sources

Waterbody	Cause of impairments	Other Potential Sources
North Fork Kaskaskia River (OKA 01)		
	Manganese	Naturally elevated concentrations in groundwater; streambank erosion of soils naturally enriched with manganese; release from bottom sediments during anoxic conditions; brine from oil wells
	Iron (dissolved)	Naturally elevated concentrations in groundwater; streambank erosion of soils naturally enriched with iron; release from bottom sediments during anoxic conditions; NPDES permitted discharger
	pH	Four NPDES permitted dischargers; Naturally acidic soils
	Dissolved Oxygen	Runoff of nutrients from lawns and agricultural lands (cropland and livestock), sewage from failing septic systems or straight pipes, two NPDES permitted dischargers
North Fork Kaskaskia River (OKA 02)		
	Manganese	Naturally elevated concentrations in groundwater; streambank erosion of soils naturally enriched with manganese; release from bottom sediments during anoxic conditions; brine from oil wells
	Iron (dissolved)	Naturally elevated concentrations in groundwater; streambank erosion of soils naturally enriched with iron; release from bottom sediments during anoxic conditions
	pH	Naturally acidic soils
	Dissolved Oxygen	Runoff of nutrients from lawns and agricultural lands (cropland and livestock), sewage from failing septic systems or straight pipes
Patoka Old Lake (SOI)		
	Manganese	Naturally elevated concentrations in groundwater; release from lake bottom sediments during anoxic conditions; brine from oil wells
Patoka New Lake (SOJ)		
	Manganese	Naturally elevated concentrations in groundwater; release from lake bottom sediments during anoxic conditions; brine from oil wells

OKA 01 (North Fork Kaskaskia River)

Segment OKA 01 is listed on the 303(d) list for manganese, iron, dissolved oxygen and pH. Designated uses for this segment include public water supply, aquatic life and fish consumption and primary contact (swimming). The fish consumption and primary contact uses are fully supported. The public water supply and aquatic life uses are partially supported.

Manganese

The IEPA guidelines (IEPA, 2004a) for identifying manganese as a cause in streams state that the aquatic life use is not supported if there is at least one exceedance of applicable standard. The guidelines also state that the public water supply use is not supported if, in untreated water, greater than 10% of the observations exceed the applicable standard, for water samples collected in 1999 or later, and for which results are readily available. As discussed below, the data support the listing of this segment for manganese. Neither the public water supply nor the aquatic life uses are fully supported due to manganese.

Over the period January 1990- June 2003, 129 manganese samples were collected. Forty-eight of these samples were collected between 1999 and 2003. To assess the appropriateness of listing this segment for manganese for the aquatic life use, all manganese data were analyzed. Results of this analysis showed that 14 out of 129 samples (11%) exceed the general use criterion for the protection of aquatic life. Exceedances ranged between 200 and 3,463 ug/L over the criterion, and, on average, exceedances were 1,309 ug/L over the criteria. The most recent exceedance of the general use criteria was in 2000. There were no exceedances of the general use criterion in the eighteen samples collected between 2001 and 2003.

To assess the appropriateness of listing this segment for manganese for the public water supply use, only the manganese data collected between 1999 and present were analyzed. Forty of the forty-eight manganese samples (83%) collected between 1999 and 2003 exceeded the public water supply criteria for manganese. Figure 5 presents a comparison of available manganese data to the public water supply and general use criteria.

As shown in Figure 6, there is a very strong correlation between dissolved and total manganese. Dissolved manganese accounts for 84% of the total manganese with an R^2 of 0.96. This indicates the presence of a dissolved manganese source. This supports the soils as a potential manganese source, as the acidity in the soils mobilizes the naturally occurring manganese. Additionally, severe stream bank erosion was noted during a watershed tour and the erosion of the manganese-enriched soils is a potential source of manganese to the river.

A plot of manganese vs. dissolved oxygen indicates that manganese exceedances of the general use criterion occurred in all but one case when dissolved oxygen was below 3 mg/L (Figure 7). It was observed that manganese generally increases as dissolved oxygen decreases, indicating that dissolved manganese may also be coming from the bottom sediments under anoxic conditions.

Finally, a potential minor source of manganese may be brine water pumped during oil drilling. Between the 1920s and 1950s, brine from oil drilling operations used to be routinely dumped in lagoons and allowed to evaporate or drain to surface waters. The environmental implications of mixing drilled water with fresh water are now better understood and the brine can be disposed of by reinjecting it in the ground to help push oil to the pump (Personal communication, Marion County SWCD). Therefore, while manganese from brine water may have accumulated on the surface and may have contributed to surface water concentrations of manganese in the past this is not expected to be a continuing source.

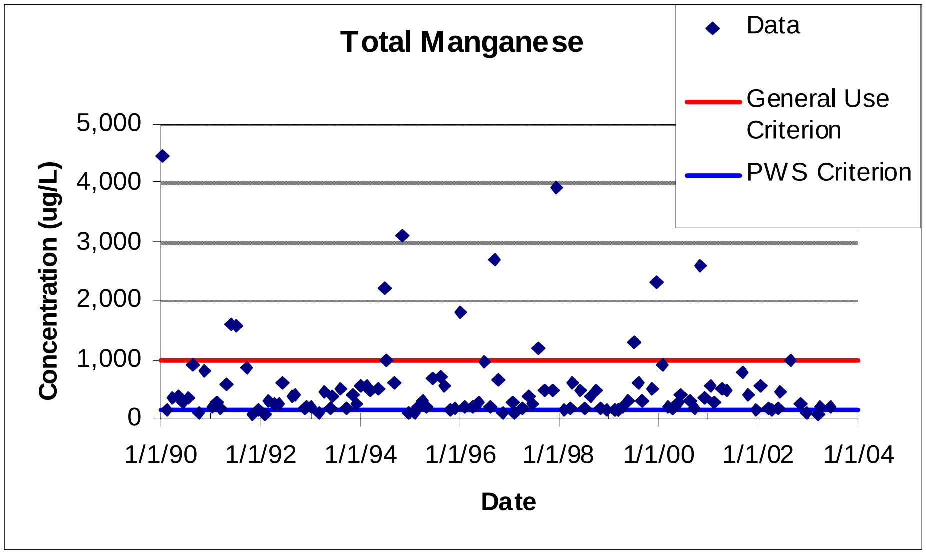

Figure 5. Total manganese in segment OKA 01 compared to criteria

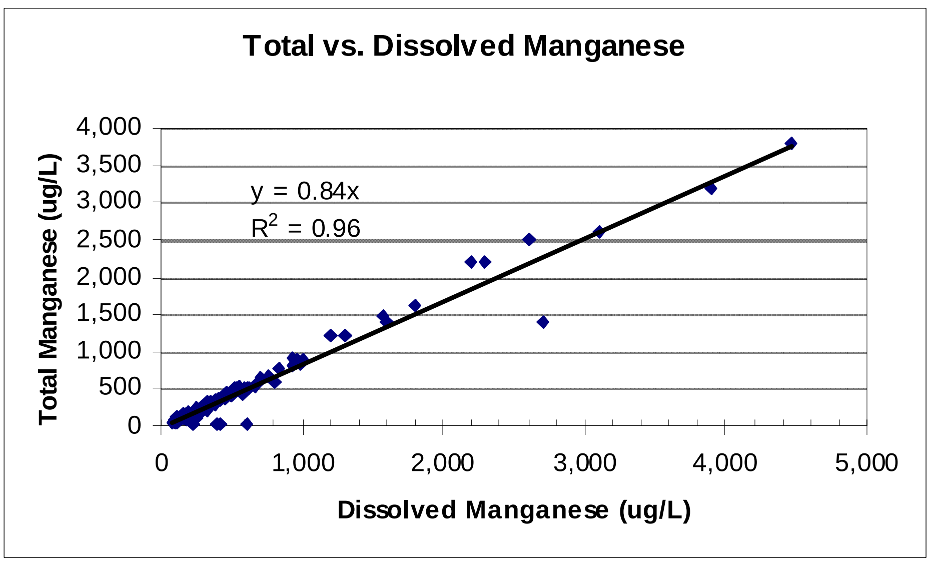

Figure 6. Total vs. dissolved manganese for segments OKA 01 and OKA 02

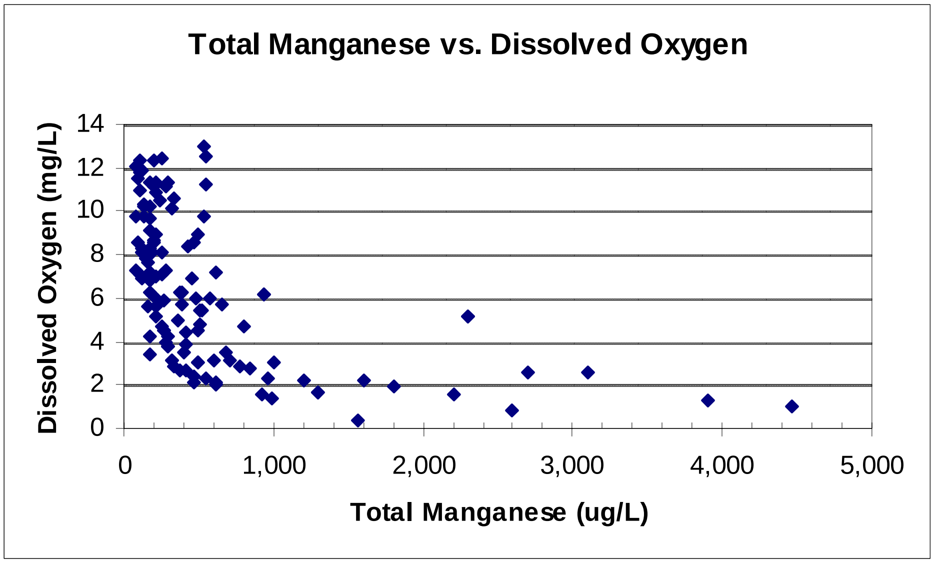

Figure 7. Total manganese vs. dissolved oxygen for segment OKA 01

Iron

The IEPA guidelines (IEPA, 2004a) for identifying iron as a cause in streams state that the aquatic life use is not supported if there is at least one exceedance of applicable acute or chronic standards. The guidelines also state that the public water supply use is not supported if, in untreated water, greater than 10% of the observations exceed the applicable standard, for water samples collected in 1999 or later, and for which results are readily available.

Over the period January 1990 through June 2003, 101 samples were collected and analyzed for iron. Forty-three of these were collected between 1999 and 2003. To assess the appropriateness of listing this segment for iron for the aquatic life use, all dissolved iron data were analyzed. Results of this analysis showed that 2 out of 101 samples (2%) exceed the general use criterion for the protection of aquatic life. Exceedances ranged between 465 and 2,200 ug/L over the criterion, and, on average, exceedances were 1,333 ug/L over the criteria. The most recent exceedance of the general use criteria was in 1997.

To assess the appropriateness of listing this segment for iron for the public water supply use, only the dissolved iron data collected between 1999 and present were analyzed. Ten of the forty-three dissolved iron samples (23%) collected between 1999 and 2003 exceeded the public water supply criteria for iron. Figure 8 presents a comparison of available iron data to the public water supply and general use criteria.

A review of the data did not provide any additional information on potential sources of iron. The two highest dissolved iron measurements were recorded when dissolved oxygen was < 2 mg/l, however, no other relationship was observed between dissolved iron and dissolved oxygen. Release from stream sediments under anoxic conditions is a potential source of iron. Because the watershed soils are naturally enriched in iron, it is suspected that the iron is a naturally occurring source that is transported to the river through erosion and also in dissolved form (the iron is mobilized due to the acidic nature of the soils). Additionally, severe stream bank erosion was noted during a watershed tour and the erosion of the iron-enriched soils is a potential source of manganese to the river.

Within the North Fork Kaskaskia River watershed, there are four NPDES permitted dischargers that discharge into segment OKA 01, downstream of the station used to list this segment for iron. These were shown previously in Table 8. Of these four facilities, only one has a permit to discharge iron. This is the Mobile Pipeline-Patoka Station. Although this facility discharges into the downstream segment (OKA 01), its discharge is downstream of the sampling station used to list this segment. Therefore, this facility is not contributing to iron concentrations measured at the sampling station, but may be contributing to iron in this river segment. Therefore, this facility is a potential iron source in segment OKA 01.

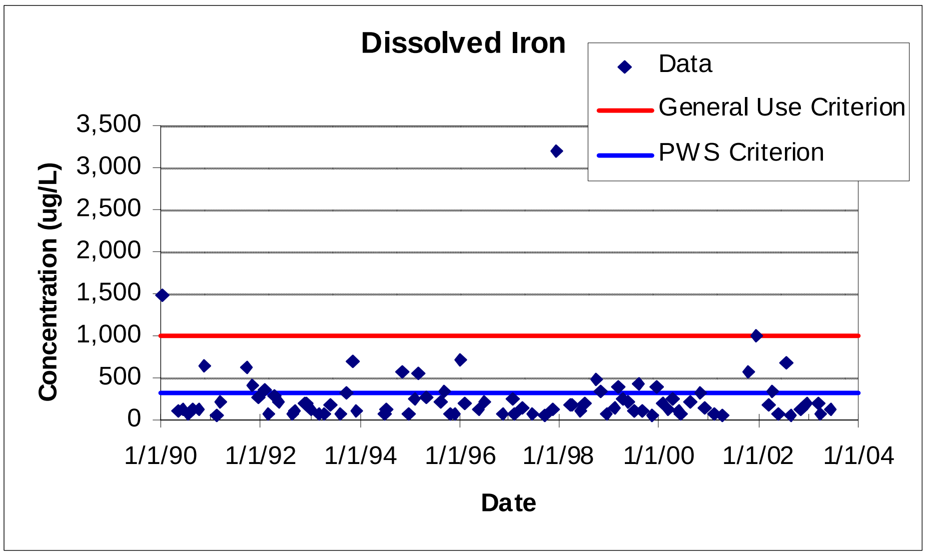

Figure 8. Dissolved iron vs. criteria for segments OKA 01 and OKA 02

Dissolved oxygen

The IEPA guidelines (IEPA, 2004a) for identifying dissolved oxygen as a cause in streams state that the aquatic life use is not supported if there is at least one exceedance of applicable standard (5.0 mg/l), or known fish kill resulting from dissolved oxygen depletion.

Over the period January 1990 through June 2003, 129 dissolved oxygen measurements were collected. Fifty of these samples (39%) were less than the general use criterion. Excursions ranged from 0.2 to 4.6 mg/l below the criterion and averaged 2.1 mg/l below the criterion. Dissolved oxygen levels were observed below the criterion throughout the sampling period with the most recent excursion noted in 2002 (Figure 9).

Available data were analyzed to assess whether there were any relationships that would be useful in identifying potential sources. The relationship between ammonia and dissolved oxygen was assessed and it was noted that in general, ammonia levels do not appear to be elevated. Furthermore, a linear relationship does not appear to exist between

DO and ammonia. Chlorophyll data were also available, however, there are too few chlorophyll a data to evaluate their relationship with dissolved oxygen. It was noted that most dissolved oxygen excursions of the criteria occur between June and September and at temperatures above 20 ^{o}F. However, many excursions also occur during colder temperatures (Figure 10). Because there are no point source discharges upstream of the monitoring station, the sources contributing to low dissolved oxygen are suspected to be nonpoint in origin. Potential sources contributing to low dissolved oxygen include runoff of nutrients from lawns and agricultural lands (cropland and livestock), and sewage from failing septic systems or straight pipes.

It should be noted that there are four NPDES permitted dischargers that discharge into segment OKA 01, downstream of the sampling station used to list this segment for low dissolved oxygen. These were shown previously in Table 8. Of these four facilities, two have a permit to discharge BOD_5 and $CBOD_5$: Patoka STP and Patoka Community Unit School. Although these two permitted facilities discharge into the downstream segment (OKA 01), they all discharge downstream of the sampling station used to list this segment. Therefore, these facilities are not contributing to low dissolved oxygen concentrations measured at the sampling station, but may be contributing to low dissolved oxygen in this waterbody segment. Therefore, these facilities are potential sources contributing to low dissolved oxygen in segment OKA 01.

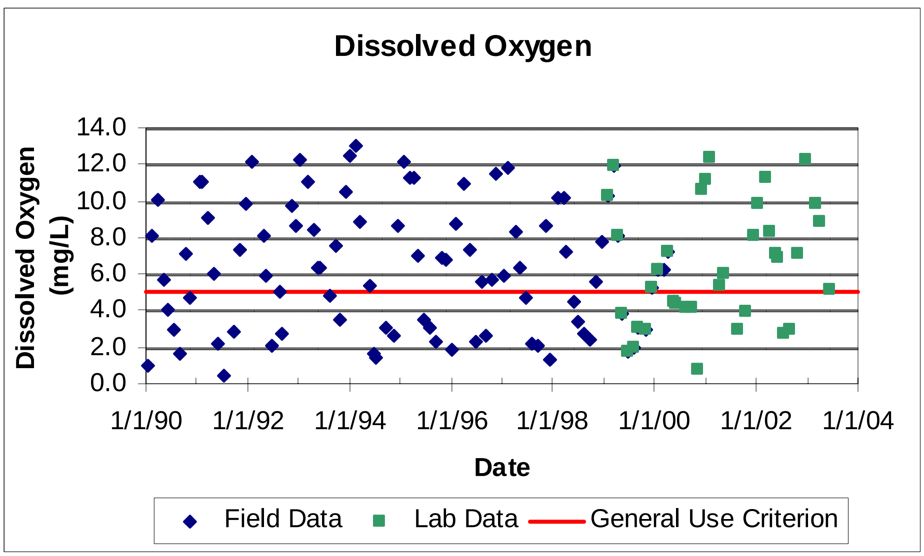

Figure 9. 1996 dissolved oxygen vs. general use criterion at OKA 01

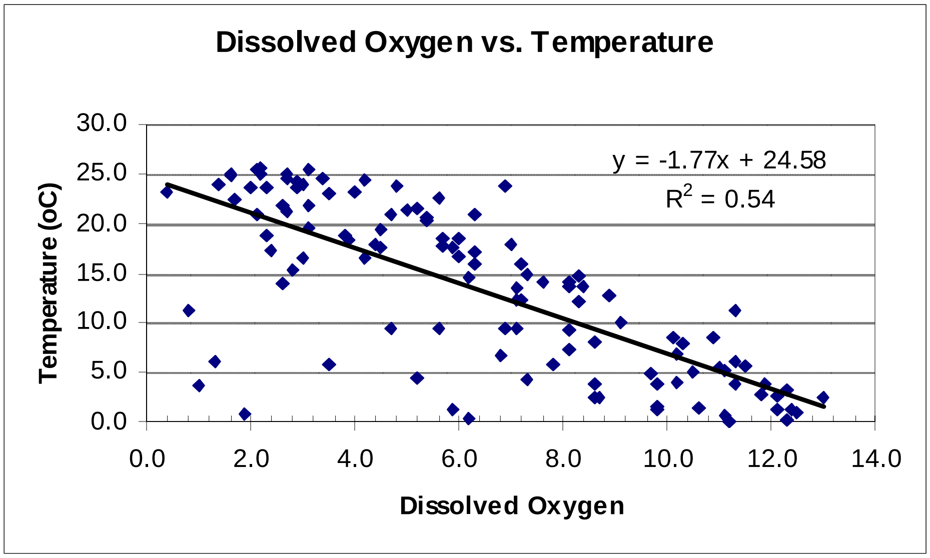

Figure 10. Dissolved oxygen vs. temperature at OKA 01

pH

The IEPA guidelines (IEPA, 2004a) for identifying pH as a cause in streams state that the aquatic life use is not supported if there is at least one exceedance of applicable standard. Over the period January 1990 through May 2000, 94 pH measurements were collected. Two of the 94 measurements (2%) fall below the minimum acceptable pH of 6.5 (Figure 11). These samples are 0.1 and 0.3 pH units below the criterion. None of the samples were greater than pH 9.0. The first pH excursion was on 11/16/1992 and the second excursion was on 11/8/1999

Relationships between pH and other parameters were examined and there does not appear to be a direct relationship between pH and dissolved oxygen, total nitrogen, nitrate+nitrite, ammonia, dissolved phosphorus or total phosphorus. There were no chlorophyll a data collected at times corresponding to pH readings. Potential reasons for the two 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. It should also be noted that there are four NPDES permitted dischargers that discharge into segment OKA 01, downstream of the sampling station used to list this segment for pH. These were shown previously in Table 8. All four of these facilities have a permit requirement to monitor and discharge pH. Although these four permitted facilities discharge into the downstream segment (OKA 01), they all discharge downstream of the sampling station used to list this segment. Therefore, these facilities are not contributing to pH excursions measured at the sampling station, but may instead be affecting pH downstream of this sampling station in the downstream portions of this waterbody segment. Therefore, these facilities are potential sources contributing to pH in segment OKA 01.

The growth and respiration of algae was investigated as a source of low pH, but the data do not support algae as a source. 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.

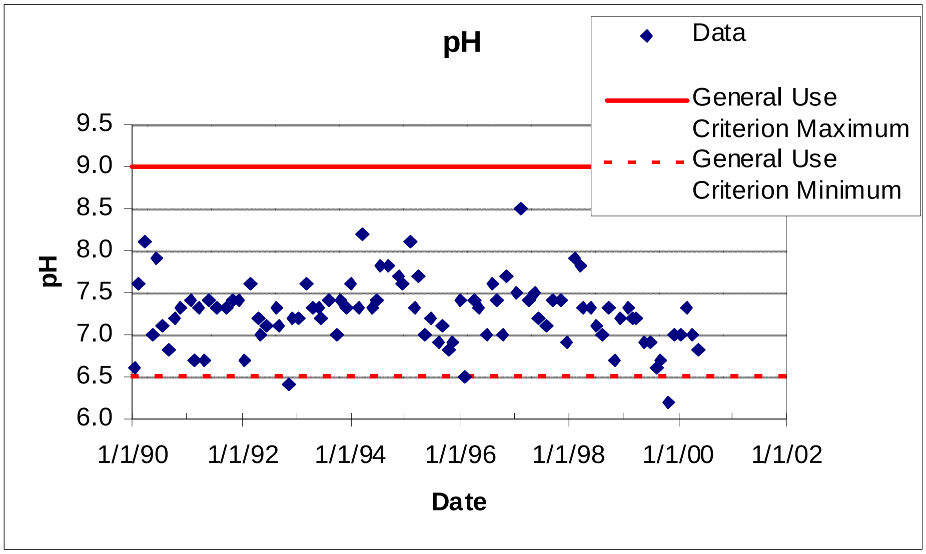

Figure 11. pH vs. general use criterion range at OKA 01

OKA 02 (North Fork Kaskaskia River)

Segment OKA 02 is listed on the 303(d) list for manganese, iron, dissolved oxygen and pH. Designated uses for this segment include public water supply and aquatic life. These two designated uses are partially supported.

Segment OKA 02 is identified as being "evaluated", and no monitoring data were identified for this segment. Segment OKA 02 is located upstream of Segment OKA 01.

According to IEPA (2004a), "any waterbody that has at least one "monitored" assessment is considered a "monitored" waterbody. Illinois EPA considers monitored assessments more reliable than evaluated assessments. Monitored assessments are based on current waterbody-specific monitoring data believed to accurately represent existing resource conditions. In general, assessments that use waterbody-specific biological, chemical, or physical monitoring data no more than five years old are included in this category. Evaluated assessments are resource-quality determinations based on other information that less reliably reflects existing resource conditions in a waterbody, such as: land-use information, location of known point and nonpoint potential sources, monitoring data more than five years old, or volunteer data."

For two reasons, it appears the listing of Segment OKA 02 for iron, manganese, pH and dissolved oxygen is appropriate, even though the assessment was "evaluated". First, segment OKA 02 is located adjacent to segment OKA 01 and the monitoring station used to list that segment. Therefore, the data collected are representative of water draining from this listed segment. Second, the causes listed for segment OKA 02 are the same as those for OKA 01, so the listing of this segment doesn't lead to a new TMDL. Additionally, this portion of the watershed (the portion draining to segment OKA 02) will need to be included in the Segment OKA 01 TMDL to define contributions from the headwaters of the North Fork Kaskaskia River.

Segment OKA 02 was evaluated based on data collected for segment OKA 01. Therefore, the previous discussion for Segment OKA 01 also applies to this segment, with one exception. The point source discharges mentioned as potential sources for segment OKA 01 all discharge downstream of segment OKA 02 and are not potential sources for this segment.

SOI (Patoka Old Reservoir)

The IEPA guidelines (IEPA, 2004a) for identifying manganese as a cause in lakes state that the aquatic life use is not supported if there is at least one exceedance of applicable standard. The guidelines also state that the public water supply use is not supported if, in untreated water, greater than 10% of the observations exceed the applicable standard, for water samples collected in 1999 or later, and for which results are readily available.

Five manganese samples were collected between May and October 2003, with concentrations ranging from 89 to 310 ug/l. Four of the five samples exceeded the public water supply criterion (Figure 12). There were no exceedances of the general use criterion.

Based on the available data, the listing of the Patoka Old Reservoir for manganese is warranted. There are insufficient data to evaluate the relationship of manganese to other parameters. However, based on the watershed characterization, specifically the soil discussion, manganese was identified as being naturally occurring in the watershed and it is thought that it is being transported to this lake (via North Fork Kaskaskia River) through groundwater, watershed runoff and/or streambank erosion. Manganese may also be entering the lake from the bottom sediments (this lake is used as a settling pond), during anoxic conditions, however, there are insufficient data to verify this is occurring.

Finally, as discussed previously for segment OKA 01, a potential minor source of manganese in the watershed may be brine water pumped during oil drilling.

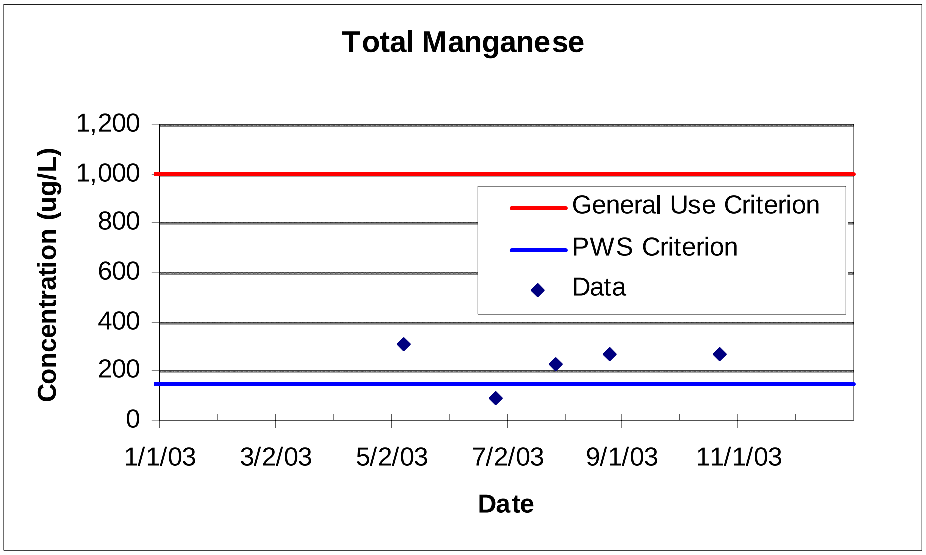

Figure 12. Total manganese at SOI (Patoka Old Reservoir)

SOJ (Patoka New Reservoir)

The IEPA guidelines (IEPA, 2004a) for identifying manganese as a cause in lakes state that the aquatic life use is not supported if there is at least one exceedance of applicable standard. The guidelines also state that the public water supply use is not supported if, in untreated water, greater than 10% of the observations exceed the applicable standard, for water samples collected in 1999 or later, and for which results are readily available. Five manganese samples were collected between May and October 2003. One of the five manganese samples exceeded the public water supply criterion by 140 ug/l (Figure 13). There were no exceedances of the general use criterion for manganese. The listing of Patoka New Reservoir for manganese is justified based on available data.

Patoka New Reservoir is a shallow lake and does not appear to become completely anoxic based on dissolved oxygen profiles from 2003. However, dissolved oxygen is lower in bottom waters in May, June and July and does approach zero.

There are insufficient data to evaluate the relationship of manganese to other parameters. However, based on the watershed characterization, specifically the soil discussion, manganese was identified as being naturally occurring in the watershed and it is thought that it is being transported to this lake (via North Fork Kaskaskia River) through watershed erosion and in dissolved form. Manganese may also be entering the lake from the bottom sediments during anoxic conditions, however, there are insufficient data to verify this is occurring. Finally, as discussed previously for segment OKA 01, a potential minor source of manganese in the watershed may be brine water pumped during oil drilling.

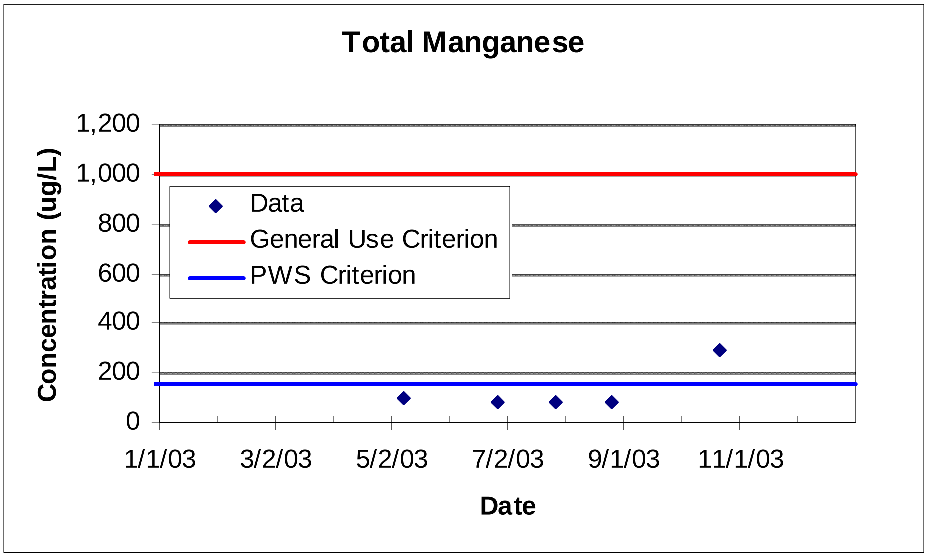

Figure 13. Total manganese at SOJ (Patoka New Reservoir)

CONCLUSIONS

Based on work completed to date, the project team has concluded that TMDLs are warranted for all of the impaired waterbodies in this targeted watershed. Specifically:

- For **Segment OKA 01 of the North Fork Kaskaskia River**, data are sufficient to support the causes listed on the draft 2004 303(d) list, and manganese, iron, dissolved oxygen, and pH TMDLs are warranted.

  Potential sources of manganese and iron are watershed and streambank erosion of soils naturally enriched in manganese and iron. Naturally elevated concentrations in groundwater and release from bottom sediments under anoxic conditions are also potential sources of iron and manganese. Brine from oil wells is a potential minor source of manganese. Finally, a NPDES permitted discharger with a permit to discharge iron may also be contributing iron to this river segment; however, it should be noted that this discharger is located downstream of the sampling station used to list this segment for iron. Because the manganese and iron concentrations reflect natural background conditions, the public water supply and general use criteria for manganese and iron may be difficult to attain.

  Potential sources of pH include the naturally acidic watershed soils and four NPDES permitted dischargers with a permit requirement to monitor pH. Potential sources of low dissolved oxygen include runoff of nutrients from lawns and agricultural lands (cropland and livestock), sewage from failing septic systems and straight pipes and two NPDES permitted dischargers with a permit to discharge biochemical oxygen demand (BOD).

- For **Segment OKA 02 of the North Fork Kaskaskia River,** data collected for segment OKA 01 are sufficient to support the causes listed on the draft 2004 303(d) list, and manganese, iron, dissolved oxygen and pH.

Potential sources of manganese and iron are watershed and streambank erosion of soils naturally enriched in manganese and iron. Naturally elevated concentrations in groundwater and release from bottom sediments under anoxic conditions are also potential sources of iron and manganese. Brine from oil wells is a potential minor source of manganese. Because the manganese and iron concentrations reflect natural background conditions, the public water supply and general use criteria for manganese and iron may be difficult to attain.

A potential source of pH is the naturally acidic watershed soils. Potential sources of low dissolved oxygen include runoff of nutrients from lawns and agricultural lands (cropland and livestock), and sewage from failing septic systems and straight pipes.

- For **Patoka Old Reservoir (SOI),** data are sufficient to support the listing of this reservoir for manganese on the draft 2004 303(d) list. The watershed soils that are naturally enriched in manganese may contribute to elevated manganese concentrations in groundwater. Manganese may also be transported through runoff as well as watershed and streambank erosion. Manganese may also be entering the lake from the bottom sediments during anoxic conditions; however, there are insufficient data to verify this is occurring. A potential minor source may also be brine from oil wells.
- For **Patoka New Reservoir (SOJ),** data are sufficient to support the listing of this reservoir for manganese on the draft 2004 303(d) list. The watershed soils that are naturally enriched in manganese may contribute to elevated manganese concentrations in groundwater. Manganese may also be transported through runoff as well as watershed and streambank erosion. Manganese may also be entering the lake from the bottom sediments during anoxic conditions; however, there are insufficient data to verify this is occurring. A potential minor source may also be brine from oil wells.

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	U S Geological Survey	http://energy.cr.usgs.gov/oilgas/noga/

Data description	Agency	Website
Population information	US Census Bureau	http://factfinder.census.gov/home/saff/main.html?_lang=en)
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/
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	STORET and STORET Modern	http://www.epa.gov/storet/dbtop.html

Table A-2. Local and state contacts

Contact	Agency/ Organization	Contact Means	Phone #	Subject
Norma Hall	US Army Corps of Engineers	telephone	618-594-2484	Norma asked Yvette Dulle (Southwestern Illinois RC&D, Inc.) send LTI several reports on watershed activities
Jon Phillips	Carlyle Lake Ecosystem Partnership	telephone	618-425-3476	Watershed projects in the Kaskaskia River watershed
Doug Schexnayder	Environmental manager for Shell Pipelines	telephone	225-265-1106	Shell Pond water intake
?	Fayette County Ag Extension	telephone	618-283-2753	talked to secretary, left message. Told to speak with the SWCD, not the Ag Extension.
Rodney Schultz	Fayette County Health Department	telephone	618-283-1044 rodney.schultz@starband.net (personal e-mail)	Discussed septic systems and pathogens
Mary Ann Hoeffliger	Fayette County NRCS District Conservationist	telephone	618-283-1095 x3	Discussed watershed characterization questions
Mary Ann Hoeffliger	Fayette County NRCS District Conservationist	e-mail	marymaryann.hoeffliger@il.usda.gov	Requested a copy of the Fayette County Soil Survey
Tony Pals	Fayette County SWCD Resource Conservationist	telephone	618-283-1095 x3	Farming practices, fertilization practices, BMPs
Jenni	Marion County Ag. Extension Office	telephone	618.548.1446	Jenni's boss said that questions should be directed to Tony Antonacci and the Marion County NRCS office.
Tony Antonacci	Marion County District Conservationist	telephone	618-548-2230 x3	BMPs, farming practices and pesticides for Marion County
Melissa Mallow	Marion County Health Department	telephone	618-548-3878 mmallow@ussonet@net	Discussed septic systems and pathogens
Burke Davies	Marion County SWCD Resource Conservationist	telephone	618-548-2230 x3	Farming practices, fertilization practices, BMPs, did not want to be recognized in report
Burke Davies	Marion County SWCD Resource Conservationist	telephone	618-548-2230	Potential sources of iron and manganese in Marion County surface waters.
??	Shell oil facility	telephone	618-432-5753	Shell Pond
Betty Collins	Treasurer of the conservation club	Telephone	618-432-5282	Conservation club 100 lake
Earl Shipley	Village of Patoka Water Department	In person		Discussed various water issues.
Rich Nickels	Illinois Department of Agriculture	Telephone	217-782-6297	Requested Cropland Transect Survey
Sue Ebetsch	Illinois State Data Center	Telephone	217/782-1381	Requested Population projection report (1990-2020)
Laura Biewick	U.S. Geological Survey	Telephone	303-236-7773	GIS data for oil & gas wells

Contact	Agency/ Organization	Contact Means	Phone #	Subject
Kathy Brown	Illinois State Water Survey	Telephone	217-333-6778	USGS gage locations; water supply intakes
Sharie Heller	SW Illinois GIS resource Center		618-566-9493	Discussed CRP maps
Steve Sobaski	IDNR		ssobaski@dnrmail .state.il.us	Formal request for conservation related GIS files
Don Pitts	NRCS	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.Meneghe tti@epa.state.il.us	Lake data and SWAPs
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.st ate.il.us	NPDES DMR data
Jeff Mitzelfelt	IEPA	e-mail	jeff.mitzelfelt@epa .state.il.us	Websites for GIS information
Teri Holland	Illinois EPA	Mail	217-782-3362	Hardcopy lake water quality data

APPENDIX B. PHOTOS

Incised, bare bank of North Fork Kaskaskia River at Vermundy Road

Falling & fallen trees along undercut bank at N. Fork Kaskaskia River at Vermundy Road

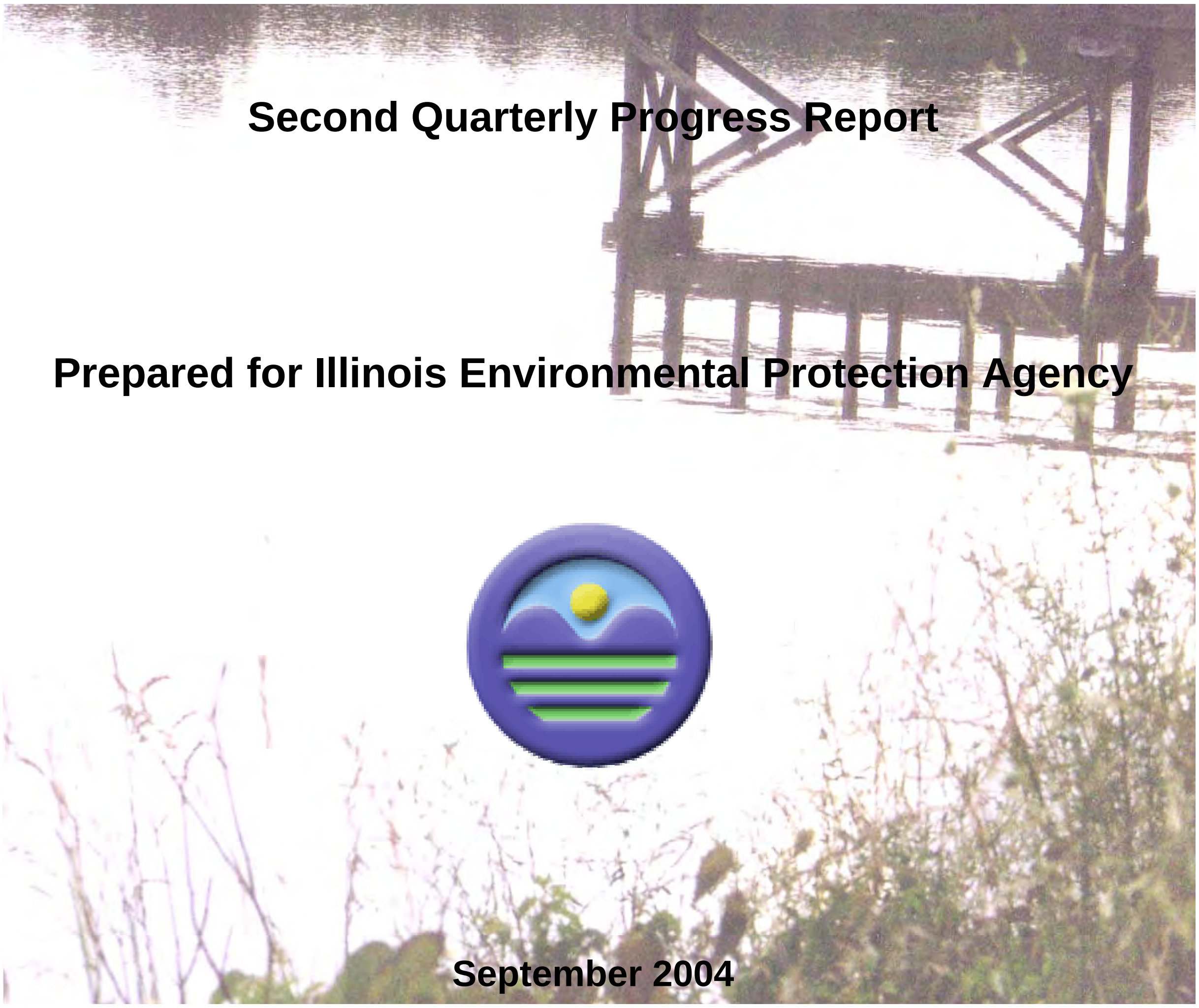
Typical landscape in North Fork Kaskaskia watershed

Patoka Old Reservoir

Patoka New Reservoir (photo taken by IEPA)

Second Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency



September 2004

North Fork Kaskaskia River Watershed

North Fork Kaskaskia River (OKA 01, OKA 02),

Patoka Old Reservoir (SOI), and Patoka New Reservoir (SOJ)

Limno-Tech, Inc.

www.limno.com

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EXECUTIVE SUMMARY

This is the second in a series of quarterly status reports documenting work completed on the North Fork Kaskaskia River project watershed, containing impairments for the North Fork Kaskaskia River (Segments OKA 01, OKA 02), Patoka Old Reservoir (SOI), and Patoka New Reservoir (SOJ). 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, 2004a), 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 North Fork Kaskaskia River 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. The North Fork Kaskaskia River watershed contains predominantly agricultural land use. For the impaired water bodies within this segment, the relevant site-specific characteristics vary across segments. Segment OKA 01 and Segment OKA 02 of the North Fork Kaskaskia River are riverine segments impaired by manganese, iron, dissolved oxygen, and pH. Patoka Old Reservoir (SOI) and Patoka New Reservoir (SOJ) are impoundments, which are listed as being impaired by manganese. The listing of these waterbodies was verified in the first quarterly status report.
- **Management objectives:** These objectives consist of the specific questions to be addressed by the model. For this application, the management objective is to define a credible TMDL.
- **Available resources:** This corresponds to the amount of time and data available to support TMDL development. Water quality data currently exist for all North Fork Kaskaskia River impaired segments. One aspect of this work is to define whether or not the existing data are sufficient to allow development of a credible TMDL.

Results

The recommended approach consists of using the water quality model QUAL2E to address dissolved oxygen problems in Segment OKA 01 and Segment OKA 02 of the North Fork Kaskaskia River. Manganese, iron and pH impairments will be addressed via spreadsheet calculations. Watershed loads for these segments will be defined using an empirical approach. Application of these approaches will require conduct of additional field sampling to synoptically measure sources and receiving water concentrations of oxygen demanding substances, manganese, iron, and pH.

The recommended approach for Patoka Old Reservoir (SOI) and Patoka New Reservoir (SOJ) consists of using the GWLF and BATHTUB models to address the manganese impairment. Specifically, GWLF will be applied to calculate phosphorus loads to the reservoirs over a time scale consistent with their nutrient residence times. BATHTUB will then be used to predict the relationship between phosphorus load and resulting in-lake phosphorus, pH and dissolved oxygen concentrations, as well as the resulting potential for manganese release from sediments. These relationships will be used to define the dominant sources of phosphorus to the lake, and the extent to which they must be controlled to attain water quality standards. In the event that field monitoring conducted for the North Fork Kaskaskia River demonstrates that excursion of the water quality standard is caused by natural levels of manganese in this watershed, no modeling will be required for these reservoirs.

Alternative model frameworks are also provided for the Patoka reservoirs 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 impaired water bodies in the North Fork Kaskaskia River 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 North Fork Kaskaskia River watershed affect the recommendation of specific methodologies.
- **Selection of specific methodologies and future data requirements:** This section provides specific recommendation of methodologies for the North Fork Kaskaskia River 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 North Fork Kaskaskia River 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 in 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, pH, 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 constituent 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 North Fork Kaskaskia River watershed. This chapter presents the general guidelines used in model selection process, and then applies these guidelines to make specific recommendations. In summary, one recommendation is provided for the North Fork Kaskaskia River, and three alternative approaches are provided for the Patoka Old and Patoka New reservoirs, with final selection dependent upon the level of implementation to be immediately conducted for the TMDLs.

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 for the two reservoirs 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 North Fork Kaskaskia River 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 North Fork Kaskaskia River watershed was provided in the first quarterly status report (LTI, 2004). In summary, the impaired waterbodies addressed in this report are all located within the North Fork Kaskaskia River watershed which is part of the larger, Middle Kaskaskia River Watershed. The North Fork Kaskaskia River watershed is located in southern Illinois, approximately 75 miles southeast of Springfield, Illinois, and 60 miles east of St. Louis, Missouri. The two segments of the North Fork Kaskaskia River discussed in this report (OKA 01 and OKA 02) are about 26 miles in combined length and drain a 77.3 square mile watershed. Water is pumped from the North Fork Kaskaskia River into the two Patoka reservoirs discussed below, to provide the village of Patoka with drinking water. The Patoka Old and Patoka New reservoirs are located within the watershed draining to the North Fork Kaskaskia River. These lakes were constructed in 1953 and 1982, respectively and are each 6 acres in size. Water is pumped from the North Fork Kaskaskia River into Patoka Old

Reservoir, which serves as a settling pond. Water from Patoka Old Reservoir is then pumped into Patoka New, which serves as a water supply for the village of Patoka. Agricultural land uses comprise 74% of the watershed, with forest, grassland, and wetlands each comprising 9% or less of the watershed area.

Segment OKA 01 and OKA 02 of the North Fork Kaskaskia River were both placed on the Illinois 303(d) list for impairment due to iron, manganese, pH, dissolved oxygen, and total phosphorus. Patoka New Reservoir (Segment SOJ) and Patoka Old Reservoir (Segment SOI) were listed as being impaired due to manganese. An analysis of data confirmed the appropriateness of the listing for all four waterbodies. The impairment listing for OKA 02 was based upon chemical data and biological/habitat data extrapolated from downstream waterbody (OKA 01), while listings for all other segments were confirmed based on a review of segment-specific data.

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 for all listed segments. Sufficient data are not available 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, data describing the distribution of manganese, iron, oxygen-demanding substances, and pH throughout the watershed, and chlorophyll a data to better define the processes controlling dissolved oxygen (and manganese release from the sediments) within the lakes.

Table 3. Water quality data summary for the North Fork Kaskaskia River watershed

Waterbody segment	Parameter[1]	Sampling station	Period of record (#)	Minimum	Maximum	Average
OKA 01	Manganese (ug/l)	OKA 01	1/1990-4/2003 (129 samples)	78	4463	562
	Dissolved Iron (ug/l)	OKA 01	1/1990-4/2003 (101 samples)	52	3200	259
	pH	OKA 01	1/1990-4/2003 (94 samples)	6.2	8.5	7.2
	Dissolved oxygen (mg/l)	OKA 01	1/1990-4/2003 (129 samples)	0.4	13	6.4
OKA 02 [2,3]	Manganese (ug/l)	N/A	N/A	N/A	N/A	N/A
	Iron (ug/l)	N/A	N/A	N/A	N/A	N/A
	pH	N/A	N/A	N/A	N/A	N/A
	Dissolved oxygen (mg/l)	N/A	N/A	N/A	N/A	N/A
SOI	Manganese (ug/l)	SOI-1	5/2003-10/2003 (5 samples)	89	310	234
SOJ	Manganese (ug/l)	SOJ-1	5/2003-10/2003 (5 samples)	78	290	126

[1]Media is water
[2]Monitoring station OKA-01 is 0.5 miles downstream of the public water supply intake and data from this site was used to assess segment OKA_02 for Public Water Supply use. Biological/habitat data were extrapolated from the downstream segment for the aquatic life use assessment.
[3]No sampling stations were identified for segment OKA 02
N/A = not available

Recommended Approaches

This section provides recommendations for specific modeling approaches to be applied for the North Fork Kaskaskia watershed TMDLs. Table 4 provides recommendations for the North Fork Kaskaskia River segments OKA 01 and OKA 02, while Table 5 provides recommendations for segments SOI and SOJ. Two alternative approaches are provided for the two reservoirs in Table 5, with each approach having unique data needs and resulting degree of detail.

Table 4. Recommended Modeling Approaches for North Fork Kaskaskia River Segments OKA 01 and OKA 02

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 approximate level of control needed
	pH, manganese, iron	Empirical approach	Spreadsheet approach	Low flow stream surveys	Identify man-made vs. natural sources

Table 5. Recommended Modeling Approaches for North Fork Kaskaskia River Segments SOI and SOJ

Modeling Approach	Pollutants considered	Watershed Model	Water Quality Model	Additional data needs	Level of TMDL implementation supported
Recommended					
	Mn	GWLF	BATHTUB	None	Identify primary sources to be controlled; and approximate level of control needed
Alternative 1					
	Mn	None	BATHTUB	None	Identify approximate level of control needed
Alternative 2					
	Mn	SWAT	CE-QUAL-W2	Tributary flow and concentrations	Define detailed control strategies

The recommended approach consists of using the water quality model QUAL2E to address dissolved oxygen problems in Segment OKA 01 and Segment OKA 02 of the North Fork Kaskaskia River. Manganese, iron and pH impairments will be addressed via spreadsheet calculations. Watershed loads for these segments 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 are 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 approach for Patoka Old Reservoir (SOI) and Patoka New Reservoir (SOJ) consists of using the GWLF and BATHTUB models to address the manganese impairment. Specifically, GWLF will be applied to calculate phosphorus loads to the reservoirs over a time scale consistent with their nutrient residence times. BATHTUB will then be used to predict the relationship between phosphorus load and resulting in-lake phosphorus and dissolved oxygen concentrations, and resulting potential for manganese release from sediments. This relationship will be used to define the dominant sources of phosphorus to the lake, and the extent to which they must be controlled to attain water quality standards. 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 Patoka reservoir 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. In the event that field monitoring conducted for the North Fork Kaskaskia River demonstrates that excursion of the water quality standard is caused by natural levels of manganese in this watershed, no TMDL (and therefore no modeling) will be required for these reservoirs.

The first alternative approach would not included 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 approach for Patoka Old Reservoir (SOI) and Patoka New Reservoir (SOJ) would consist of applying the SWAT watershed model to define watershed loads of phosphorus, coupled with application of the reservoir model CE-QUAL-W2 to define hydrodynamics and eutrophication processes. This alternative approach would be capable of defining with some detail the specific action strategies necessary to attain water quality standards.

Assumptions Underlying the Recommended Methodologies

The recommended approach is based upon the following assumptions:

- The only controllable source of manganese to the Patoka reservoirs 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

Application of the recommended approaches 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, manganese, iron, and pH in the North Fork Kaskaskia River.

Should the first alternative approach be selected for the Patoka reservoirs, no data collection is required.

Should the second alternative approach be selected for the Patoka 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 lakes, and
3) define important reaction processes in the Patoka reservoirs

To satisfy objective one, wet weather event sampling of phosphorus and manganese at multiple tributary and mainstem locations in the watershed will be needed. To satisfy objective two, routine monitoring of loads to the lake will be needed. Flows could be estimated using the USGS gage on the East Fork Kaskaskia River; however, water quality sampling and analyses would be required for several wet and dry weather events for: total suspended solids, manganese, total phosphorus, ortho-phosphorus, dissolved oxygen, CBOD, ammonia, organic nitrogen, nitrate-nitrogen and chlorophyll a. To satisfy the third objective, routine in-lake monitoring will be needed. In the Patoka reservoirs, bi-monthly sampling would need to be conducted for water temperature, in addition to total suspended solids, manganese, total phosphorus, ortho-phosphorus, dissolved oxygen, CBOD, ammonia, organic nitrogen, nitrate-nitrogen, and chlorophyll a.

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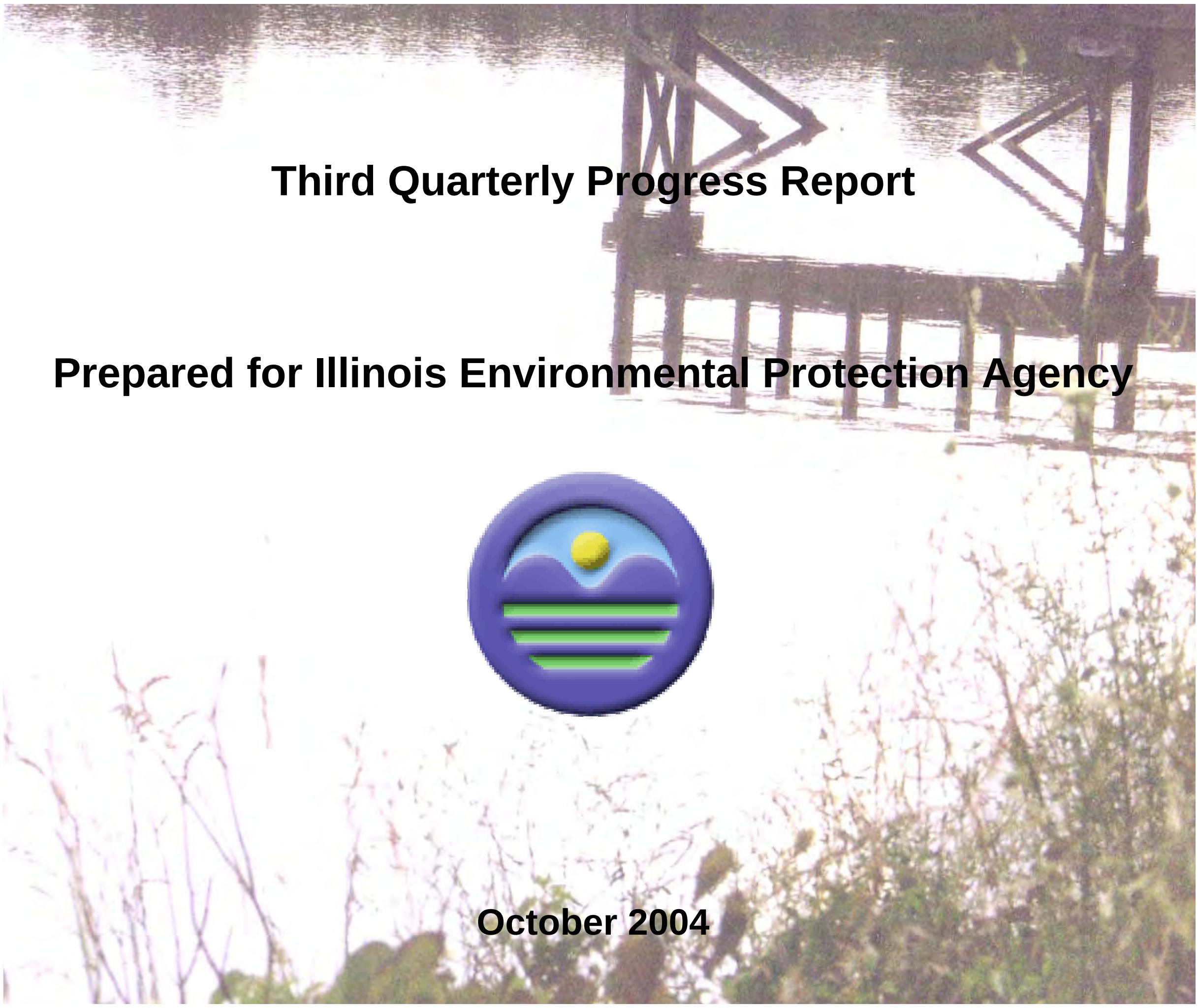

Third Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

October 2004

North Fork Kaskaskia River Watershed

North Fork Kaskaskia River (OKA 01, OKA 02),

Patoka Old Reservoir (SOI), and Patoka New Reservoir (SOJ)

Limno-Tech, Inc.

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EXECUTIVE SUMMARY

This is the third in a series of quarterly status reports documenting work completed on the North Fork Kaskaskia River 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 approach consists of using the water quality model QUAL2E to address dissolved oxygen problems in Segment OKA 01 and Segment OKA 02 of the North Fork Kaskaskia River. Manganese, iron and pH impairments will be addressed via spreadsheet calculations. The recommended approach for Patoka Old Reservoir (SOI) and Patoka New Reservoir (SOJ) consists of using the GWLF and BATHTUB models to address the manganese impairment.

Application of the recommended approaches for the North Fork Kaskaskia River segments will require conduct of additional field sampling to synoptically measure sources and receiving water concentrations of oxygen-demanding substances, manganese, iron and pH. A data collection plan is provided for two low- to medium-flow surveys of the North Fork Kaskaskia River watershed.

Application of the recommended models to the two Patoka reservoirs will require no additional data collection.

INTRODUCTION/PURPOSE

This Stage 1 report describes intermediate activities related to the development of TMDLs for impaired water bodies in the North Fork Kaskaskia River 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 North Fork Kaskaskia River watershed (LTI, 2004), modeling approaches were recommended. The recommended approach consists of using the water quality model QUAL2E to address dissolved oxygen problems in Segment OKA 01 and Segment OKA 02 of the North Fork Kaskaskia River. Manganese, iron and pH impairments will be addressed via spreadsheet calculations. Watershed loads for these segments will be defined using an empirical approach. The recommended approach for Patoka Old Reservoir (SOI) and Patoka New Reservoir (SOJ) consists of using the GWLF and BATHTUB models to address the manganese impairment. As noted in the second quarterly status report, the recommended modeling approaches described above 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. One low-flow survey is recommended to synoptically measure sources and receiving water concentrations of manganese, iron and pH at the seven essential stations in the North Fork Kaskaskia River watershed shown in Figure 1. Two low- to medium-flow surveys are recommended to synoptically measure sources and receiving water concentrations of oxygen demanding substances at these same seven stations. No additional data collection is recommended for the two Patoka reservoirs.

Data Collection Plan

The data collection plan outlined in general terms below, will support development of the recommended approaches for TMDL development. As noted above, one low-flow survey is recommended to synoptically measure sources and receiving water concentrations of manganese, iron and pH at the seven essential stations in the North Fork Kaskaskia River watershed shown in Figure 1. Two low- to medium-flow surveys are recommended to synoptically measure sources and receiving water concentrations of oxygen demanding substances at these same seven stations. No additional data collection is recommended for the two Patoka reservoirs.

Sample collection

Seven essential monitoring stations and six discretionary stations are shown in Figure 1. It is recommended that the seven essential stations should be sampled during low- to medium-flow conditions to support model development and application. Five of the seven essential stations are located along the mainstem of the North Fork Kaskaskia River and two are located on tributaries. One tributary station is located near the mouth of Louse Run, a large tributary to the North Fork Kaskaskia River and another is located on an unnamed tributary which receives discharge from the Patoka STP.

Essential monitoring

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

Table 1. Sampling recommendations

Measurement	Number of low flow surveys recommended
Dissolved oxygen	2
Water temperature	2
Biochemical oxygen demand (BOD),	2
Ammonia	2
Total manganese	1
Total iron	1
pH	1
Channel morphometry	2

In addition, it is recommended that depth and velocity be measured at three of the mainstem sites, at the same time as the water quality sampling, to support flow calculation.

Finally, at a station determined to be representative of the river 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.

Discretionary monitoring

Six discretionary monitoring stations are shown in Figure 1. These stations are located on the larger tributaries to the North Fork Kaskaskia River. Dissolved oxygen, water temperature, BOD, ammonia, flow, manganese, iron and pH, and channel morphometry measurements at these stations would improve the modeling and contributions of watershed sources to instream dissolved oxygen, manganese, iron and pH. However, data collection at these stations is not required to support development of a credible model and, as such, these stations would only be sampled at the discretion of the agency.

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 North Fork Kaskaskia River watershed.

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.

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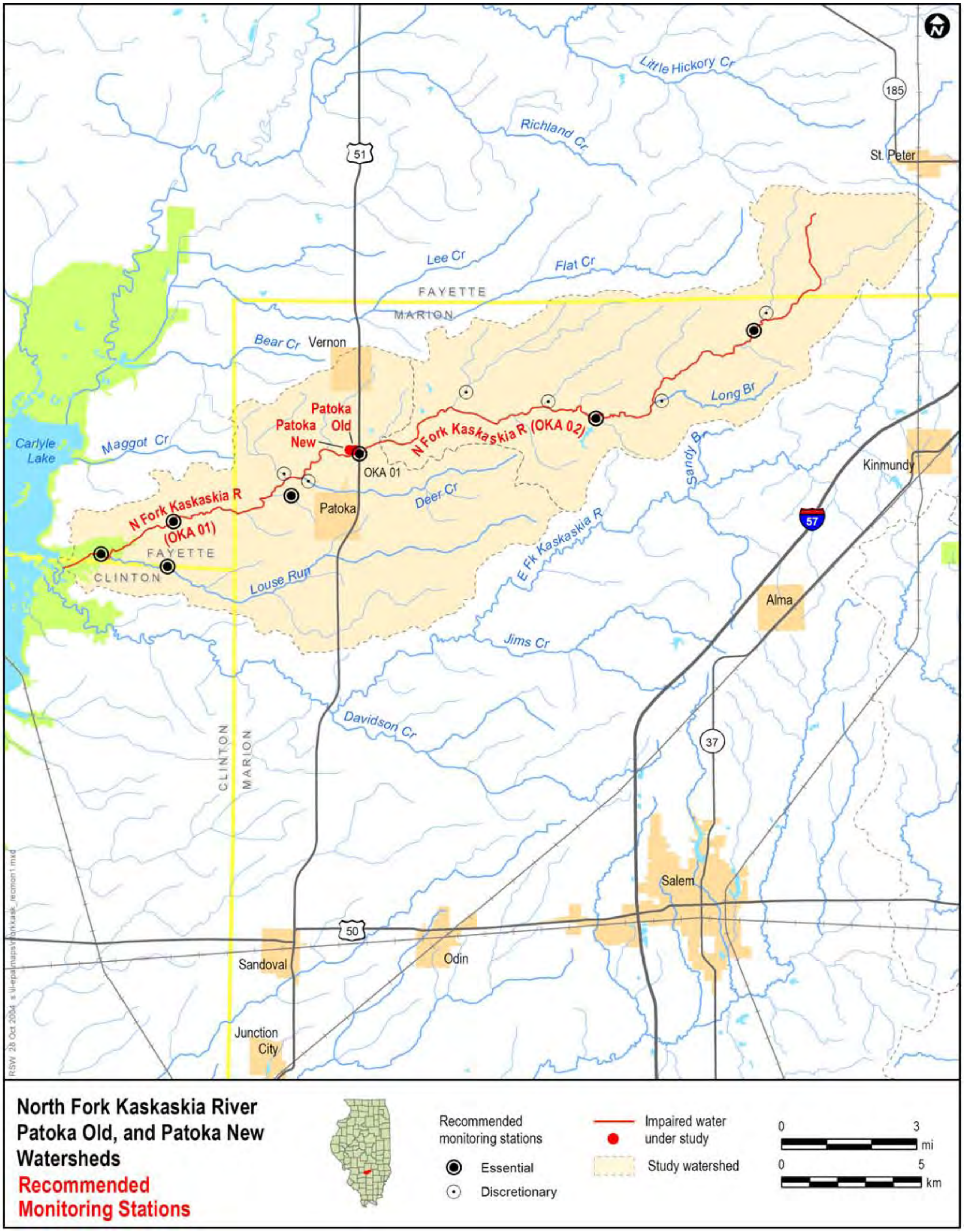
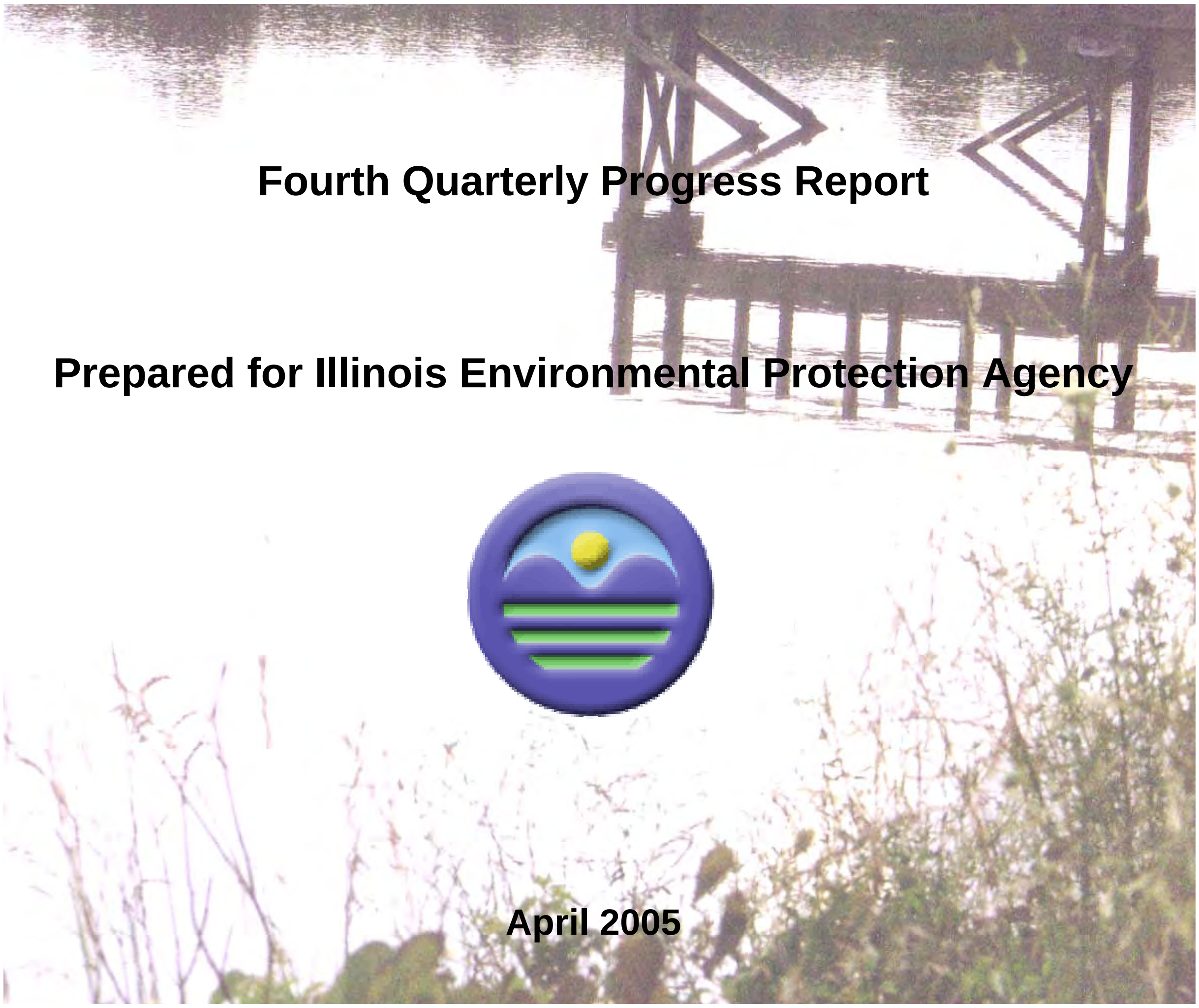


Figure 1. Recommended Stage 2 Sampling Locations



Fourth Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

April 2005

North Fork Kaskaskia River Watershed

North Fork Kaskaskia River (OKA 01, OKA 02),

Patoka Old Reservoir (SOI), and Patoka New Reservoir (SOJ)

Limno-Tech, Inc.

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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 Wednesday, March 16, 2005 in Patoka, Illinois at the Village Civic Center. In addition to the meeting's sponsors, 12 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 at least through April 17, 2005. While there were several general questions, the Marion County SWCD Resource Conservationist expressed skepticism that Manganese and Iron TMDLs could be conducted, given their prevalence in the soils in the watershed. The Village of Patoka expressed concerns regarding whether their disinfection exemption will be affected by the TMDL. One resident expressed frustration that the areas that will likely be targeted under the TMDL implementation plan do not meet the slope requirements of the CRP program and so there are fewer economic incentives to participate in the TMDL implementation plan.

This is the fourth in a series of quarterly status reports documenting work completed on the North Fork Kaskaskia 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

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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 (Appendix 1; 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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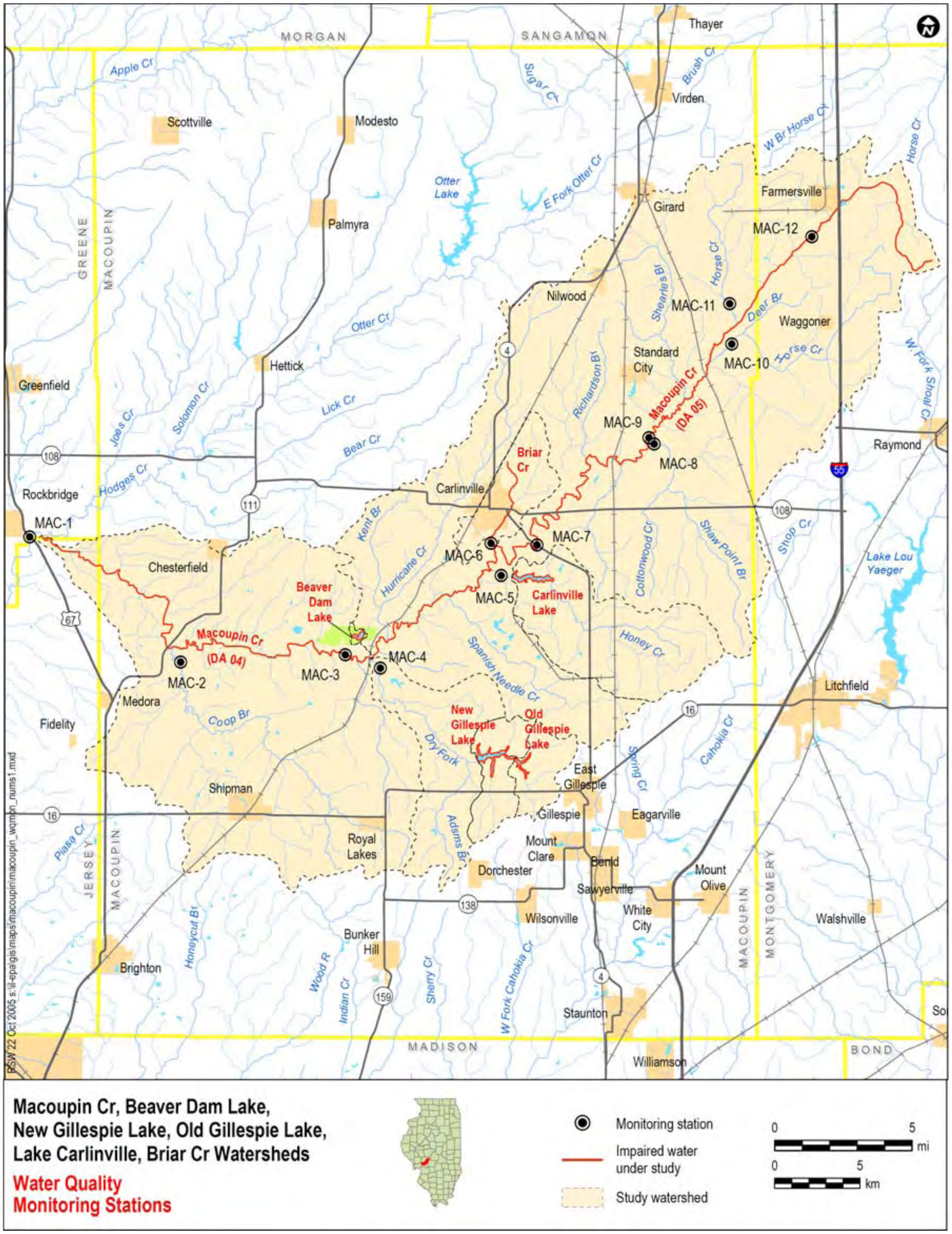

Figure 1. Macoupin Creek Watershed Sampling Locations

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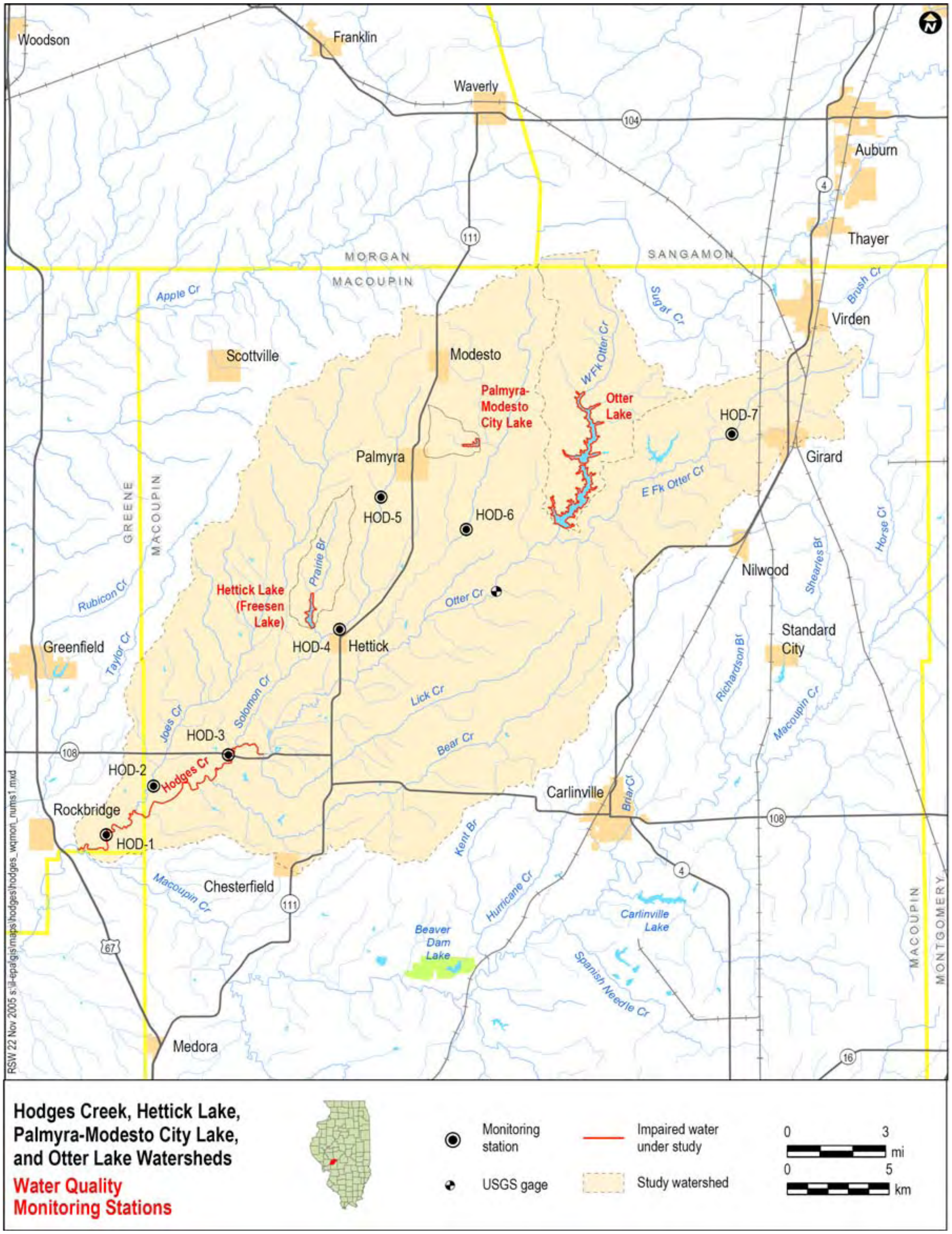

Figure 2. Hodges Creek Watershed Sampling Locations

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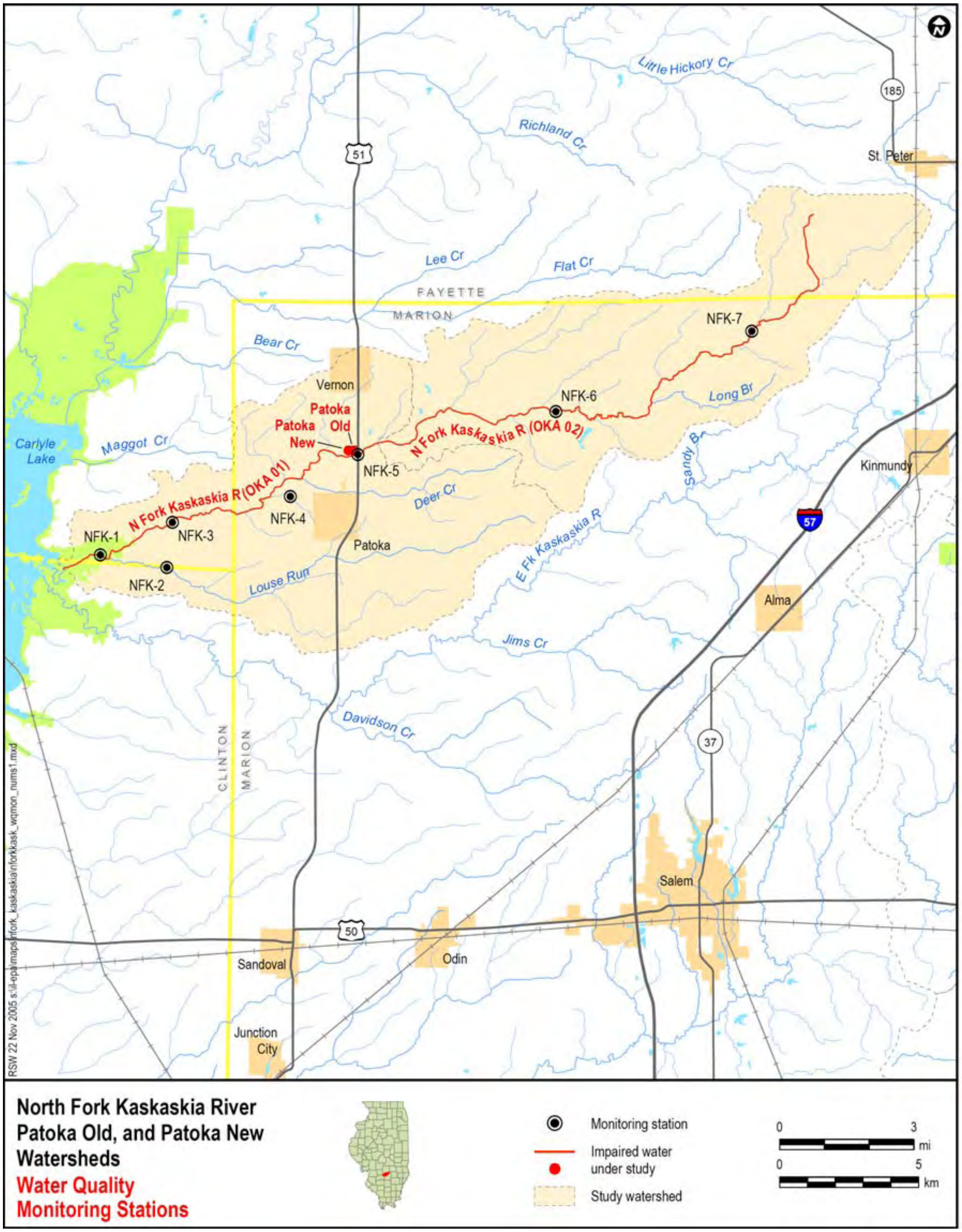

Figure 3. North Fork Kaskaskia River Watershed Sampling Locations

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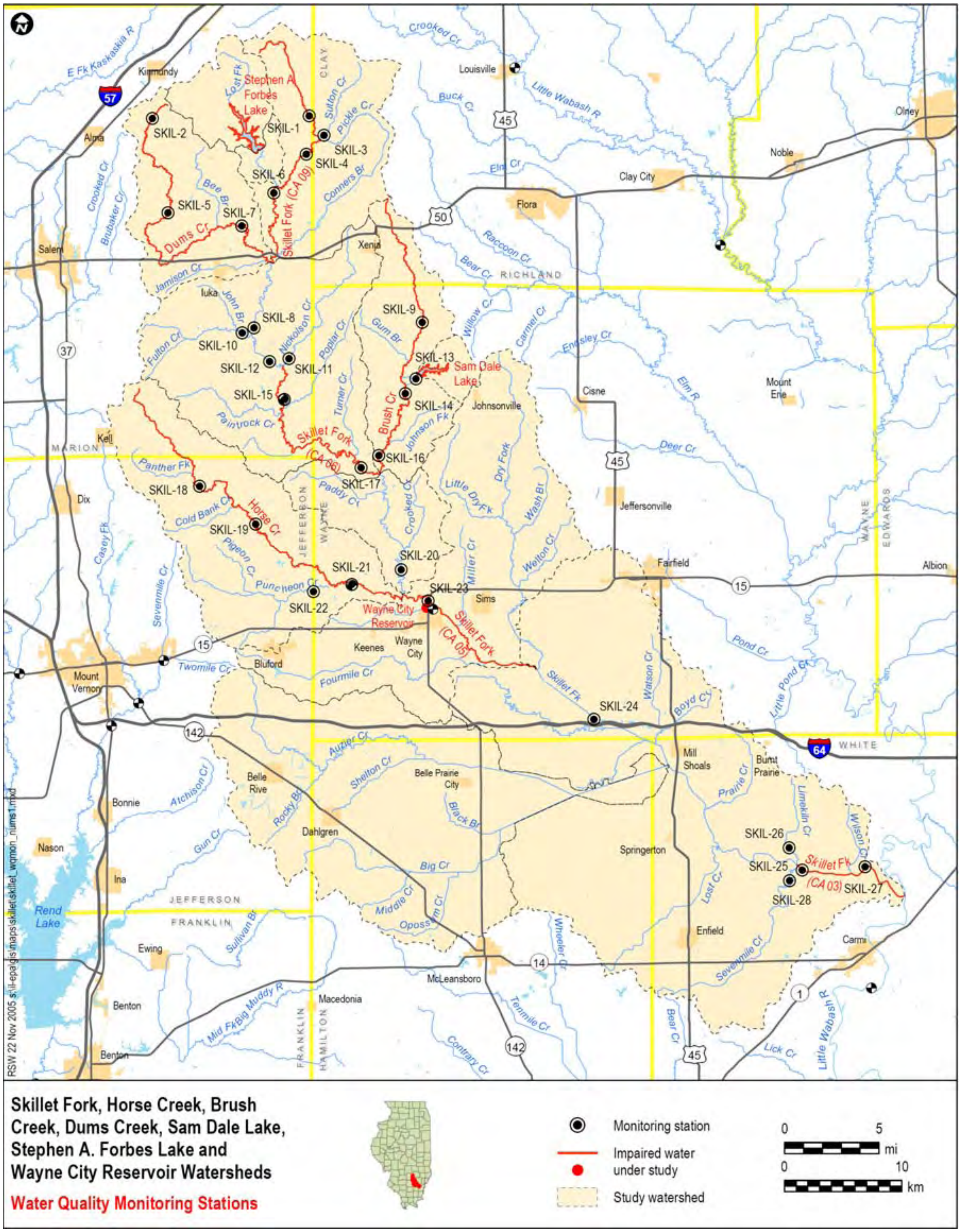

Figure 4. Skillet Fork Watershed Sampling Locations

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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						
Site ID:	HOD-1		HOD-3		HOD-7	
Date	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**
8/24/05	10:35	0.067	9:55	0.008	8:25	0*
10/11/05	8:55	0*	9:55	0.0006	11:45	0.13

North Fork Kaskaskia Watershed						
Site ID:	NFK-1		NFK-5		NFK-6	
Date	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**
8/24/05	12:05	1.62	12:05	1.33	8:40	0.2
10/11/05	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 and are also presented in Appendix 2.

Table 6. Sediment Oxygen Demand Results

Date	Site ID	<=SOD, g/m2/day @ 20c
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

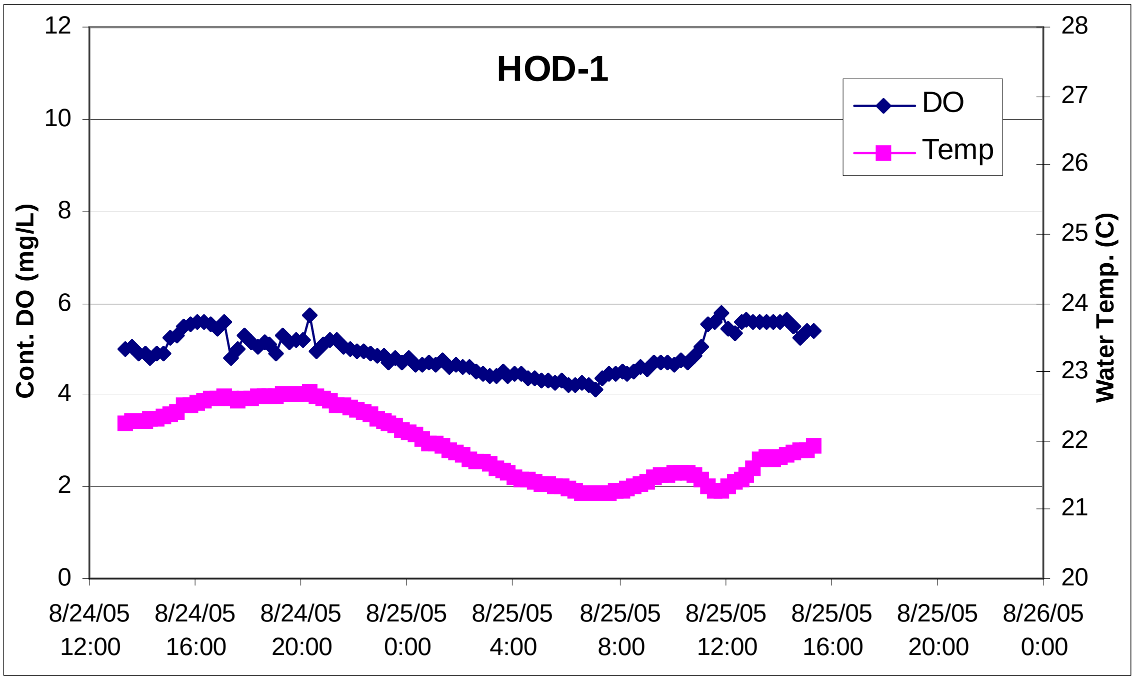

Figure 5. Continuous DO and Temperature at Hodges Creek Station HOD-1

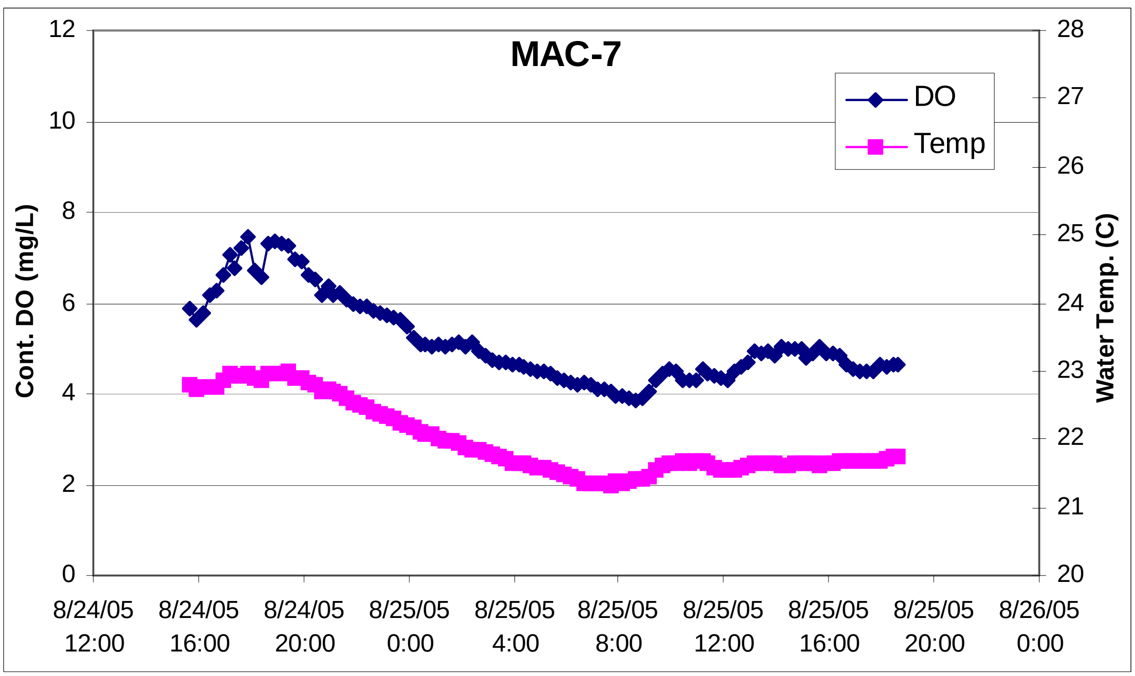

Figure 6. Continuous DO and Temperature at Macoupin Creek Station MAC-7

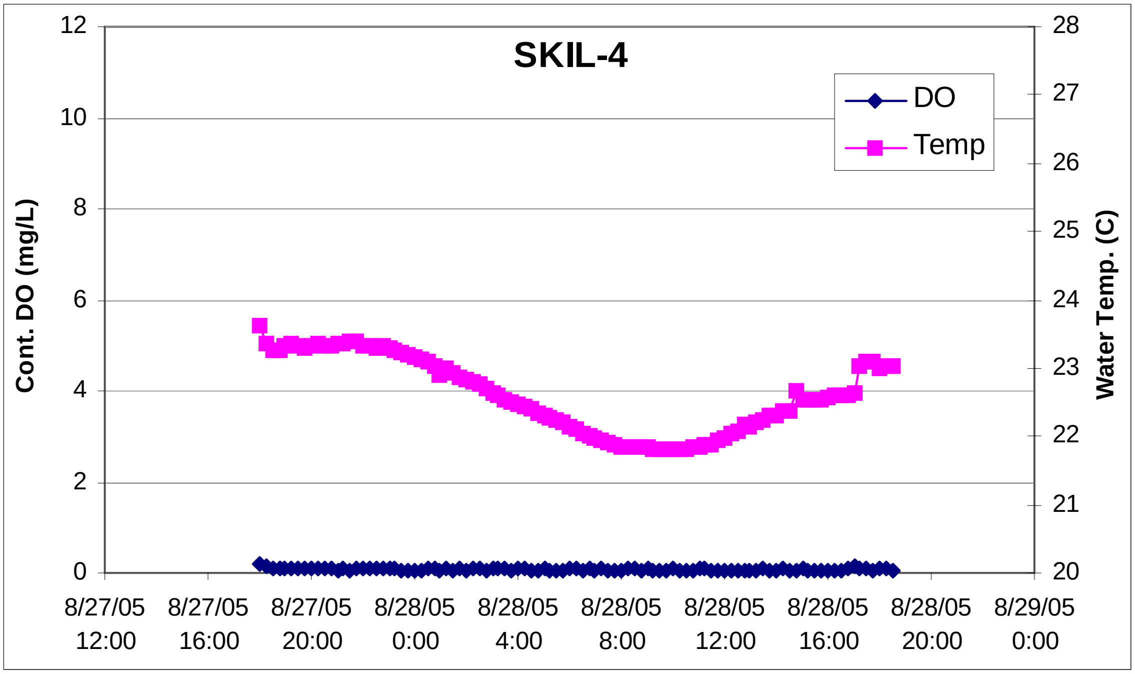

Figure 7. Continuous DO and Temperature at Skillet Fork Station SKIL-4

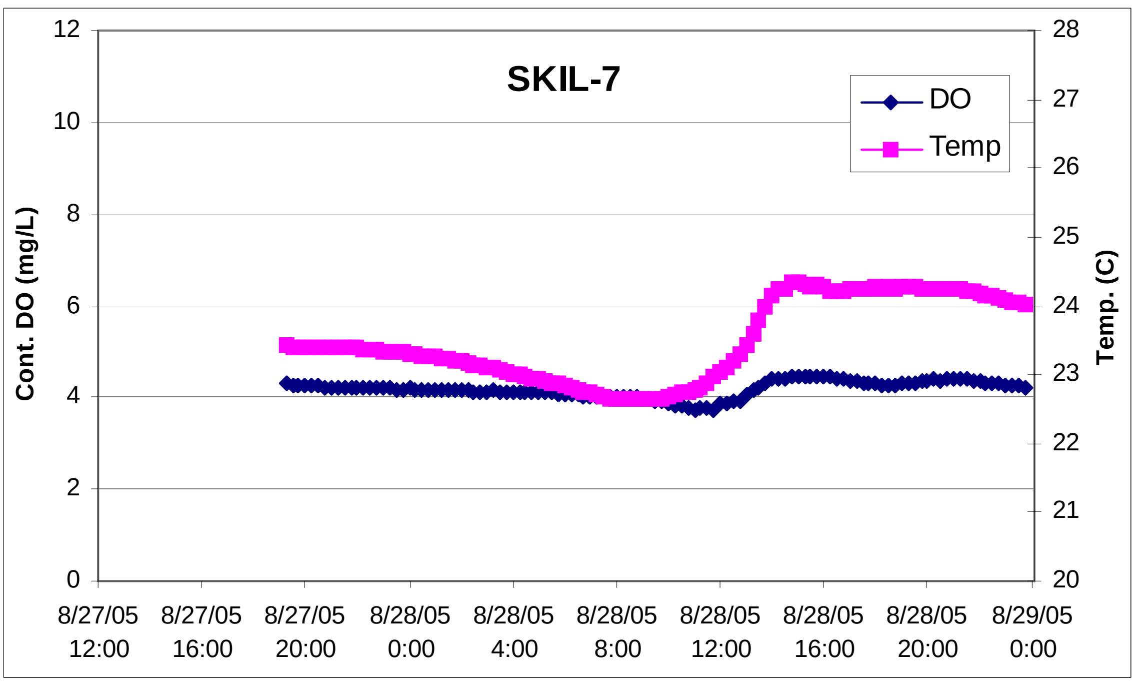

Figure 8. Continuous DO and Temperature at Dums Creek Station SKIL-7

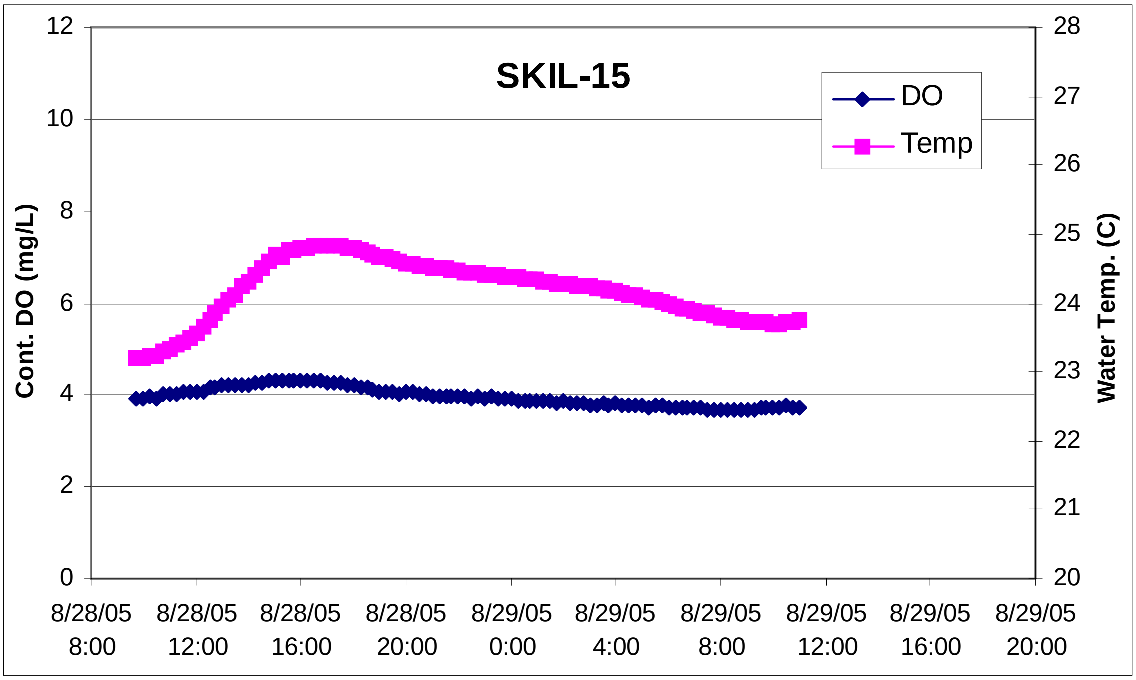

Figure 9. Continuous DO and Temperature at Skillet Fork Station SKIL-15

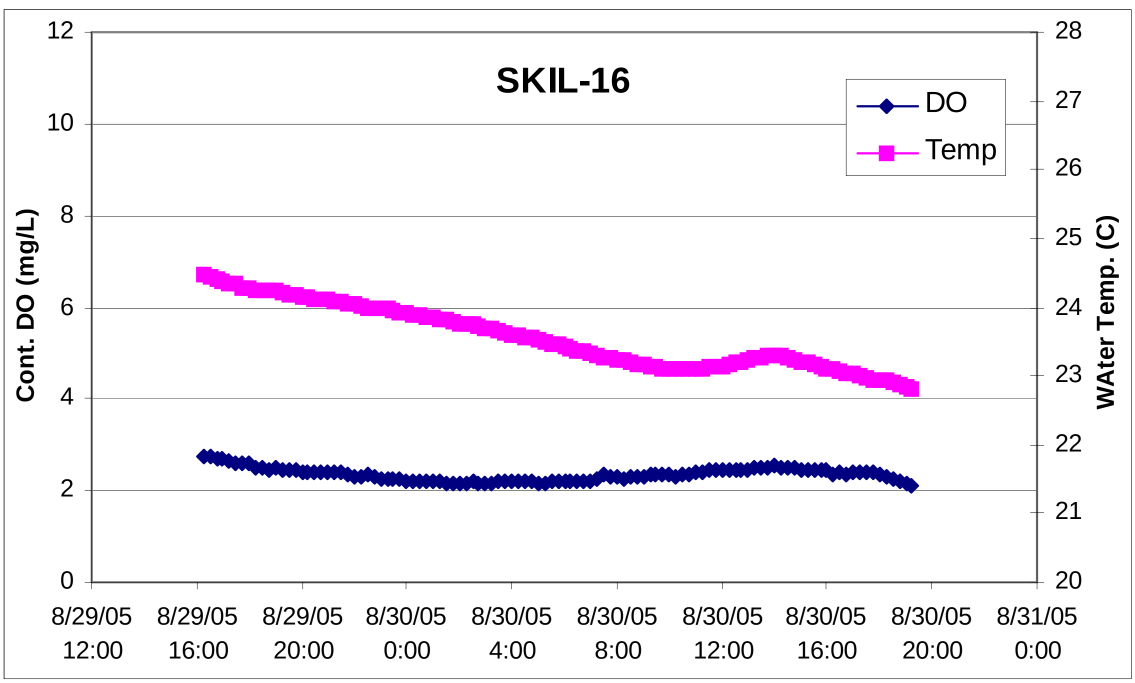

Figure 10. Continuous DO and Temperature at Brush Creek Station SKIL-16

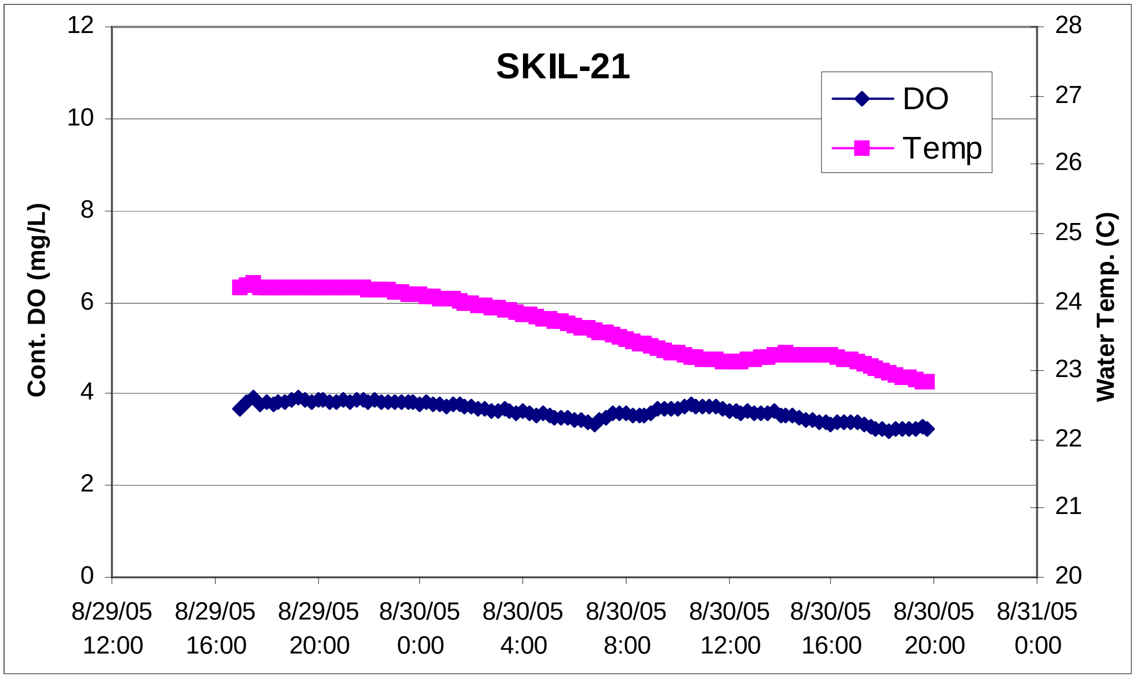

Figure 11. Continuous DO and Temperature at Horse Creek Station SKIL-21

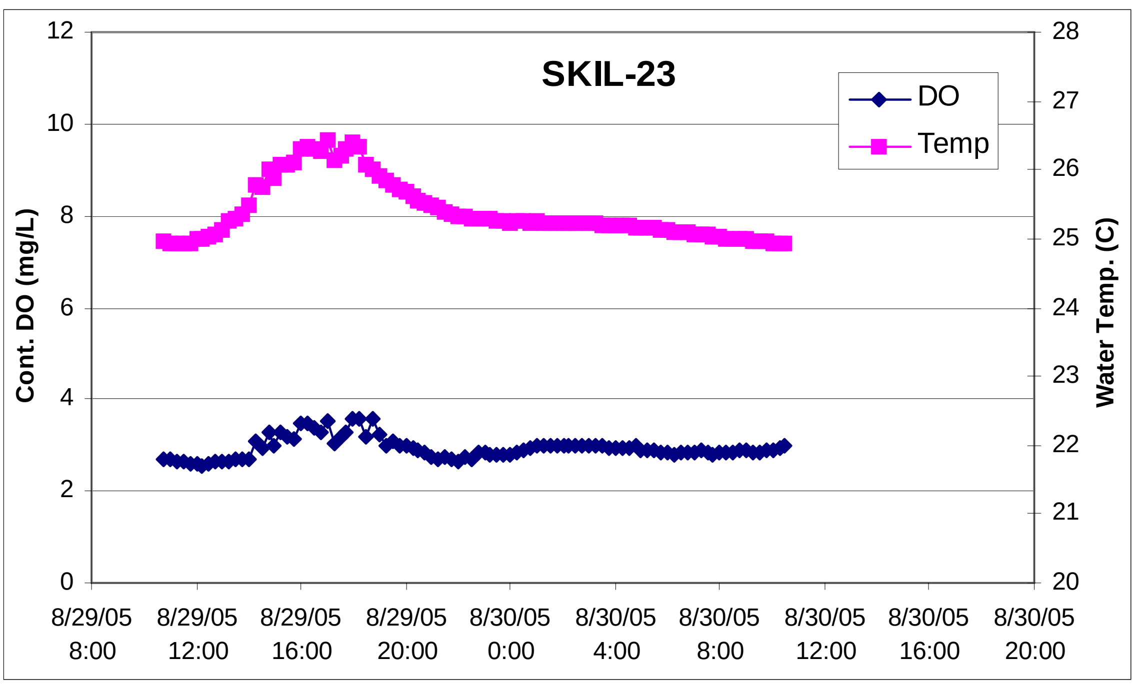

Figure 12. Continuous DO and Temperature at Skillet Fork Station SKIL-23

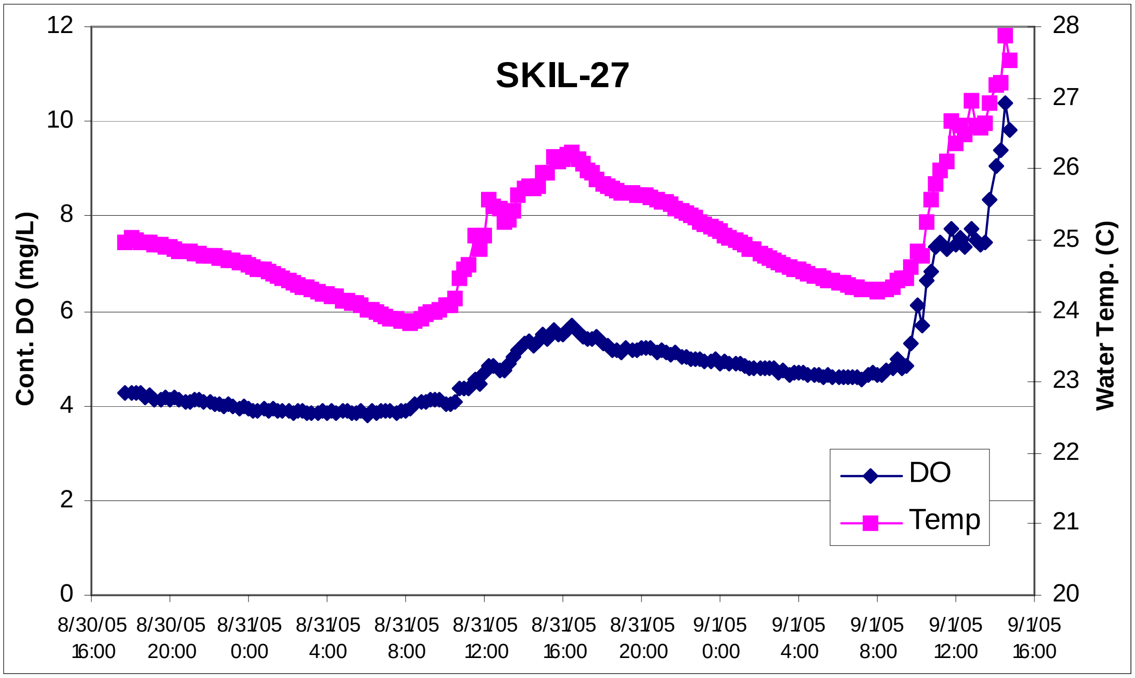

Figure 13. Continuous DO and Temperature at Skillet Fork Station SKIL-27

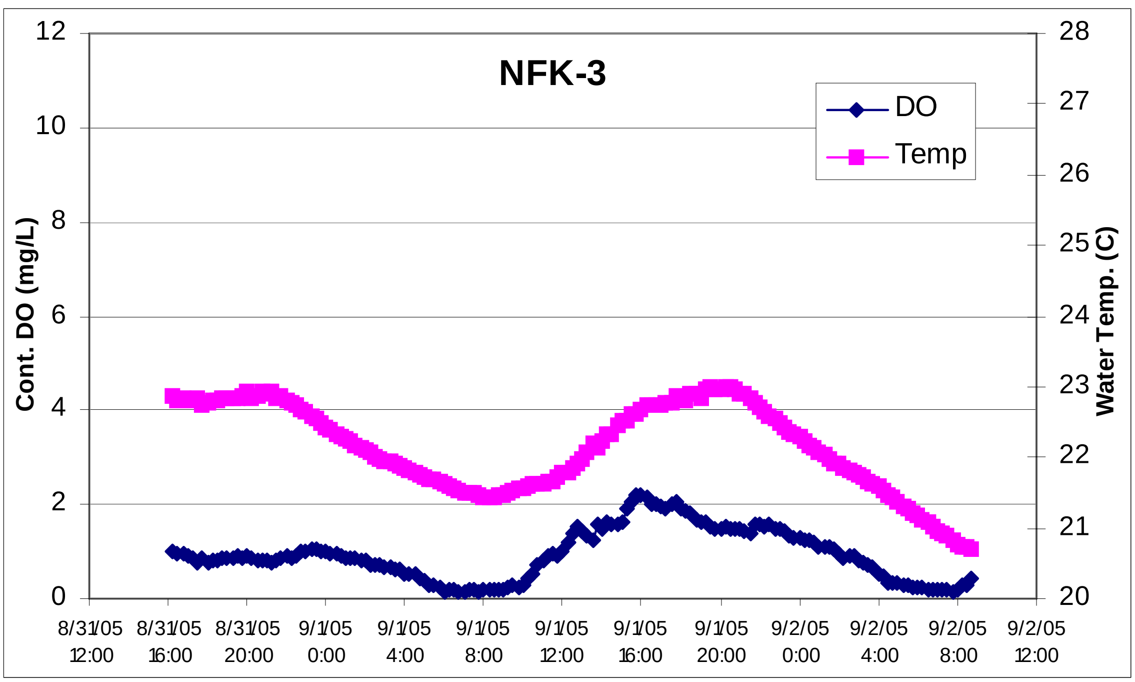

Figure 14. Continuous DO and Temperature at North Fork Kaskaskia River Station NFK-3

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

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Appendix 1. Quality Assurance Project Plan

Quality Assurance Project Plan

for TMDL Sampling Activities
at the following State of Illinois Watersheds:

Macoupin Creek
Hodges Creek
Mauvaise Terre Creek
East Fork Kaskaskia River
North Fork Kaskaskia River
Skillet Fork

Prepared for Illinois Protection Agency

Revised: July, 2005

Project Contact: David Dilks (734) 332-1200, ddilks@limno.com

Limno-Tech, Inc.
Environmental Engineering

Ann Arbor, Michigan

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APPROVAL SHEET

Signature:		Date:	Aug 17, 2005
Name:	David Dilks		
Title:	Project Administrator, Quality Assurance Officer	Affiliation:	Limno-Tech, Inc.
Signature:		Date:	Aug. 17, 2005
Name:	Penelope Moskus		
Title:	Project Manager	Affiliation:	Limno-Tech, Inc.
Signature:		Date:	10/11/05
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Title:	Manager of the IEPA Bureau of Water Surface Water Section	Affiliation:	Illinois Environmental Protection Agency
Signature:		Date:	10/04/2005
Name:	Mike Henebry		
Title:	Bureau of Water QA Officer	Affiliation:	Illinois Environmental Protection Agency
Signature:		Date:	Aug 15, 2005
Name:	David Pott		
Title:	Subconsultant Project Manager	Affiliation:	Baetis Environmental Services, Inc.
Signature:		Date:	
Name:			
Title:		Affiliation:	
Signature:		Date:	
Name:			
Title:		Affiliation:	

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1 Project Management (Group A)

The purpose of the Quality Assurance Project Plan (QAPP) is to document the necessary procedures required to assure that the project is executed in a manner consistent with applicable United States Environmental Protection Agency (U.S. EPA) guidance documents and with generally accepted and approved quality assurance objectives. In this QAPP, U.S. EPA QAPP Guidance Group A requirements are discussed in this section (Section 1), Group B requirements are discussed in Section 2, Group C requirements are discussed in Section 3 and Group D requirements are discussed in Section 4.

This QAPP was prepared to support surface water sampling activities related to the development of Total Maximum Daily Loads (TMDLs) for impaired water bodies in the following six State of Illinois watersheds:

- Macoupin Creek,
- Hodges Creek,
- Mauvaise Terre Creek,
- East Fork Kaskaskia River,
- North Fork Kaskaskia River and
- Skillet Fork.

This QAPP provides guidance and specifications to assure that:

- proper preventive maintenance, equipment calibration, and approved analytical protocols will be implemented so that all field measurements and sampling analytical results will be valid;
- sampling is conducted using sample tracking systems and chain-of-custody procedures which properly identify samples being collected and ensure the control of those samples from field collection through analysis and data reduction;
- records are produced and retained to document the quality of samples collected and analyzed, the validity of applied procedures, and the completeness of the investigation in relation to the approved scope of the project;
- generated data is validated; and
- calculations, evaluations, and decisions completed or deduced during the execution of the study are accurate, appropriate, and consistent with the objectives of the investigation.

The requirements of this QAPP are applicable to the activities of all participants in the investigation. This QAPP will address all anticipated activities necessary to execute the investigation.

1.1. Distribution List (A3)

Each organization listed on the approval sheet will receive a copy of this quality assurance project plan. Individuals taking part in the project may request additional copies of the Quality Assurance Project Plan (QAPP) from the LTI project manager listed in the following section of this QAPP.

1.2. Project Organization (A4)

Limno-Tech, Inc. (LTI) of Ann Arbor, Michigan, and its subcontractors, Baetis

Environmental Services, Inc. (Baetis) of Chicago, Illinois, Brighton Analytical Laboratories (BAL) of Brighton, Michigan, Animal Disease Laboratory – Illinois Department of Agriculture of Centralia, Illinois and ARDL, Inc. of Mt. Vernon, Illinois will conduct activities on behalf of the Illinois Environmental Protection Agency in support of TMDL development for impaired water bodies. LTI will maintain the technical responsibility for implementing the water quality sampling activities for the following watersheds: Macoupin Creek, Hodges Creek, Mauvaise Terre Creek, North Fork Kaskaskia River and Skillet Fork. Baetis will maintain the technical responsibility for implementing the water quality sampling activities for East Fork Kaskaskia River watershed. Brighton Analytical Laboratories (BAL) of Brighton, Michigan will provide analytical laboratory services for LTI. The Animal Disease Laboratory of Centralia, Illinois and ARDL, Inc. of Mount Vernon, Illinois will provide analytical laboratory services for Baetis.

LTI will coordinate activities with its subcontractors. The staff of LTI, Baetis and the laboratories will report to their respective team leaders and project managers for technical and administrative direction. Each staff member has responsibility for performance of assigned quality control duties in the course of accomplishing identified tasks. The quality control duties include:

- completing the assigned task in a quality manner in accordance with the schedule and with established procedures.
- ascertaining that the work performed is technically correct and meets all aspects of the QAPP.

The roles and responsibilities of LTI and Baetis personnel that will work on this project are presented below and in Table 1:

Table 1 Project Organization/Responsibilities

Role	Personnel	General Responsibilities
Project Administrator, Quality Assurance Officer	David Dilks/LTI	General and QA oversight; Review/approval of all work products
Project Manager	Penelope Moskus/LTI David Pott/Baetis	Project management; Direct all field, data evaluation, and reporting activities
Project Engineer/Scientist	Robert Betz, Chris Cieciek, Cathy Whiting/LTI David Pott/Baetis	Supervise all field sampling, quality assurance, data evaluation, and reporting activities
Assistant Project Engineer/Scientist	Chris Behnke, Nick Bogater, Brian Lord, Cullen O’Brien, Ed Verhamme/LTI Chloe Pott/Baetis	Field and technical support

Responsibilities and duties of the analytical laboratories include the following:

- Perform analytical procedures;
- Supply sampling containers and shipping cartons;
- Maintain laboratory custody of samples;
- Strictly adhere to all protocols in the QAPP;
- Notify LTI project manager in advance of any deviations to QA protocols.

Project Administrator. The project administrator is responsible for the overall administration and staffing of the project. As part of the QA/QC responsibilities, the project administrator will:

- Provide for overall direction of project objectives and activities;
- Provide for QA/QC management of all aspects of the project within the stated scope of responsibility;
- Approve reports and other materials for release to members of the project team and other external organizations.

Project Manager. The project manager is responsible for maintaining a clear definition of and adherence to the scope, schedule, and budget of the project. As a part of this responsibility, the project manager will:

- Serve as the communication link with the project team members and client(s);
- Direct all work performed by the organization and its subcontractors;
- Perform final review of field data reductions, report submittals, and presentations;
- Assure corrective actions are taken for deficiencies noted during project activities;
- Maintain budgetary and schedule surveillance of the work.

Project Engineer/Scientist. The project engineer/scientist is responsible for the implementation of field activities, initial data acquisition, health and safety aspects of field activities, and for the proper selection and execution of procedures that have been accepted for use in the investigation. As part of the QA/QC responsibilities, the project engineer/scientist will:

- Supervise assistant project engineers/scientists, technicians, or subcontractors executing data gathering tasks;
- Supervise the collection of samples so that sampling remains representative of actual field conditions;
- Supervise the regular maintenance of equipment to prevent unnecessary equipment failures and project delays caused thereby;
- Review the effectiveness of procedures and suggest changes that will enhance or more efficiently accomplish the objectives of the investigation;
- Prepare and review field data reductions, reports, submittals, and presentations to assure that data and conclusions accurately reflect observed conditions in the field;
- Assist in the maintenance of budgetary and scheduling surveillance.

Assistant Project Engineer/Scientist. The assistant project engineer/scientist is responsible for the assisting in the implementation of field activities, initial data acquisition, health and safety aspects of field activities, and for the proper selection and execution of procedures that have been accepted for use in the investigation. As part of the QA/QC responsibilities, the assistant project engineer/scientist will:

- Perform data gathering and compilation tasks;

- Assist in supervising technicians and subcontractors;
- Assist in reviewing the effectiveness of procedures and suggest changes that will enhance or more efficiently accomplish the objectives of the investigation;
- Assist in the collection of samples so that sampling remains representative of actual field conditions;
- Perform regular maintenance and calibration of equipment to prevent unnecessary equipment failures and project delays caused thereby;
- Assist in the preparation and review of field data reductions, reports, submittals, and presentations to assure that data and conclusions accurately reflect observed conditions in the field.

1.3. Problem Definition/Background (A5)

The project activities associated with this QAPP will include surface water sampling activities to provide data that will be used to support development of TMDLs for impaired water bodies in the following six State of Illinois watersheds:

- Macoupin Creek,
- Hodges Creek,
- Mauvaise Terre Creek,
- East Fork Kaskaskia River,
- North Fork Kaskaskia River and
- Skillet Fork.

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 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 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 compiled, reviewed and evaluated the sufficiency of available data to support TMDL development for the listed watersheds. For each listed watershed, the data review included:

- confirmation of the impairments identified on the 303(d) list,
- further identification of potential sources causing these impairments,
- identification, description and recommendations for methodologies, procedures and/or models to be used in the development of TMDLs, and
- recommendations for additional data needed to support the modeling, where necessary, along with general data collection plans

The additional data collection work approved by Illinois EPA for the above-bulleted watersheds is presented and described in the following subsection of this QAPP. The data will be used for model development and calibration in support of TMDL development. Stream measurements of flow, dissolved oxygen, BOD, ammonia, water temperature, SOD and diurnal dissolved oxygen will be used to support QUAL2E dissolved oxygen modeling in streams. Coliform bacteria measurements will be used support development of a load-duration curve, and pH and iron measurements will support an empirical approach combined with spreadsheet calculations. Finally, manganese measurements in the Skillet Fork watershed will be collected to help determine its source (e.g., mining or natural background).

1.4. Project/Task Description (A6) and Schedule

Monitoring will be conducted within six watersheds in southern Illinois. Table 2 summarizes the scope of work for each watershed. The sampling sites and coordinates for each watershed are presented in Table 3 and depicted on Figures 1-6. All sampling activities will be conducted in accordance with standard operating procedures (SOPs) presented in Appendix A.

Stream Surveys. Stream sampling surveys will be conducted during low to medium flow conditions, as specified in Table 2. Coliform sampling will also be conducted during wet weather conditions. Survey deployment decisions will be based on real-time streamflows at USGS gages in or near the watershed. Low to medium flow surveys will be targeted for dry conditions and periods when the real-time streamflow of the nearest gage is in the vicinity of the 20th percentile flow value, based on the period of record data.. If necessary, low to medium flow surveys may be conducted at slightly higher flows, when the real-time streamflows are in the vicinity of or less than the 50th percentile flow value. Tributary monitoring will be conducted if the tributaries are flowing. The USGS gages and daily mean flow statistics are presented in Table 4.

Surface Water Quality Sampling. Water quality grab samples and water quality measurements will be collected at mid-stream or at the location where maximum flow is observed, where safely practicable. Grab samples will be collected from bridges, where possible, preferably using weighted bottle, dip or direct samplers attached to a pole or a line. Sampling equipment will be decontaminated between locations using a river water rinse followed by a triple deionized water rinse and generally following the SOP for Equipment Cleaning presented in Appendix A. Water quality samples will be stored in an iced cooler prior to and during overnight express shipment to the analytical laboratory following strict chain-of-custody procedures as specified in the Sample Handling, Packing and Shipping SOP presented in Appendix A. As an exception, E. coliform samples will be delivered directly to the laboratory by sampling personnel or picked up in the field by a laboratory courier in order to meet holding times. The samples will be analyzed for BOD_5, ammonia, nitrate-nitrite, coliform bacteria, total manganese and/or total iron, as specified for the different watershed surveys in Table 2.

Surface Water Measurements. Field water quality measurements (i.e., water temperature, pH, dissolved oxygen (DO)) will be recorded using instruments (e.g., YSI, Hydrolab meters) that are calibrated daily in accordance with manufacturer recommendations. Channel morphometry/stream depth, and water velocity measurements will be conducted in accordance with the SOP for Surface Water Flow Measurements in Appendix A. Locations will be selected for channel morphometry/stream depth and water velocity measurements based on two factors: 1) is it a good site for flow calculation; and 2) are the sites spaced out throughout the watershed. Sediment oxygen demand (SOD) and continuous DO measurements will be conducted in accordance with the SOPs for Sediment Oxygen Demand Measurements and Field Water Quality Measurements, respectively, presented in Appendix A. Locations for SOD measurements will be selected in the field, and will be representative of conditions in the river.

Schedule. An example schedule for implementation of data collection activities is presented in Table 5. Field activities will commence within two weeks after Illinois EPA communicates approval of the QAPP and approval to proceed, subject to the sampling requirements (i.e., discharge level and precipitation conditions) being met for each watershed. It is anticipated that all dry weather low or medium flow events will be conducted before the fall wet weather season. Available USGS surface water discharge gages in or near the watersheds will be monitored to determine the occurrence of appropriate flow levels for field deployment. The schedule will be updated as necessary and will be used by the Project Manager to review overall progress of the project.

Table 2 Scope of Work

Watershed	Waterbody name (ID)	Work Description
Macoupin Creek	Macoupin Creek (DA04, DA05), Briar Creek (DAZN)	1 low-to-medium-flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 12 sites (5 mainstem, 7 tribs) • Depth and velocity at 4 mainstem sites (to be determined in the field) • SOD and continuous DO monitoring at 1 site representative of river (to be determined in field) 1 low-to-medium flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 12 sites (5 mainstem, 7 tribs) • Depth and velocity at 4 mainstem sites (to be determined in the field)
Hodges Creek	Hodges Creek (DAG02)	1 low-to-medium-flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 7 sites (1 mainstem, 6 tribs) • Depth and velocity at 4 sites (Hodges Ck @ Cnty Hwy 24, Otter Ck @ Rte 108 bridge, Otter Cr @ Henry Rd, 1 tributary to be determined in the field) • SOD and continuous DO monitoring at 1 site representative of river (to be determined in field) 1 low-to-medium-flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 7 sites (1 mainstem, 6 tribs) • Depth and velocity at 4 sites (Hodges Ck @ Cnty Hwy 24, Otter Ck @ Rte 108 bridge, Otter Cr @ Henry Rd, 1 tributary to be determined in the field)
Mauvaise Terre Creek	North Fork Mauvaise Terre Creek (DDC)	1 low-to-medium-flow survey to measure: • DO, water temperature, BOD, ammonia, channel morphometry at 4 sites (3 mainstem, 1 trib) • Depth and velocity at 2 sites (NF Mauvaise Terre Ck @ IL Rte 123, NF Mauvaise Terre Ck @ Lisbon Rd) • SOD and continuous DO monitoring at 1 site representative of river (to be determined in field)
East Fork Kaskaskia River	East Fork Kaskaskia River (OK01)	1 low-to-medium flow survey to measure: • BOD, nitrate-nitrite, ammonia at 15 locations (3 IEPA legacy stations, 2 other mainstem stations, 10 tributary stations) • SOD at one location representative of river (to be determined in the field) • DO and water temperature at 35 locations (4 IEPA legacy stations, 7 other mainstem stations, 3 NPDES stations, and 21 tributary stations) • Discharge, stream morphology, depth and velocity at 12 locations (3 IEPA legacy stations, 1 other mainstem station, 3 NPDES stations, 5 tributary stations) • Coliform bacteria at 17 stations (3 IEPA legacy stations, 1 other mainstem station, 3 NPDES stations, 10 tributary stations) 1 wet weather survey to measure: • Coliform bacteria at 17 stations (3 IEPA legacy stations, 1 other mainstem station, 3 NPDES stations, 10 tributary stations)

Watershed	Waterbody name (ID)	Work Description
North Fork Kaskaskia River	North Fork Kaskaskia (OKA01, OKA02)	1 low-to-medium-flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 7 sites (5 mainstem, mouth Louse Run, unnamed trib with discharge from Patoka STP) • Depth and velocity at 3 mainstem sites (to be determined in the field) 1 low-to-medium flow survey to measure: • pH and total Fe at 7 locations (5 mainstem, mouth Louse Run, unnamed trib with discharge from Patoka STP) • SOD and continuous DO monitoring at 1 site representative of river (to be determined in field) • DO, temperature, BOD, ammonia, channel morphometry at 7 sites (5 mainstem, mouth Louse Run, unnamed trib with discharge from Patoka STP) • Depth and velocity at 3 mainstem sites (to be determined in the field)
Skillet Fork	Skillet Fork (CA03, CA05, CA06, CA09), Horse Creek (CAN01), Brush Creek (CAR01), Dums Creek (CAW01)	1 low-to-medium flow survey to measure: • Mn at 10 locations (2 each per segments CA03, CA05, CA06, CAN01, CAR01) • pH at 6 locations (2 each per segments CA03, CA05, CA06) • SOD and continuous DO at 7 sites representative of each stream segment (to be determined in field) • DO, temperature, BOD, ammonia, channel morphometry at 28 sites (12 mainstem, 16 tribs) • Depth and velocity at 6 sites representative of each stream segment (excluding segment CA05 with USGS gage) 1 low-to-medium-flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 28 sites (12 mainstem, 16 tribs) • Depth and velocity at 6 sites representative of each stream segment (excluding segment CA05 with USGS gage)

Table 3 Sampling Locations

Stream	Access	TMDL Station ID	Longitude	Latitude
Macoupin Creek Watershed				
Macoupin Cr	U.S. 67	DA 03	-90.19483079590	39.26235488860
Coop Branch	Victory Rd		-90.09148094130	39.19683004470
Macoupin Cr	Shipman Rd	DA 04	-89.97935149050	39.20104990470
Dry Fork	Lake Catatoga Rd		-89.95550388800	39.19418235490
Honey Cr	Brushy Mound Rd		-89.87360501930	39.24342942380
Briar Cr	Crumystone Rd	DAZN	-89.88056449760	39.26046630510
Macoupin Cr	Illinois Route 4	DA 05	-89.84931859880	39.25961219940
Shaw Point Branch	Sumpter Rd		-89.76970998510	39.31317888700
Macoupin Cr	Coops Mound Rd	DA 11	-89.77338896040	39.31660949520
Horse Cr	Sulphur Springs Rd		-89.71699036180	39.36629309710
Horse Cr	Boston Chapel Rd		-89.71851666130	39.38752831690
Macoupin Cr	2nd Rd		-89.66246194810	39.42305698530
Hodges Creek Watershed				
Hodges Cr	County Highway 24	DAG 03	-90.16966141040	39.26941869650
Joes Cr	Joes Cr Rd		-90.14273781100	39.29107306560
Otter Cr	Illinois Route 108		-90.10025314080	39.30522380070
Solomon Cr	Boyscout Rd		-90.03690323180	39.36116261880
Solomon Cr	not at a bridge		-90.01120398330	39.42342966540
unnamed tributary	near end of Wildcat Rd		-89.96479296510	39.40580948260
East Fork Otter Cr	Henry Rd		-89.81287422150	39.44858595910
Mauvaise Terre Creek Watershed				
N Fork Mauvaise Terre Cr	Lisbon Rd	DDC 11	-90.20582047410	39.74953834210
N Fork Mauvaise Terre Cr	Mobil Rd	DDC 12	-90.18233912890	39.74710985640
unnamed tributary	I-72		-90.15349792340	39.73605259570
N Fork Mauvaise Terre Cr	Illinois Route 123		-90.04261497410	39.77177676000

Stream	Access	TMDL Station ID	Longitude	Latitude
East Fork Kaskaskia River Watershed				
East Fork Kaskaskia River	Gerrish Road	B OK 99	-89.12058888889	38.70354444444
East Fork Kaskaskia River	US 51	B OK 01	-89.10000000000	38.69102222222
Davidson Creek	Ferrydale Road	B OKB 11	-89.09776944444	38.68897222222
Davidson Creek	Seven Hills Road	B OKB 12	-89.04945833333	38.67211388889
Davidson Creek	Hoots Chapel Road	B OKB 13	-89.01400000000	38.66851111111
Barden Creek	Seven Hills Road	B OKBA 11	-89.04880833333	38.68203055556
East Fork Kaskaskia River	County Rd 1600	B OK 11	-89.07460833333	38.70666666667
East Fork Kaskaskia River	Marshall Creek Road	B OK 12	-89.03108888889	38.72515833333
East Fork Kaskaskia River	McNicol Road	B OK 02	-89.01072500000	38.73550000000
Jims Creek	Marshall Creek Road	B OKC 11	-89.03095555556	38.71138333333
Jims Creek	Jims Creek Road	B OKC 12	-89.00461388889	38.70933055556
Jims Creek	Oak Grove Road	B OKC 13	-88.97185555556	38.72206944444
Wills Creek	Alma Hatchery Road	B OKCA 11	-88.98985555556	38.70728611111
Warren Branch	Bilek Road	B OKG 11	-88.94855277778	38.75850555556
Warren Branch	Hicks Road	B OKG 12	-88.93192777778	38.73668055556
unnamed tributary 1	Hester Lane	B OKGZ 11	-88.91284722222	38.72951388889
unnamed tributary 2	Malone Road	B OKGZ 21	-88.92349166667	38.72885833333
East Fork Kaskaskia River	Kinoka Road	B OK 13	-88.94912500000	38.76224444444
unnamed tributary 3	County Road 1425	B OKZ 11	-88.87928611111	38.77494722222
unnamed tributary 4	West Case Street	B OKZ 21	-88.85903888889	38.77711388889
East Fork Kaskaskia River	St Peter Road	B OK 03	-88.84549166667	38.80626111111
East Fork Kaskaskia River	Gentry Road	B OK 14	-88.85922777778	38.80478611111
Lone Grove Branch	Gentry Road	B OKE 11	-88.86239166667	38.81023611111
Lone Grove Branch	County Road 700	B OKE 12	-88.84495555556	38.83899722222
Lone Grove Branch	County Road 800	B OKE 13	-88.83516944444	38.85336111111
unnamed tributary 5	County Road 2200	B OKEZ 11	-88.84451111111	38.85566388889
East Fork Kaskaskia River	Blomberg Road	B OK 15	-88.82674722222	38.80373888889
unnamed tributary 6	Vandeveer Street	B OKFZ 11	-88.82664722222	38.78469166667
Schneider Springs Branch	Illinois Route 37	B OKF 11	-88.81688055556	38.79656667000
East Fork Kaskaskia River	Sullivan Road	B OK 16	-88.80781666667	38.81533333000

Stream	Access	TMDL Station ID	Longitude	Latitude
unnamed tributary 7	local Farina street	B OKZ 31	-88.78804722222	38.82535555556
unnamed tributary 8	local Farina street	B OKZ 41	-88.78504722222	38.82707777778
unnamed tributary 7	Echof Street	B OKZ 32	-88.78126944444	38.83217500000
unnamed tributary 7	Illinois Road 185	B OKZ 33	-88.77479166667	38.83786111000
East Fork Kaskaskia River	Echof Street	B OK 17	-88.79771388889	38.82601111111
North Fork Kaskaskia River Watershed				
North Fork Kaskaskia River	County Road 300	OKA 01	-89.19385616200	38.74162579850
Louse Run	County Road 2150		-89.16621508190	38.73750964400
North Fork Kaskaskia River	County Road 100		-89.16377644200	38.75219332070
unnamed tributary	not at a bridge		-89.11480254660	38.76036325090
North Fork Kaskaskia River	U.S. 51		-89.08657432240	38.77396168120
North Fork Kaskaskia River	not at a bridge		-88.98827934220	38.78507402690
North Fork Kaskaskia River	Hadley Rd		-88.92251900000	38.81332160000
Deer Cr	Boat Dock Rd		-89.10775406760	38.76519444490

Stream	Access	TMDL Station ID	Longitude	Latitude
Skillet Fork Watershed				
Skillet Fork	County Highway 1	CA 03	-88.16415217920	38.15479579740
Limekiln Cr	not at a bridge		-88.22938678370	38.16103442950
Sevenmile Cr	not at a bridge		-88.23160843460	38.15357838750
Skillet Fork	County Road 475	CA 02	-88.28406719800	38.16359967360
Skillet Fork	~1 mi south of County Road 500N		-88.49457745840	38.31343869660
Skillet Fork	near Illinois Route 15	CA 05	-88.58337492580	38.35831917750
Puncheon Cr	near County Rd 100E		-88.68415188910	38.37476836780
Horse Cr	County Road 200E	CAN 01	-88.66257719530	38.37677587620
Skillet Fork	County Road 900N		-88.61409624450	38.38777369600
Horse Cr	Malecki Rd		-88.75649378860	38.42393172170
Horse Cr	Moonbeam Ln		-88.81111003440	38.45344064110
Skillet Fork	County Highway 13		-88.65238195360	38.46648093630
Brush Cr	County Highway 27	CAR 01	-88.63489866570	38.47584424840
Skillet Fork	Strt 161 Extension	CA 06	-88.72705842260	38.51960397070
Brush Cr	County Highway 16		-88.60850107560	38.52338314200
Bob Branch	County Road 1900N		-88.59792835420	38.53449893060
Skillet Fork	at end of Seed House Rd		-88.74108667380	38.54880816290
Nickolson Cr	Dago Hill Rd		-88.72201515260	38.55124806790
Fulton Cr	Landmark Rd		-88.76797079850	38.57135034760
Brush Cr	County Road 2200N		-88.59131791570	38.57809407280
Skillet Fork	near end of Blank Rd	CA 08	-88.74828647270	38.59112024710
Dums Cr	Landmark Rd	CAW 04	-88.76750287030	38.65369981820
Skillet Fork	near end of Burkett Rd		-88.73375590070	38.65647408140
Dums Cr	Bee Branch Rd		-88.83988279890	38.66420459560
Skillet Fork	at end of County Road 80E	CA 09	-88.69735030890	38.71610228030
Sutton Cr	County Road 150		-88.68603981220	38.72281392080
Dums Cr	Williams Rd		-88.85472799280	38.73694029780
Skillet Fork	near Krustinger Rd		-88.70500602780	38.74410228390

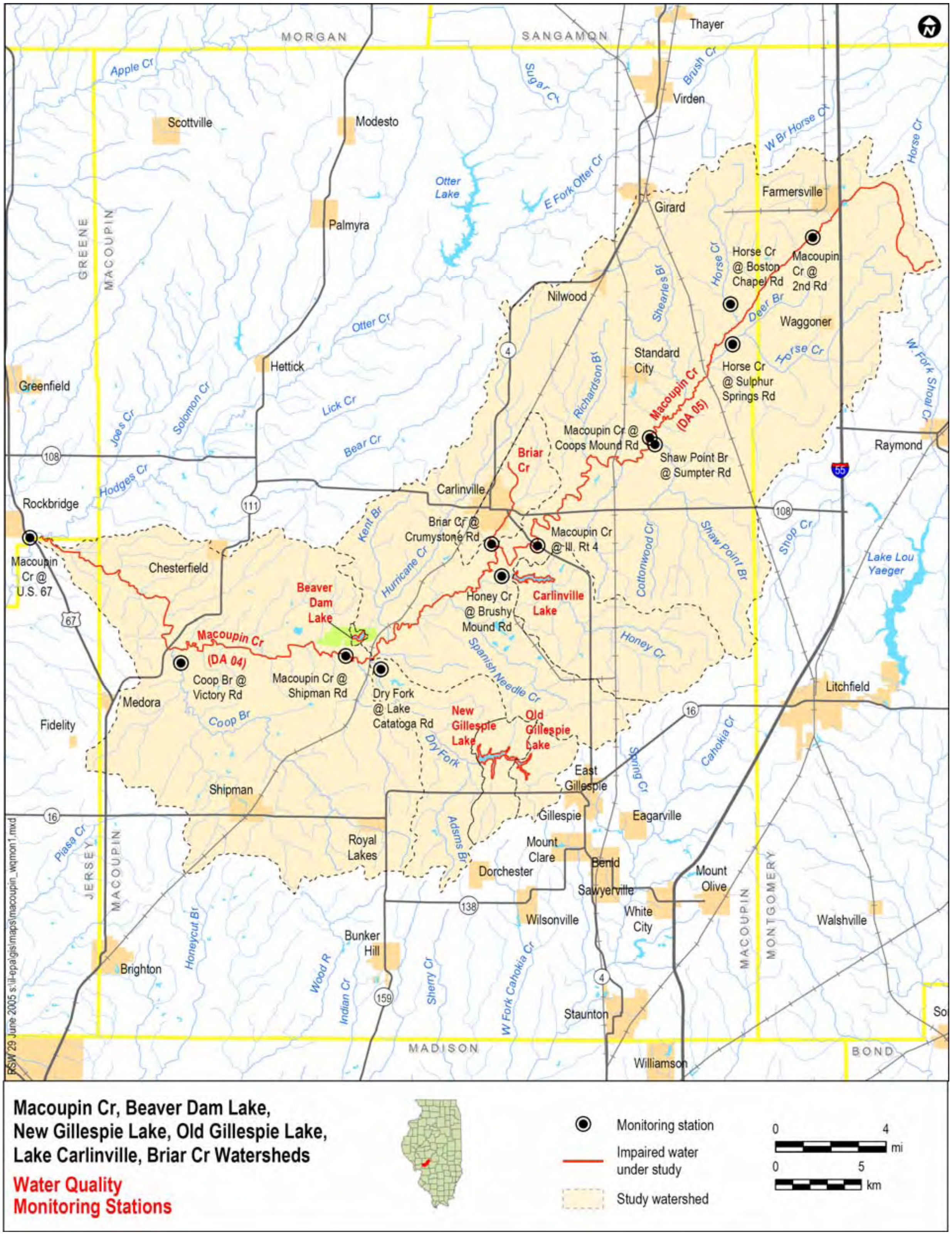

Figure 1. Macoupin Creek Watershed Sampling Locations

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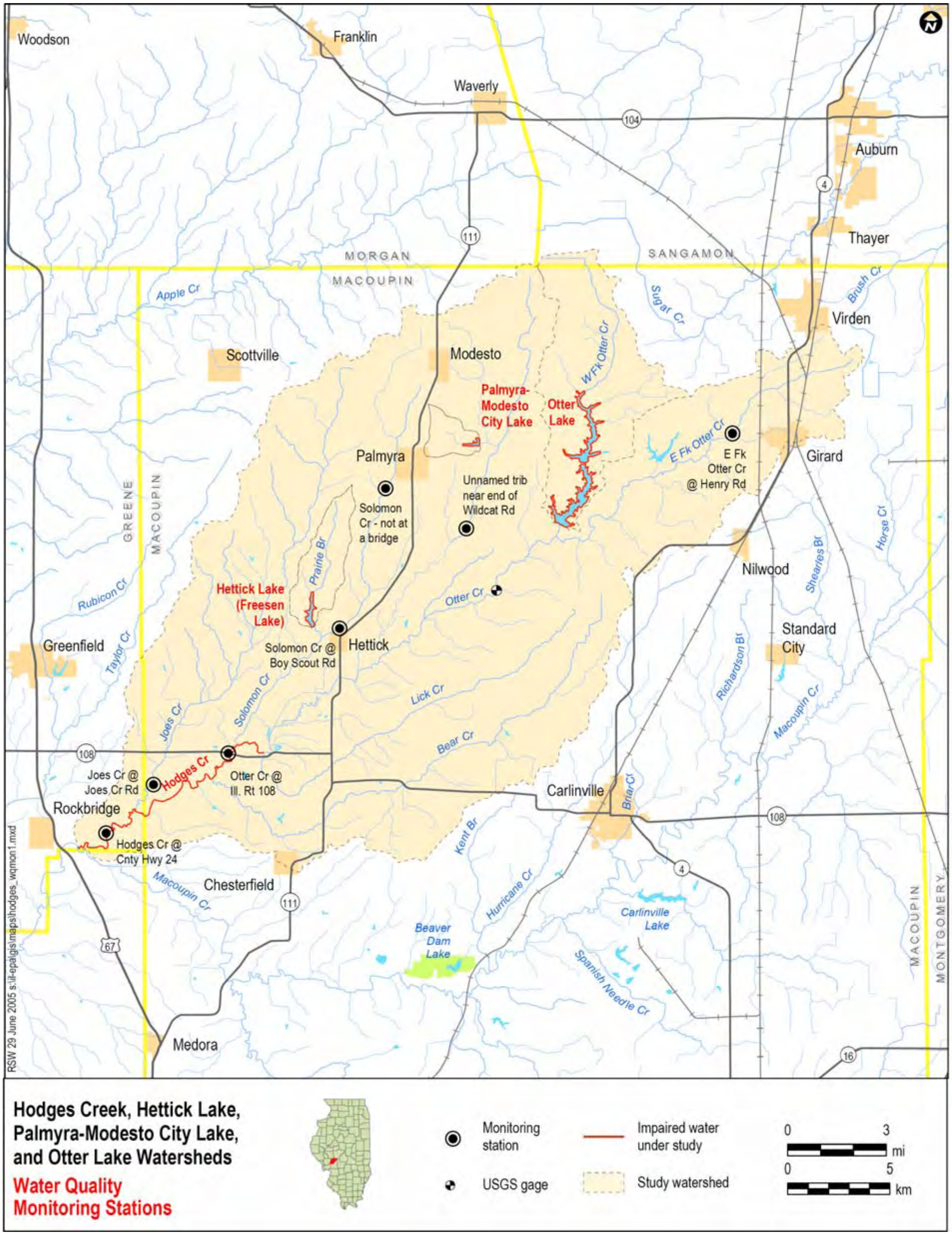

Figure 2. Hodges Creek Watershed Sampling Locations

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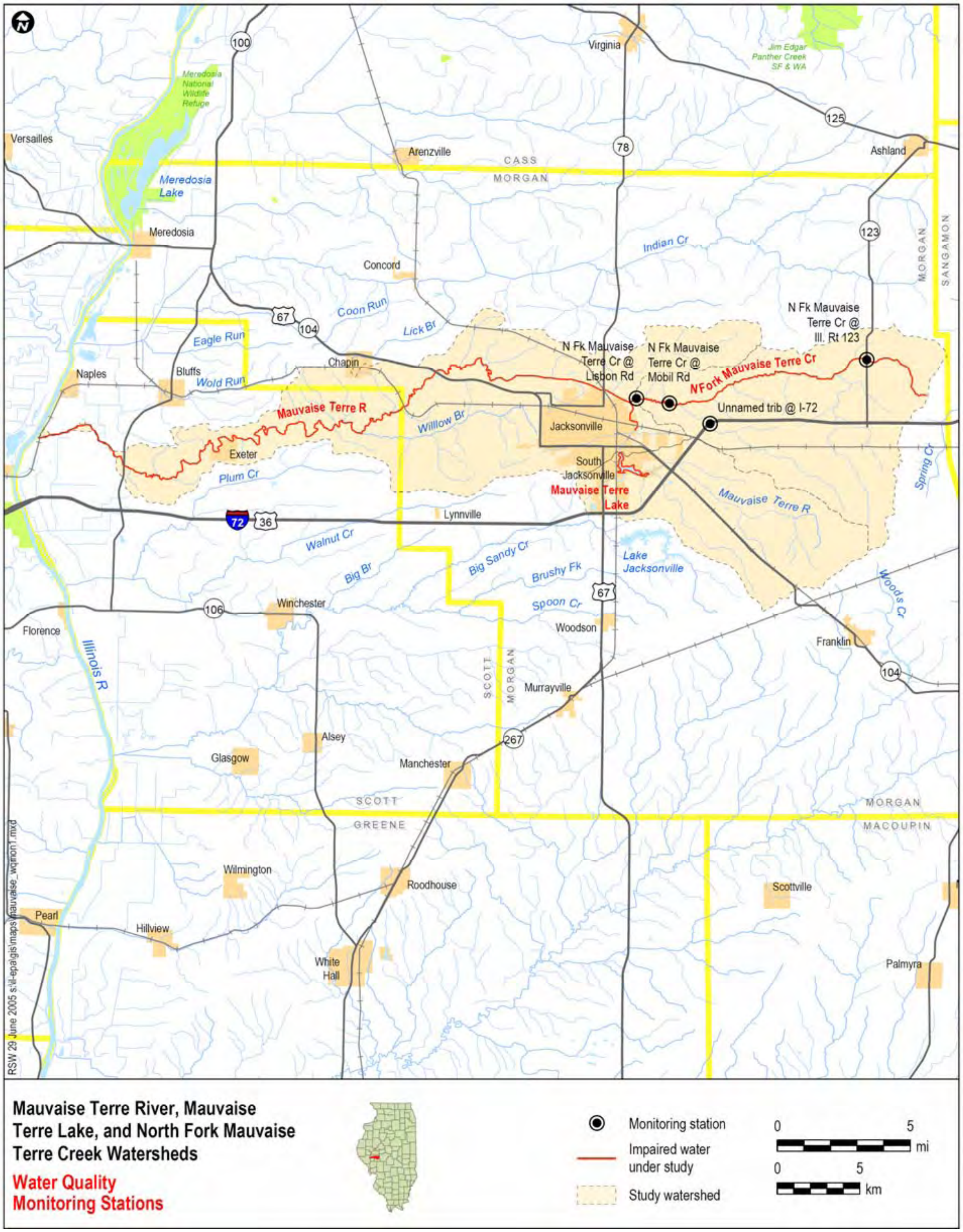

Figure 3. Mauvaise Terre Creek Watershed Sampling Locations

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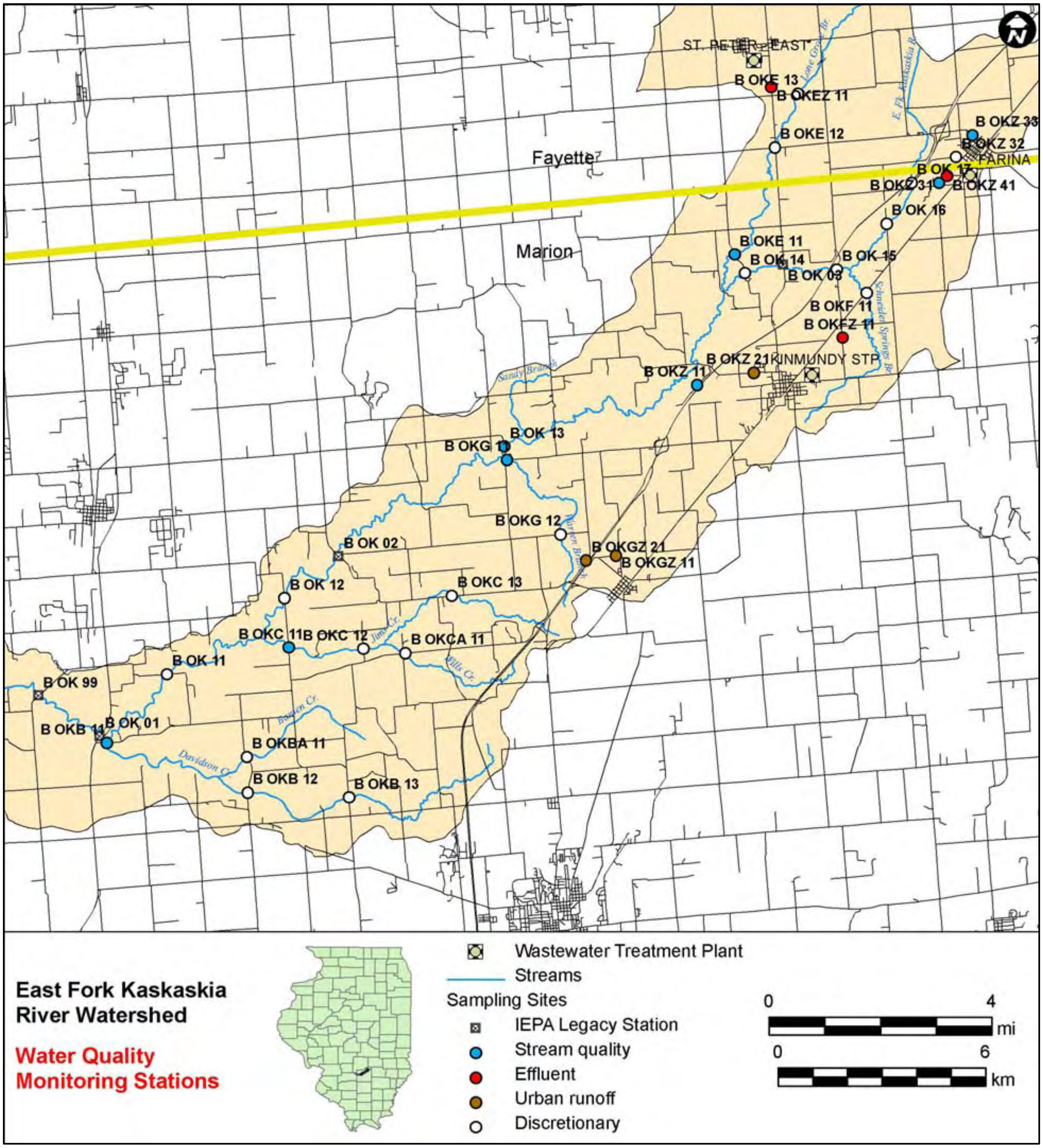

Figure 4. E. Fork Kaskaskia River Watershed Sampling Locations

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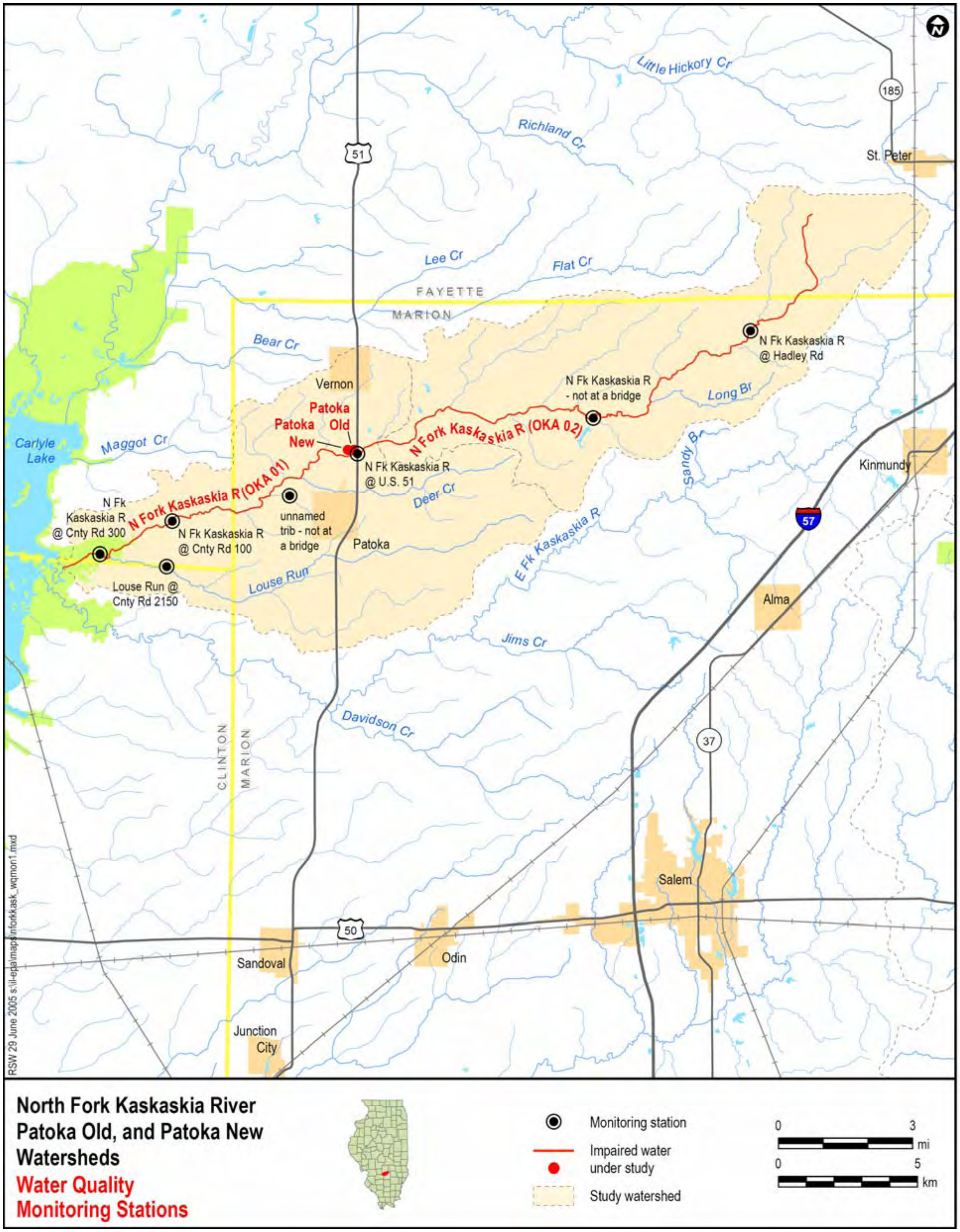

Figure 5. N. Fork Kaskaskia River Watershed Sampling Locations

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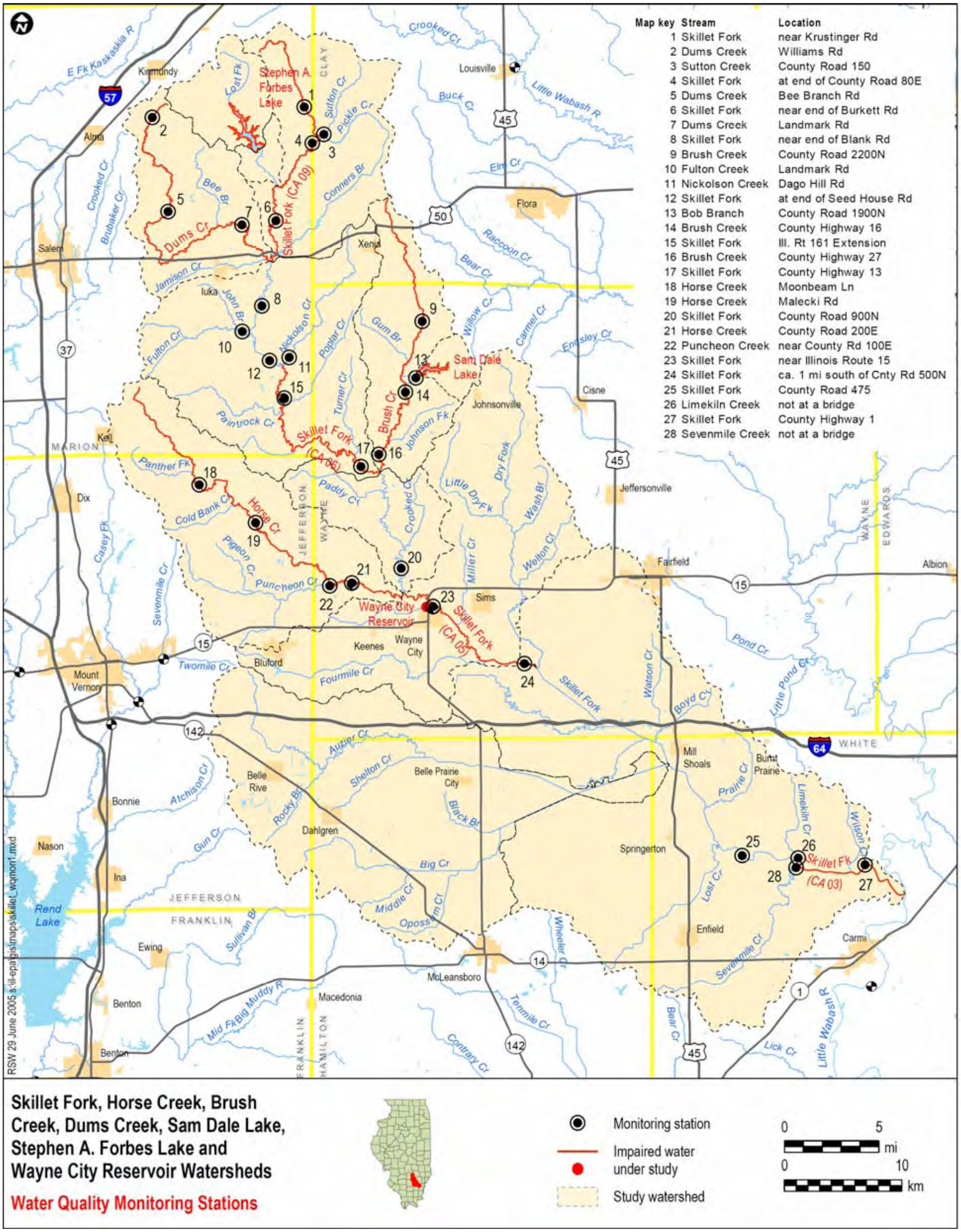

Figure 6. Skillet Fork Watershed Sampling Locations

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Table 4 USGS Gage Streamflow Statistics

Watershed	Nearest USGS Gage	USGS Gage Number	20th Percentile Flow (cfs)	50th Percentile Flow (cfs)	80th Percentile Flow (cfs)
Mauvaise Terre	Spring Cr at Springfield, IL	05577500	1.2	21	80
Hodges	(See Macoupin Cr Gage)				
Macoupin	Macoupin Cr near Kane, IL	05587000	16	100	465
NF Kaskaskia	(See E Fork Kaskaskia River gage)				
EF Kaskaskia	E Fork Kaskaskia River near Sandoval, IL	05592900	0.5	8.5	54
Skillet Fork	Skillet Fork at Wayne City, IL	03380500	3.9	36	312

Percentile values calculated from USGS website daily mean streamflow values for the period of record
The USGS real-time streamflow values for these gages can be accessed at the following URL:
http://waterdata.usgs.gov/il/nwis/uv?multiple_site_no=05587000%0D%0A05586800%0D%0A05586000%0D%0A05577500%0D%0A05594450%0D%0A05592900%0D%0A03380500%0D%0A&search_site_no_match_type=exact&index_pmcode_00065=3&index_pmcode_00060=4&index_pmcode_00045=5&index_pmcode_00055=&index_pmcode_72019=&sort_key=site_no&group_key=NONE&sitefile_output_format=html_table&column_name=agency_cd&column_name=site_no&column_name=station_nm&column_name=lat_va&column_name=long_va&column_name=state_cd&column_name=county_cd&column_name=alt_va&column_name=huc_cd&period=7&begin_date=&end_date=&format=gif&date_format=YYYY-MM-DD&rdb_compression=file&list_of_search_criteria=multiple_site_no%2Crealtime_parameter_selection

Table 5 Schedule

Event	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Approval to proceed from IL-EPA	X							
Macoupin Creek								
Survey 1 - low/medium flow								
Survey 2 - low/medium flow								
Hodges Creek								
Survey 1 - low/medium flow								
Survey 2 - low/medium flow								
Mauvaise Terre Creek								
Survey 1 - low/medium flow								
East Fork Kaskaskia River								
Survey 1 – low/medium flow								
Wet Weather Bacteria Survey		As weather permits						
North Fork Kaskaskia River								
Survey 1 - low/medium flow								
Survey 2 - low/medium flow								
Skillet Fork								
Survey 1 - low/medium flow								
Survey 2 - low/medium flow								

1.5. Quality Objectives and Criteria (A7)

The monitoring information collected will meet the quality objectives and criteria outlined in this section and presented in Table 6. Data quality will be measured for the monitored parameters in terms of minimum measurement criteria, minimum measurement objectives, required detection limits, accuracy, precision and completeness.

Minimum measurement criteria will be established at the lowest analyte concentration required for planned uses of the measurement data. Minimum measurement criteria are State of Illinois water quality standards for general use waters, where applicable. Where no minimum measurement criteria can be identified, the water samples will be analyzed to the lowest concentration readily achievable by the contract laboratory.

The minimum measurement objectives will be set at approximately one-fifth of the minimum measurement criteria shown to ensure that analytes will be measured with reasonable accuracy at the minimum measurement criteria concentrations, and measured to reasonable levels below the minimum measurement criteria. The minimum measurement objective for any analyte will be achieved when the analytical procedure selected for sample analysis can be shown to have a method detection limit (MDL) at or below the minimum measurement objective. Analyte MDLs will be determined from the USEPA analytical methods used (as found in the Code of Federal Regulations (CFR), Volume 40, Part 136, Appendix B). The MDL is defined as the minimum constituent concentration that can be distinguished from a sample with no analyte at a 95 percent confidence level. Since the MDL procedure is based upon precision obtained for a standard greater than the MDL, it also is a measure of method sensitivity at concentrations near the MDL.

For analytes without minimum measurement criteria, the minimum measurement objectives will be understood to be the MDL level that is readily achievable using analytical methods generally employed at the contract laboratory. For field parameters where MDLs are not applicable such as pH, temperature, and dissolved oxygen, the minimum measurement objectives are the sensitivity of the measurement method.

Table 6 Measurement Objectives and Criteria

Parameter	Minimum Measurement Criteria	Minimum Measurement Objectives	Method*; MDL[1]	MS/MSD * Accuracy (% recovery)	MS/MSD * Precision (RPD)	LCS * Accuracy (% recovery)	Completeness
Dissolved Oxygen	NA	0.1 mg/l [s]	Field; NA	NA	NA	NA	90%
Water Temperature	NA	0.1 degree C [s]	Field; NA	NA	NA	NA	90%
pH	NA	0.1 pH unit[s]	Field; NA	NA	NA	NA	90%
Ammonia	15.0 mg/l[G]	3.0 mg/l	EPA 350.1/ 350.3; 0.01/0.03 mg/l	80-120%	20%	80-120%	90%
Nitrate-Nitrite	No Standard	0.05 mg/l	EPA 353.1	80-120%	6%	80-120%	90%
BOD_5	No Standard		EPA 405.1/ SM5210 B; 2 mg/l	N/A	20%	N/A	90%
Iron, Total	0.017 mg/l[G, 2]	0.005 mg/l	EPA 200.8; 0.02 mg/l	70-130%	20%	80-120%	90%
Manganese, Total	1 mg/l[G]	0.2 mg/l	EPA 200.8 0.02 mg/l	70-130%	20%	80-120%	90%
Eschericia coli	No standard	20 counts/100ml	SM 9223 B; 1 count/100ml	NA	NA	Positive	90%

NA = Not Applicable
SM - Standard Methods of the Examination of Water and Wastewater, 20th Edition
[s] = Required sensitivity
EPA - EPA Methods for Chemical Analysis of Water and Wastes, March 1983
* = Limits are subject to change based upon capabilities of contract labs
[1] = Method Detection Limit (MDL) from SM and EPA.
[2] = Calculated acute standard based on a minimum water hardness of 100 mg/L as $CaCO_3$
[G] = State of Illinois General Use Water Quality Standard

1.6. Special Training/Certification (A8)

A variety of professional staff (engineers, scientists and others) will be involved in this monitoring program. Project staff will be assigned duties based on their qualifications to accomplish the task. The Project Manager will determine the appropriateness of an individual to undertake a task.

Training sessions will be carried out for all field staff on proper sampling, sample handling and shipping, and general field procedures prior to conducting the first sampling event. Specific emphasis will be placed on QA/QC issues as well as on health and safety. Field staff will receive a safety briefing conducted by the Field Manager with emphasis on field hazards and materials handling. Training will also include the operation, maintenance and calibration of field equipment, including multi-parameter probes, velocity meters, and all other on-site equipment used throughout the field program. SOPs for program elements will be distributed to appropriate staff and available at all times.

The laboratory Technical Director will be responsible for training and certifications of laboratory personnel. All laboratory personnel will receive appropriate training and have proven proficiency in their designated analytical procedures. Laboratory personnel will be provided copies of the appropriate laboratory procedures, which will be available at all times.

1.7. Documents and Records (A9)

The Project Manager will ensure that the project team has the most current approved version of the QAPP. The project manager is responsible for initiating project files and for overseeing maintenance of the files during the course of the project. All project files will be properly identified by client, project name, project code and file description for all appropriate correspondence, memoranda, calculations, technical work products, and other project-related data. In addition, a quality assurance file will be maintained containing all QA/QC related information. A back up of all computer files containing important project information will also be maintained.

Documents generated by field activities may include staff notes, field logs, equipment logs, field on-site measurement data sheets, field audit reports and chain of custody forms. Documents generated by laboratory activities may include QA/QC documentation, laboratory bench sheets, laboratory results, and laboratory audit reports. These documents will be maintained in the project files.

At the conclusion of the project, all relevant information from the project files and computer disks will be archived. Documents will be retained for a minimum period of three years following archiving.

2 Data Generation and Acquisition (Group B)

The U.S. EPA QAPP Guidance Group B Data Generation and Acquisition elements (B1-B10) are addressed below.

2.1. Sampling Process Design (B1)

The sampling process design is presented in Sections 1.3 and 1.4 of this QAPP, including sampling rationale, locations, media, frequencies, and schedules.

2.2. Sampling Methods (B2)

Standard operating procedures (SOPs) will be employed to provide consistency and reproducibility to the sampling methods used by field personnel. The following sections present or reference the detailed methods for performing sampling activities including related support procedures for equipment cleaning, field measurements, and calibration and maintenance of field instruments. Sample custody procedures are presented in the Sample Handling and Custody Section of this QAPP.

2.2.1. Surface Water Sample Collection

Surface water grab samples will be collected as specified in the Section 1.4 and according to the procedures presented in Appendix A.

2.2.2. Stream Morphometric and Discharge Monitoring

Stream discharge monitoring will be conducted as specified in Section 1.4 and according to the procedures presented in Appendix A.

2.2.3. Field Water Quality Measurements and Monitoring

Instantaneous water quality measurements (e.g. temperature, pH and DO) will be collected using field instruments according to the procedures presented in Appendix A. In-situ monitoring instruments and equipment will be installed in a manner using methods that incorporate the unique requirements of specific locations. The main concern will be the security of the instruments, equipment and generated data. Maintenance, cleaning and/or data download activities for in-situ instruments will be performed at a frequency necessary to assure that representative data are generated and recorded for transfer to the project files.

2.2.4. Cleaning of Equipment and Materials

All reusable equipment and materials used during the field activities will be cleaned prior to use at the site and at specified intervals during the field activities. Cleaning will be performed according to the procedures specified in Section 1.4 and as presented in Appendix A to avoid the introduction of any chemical constituents or cross-contamination to the soils or groundwater. Equipment and materials that may be used during the investigation include water and/or sediment sample collection devices.

Equipment cleaning will be performed using water from a source approved by the project manager. If needed, a designated cleaning or decontamination area will be used or constructed so that all water generated during cleaning operations will be contained for proper disposal.

2.3. Sample Handling and Custody (B3)

Sample handling will be performed so as to collect, store, submit to the laboratory and analyze representative samples using methods as specified in Section 1.4 and according to the procedures presented in Appendix A. Sample containers, volumes, preservatives and holding times are summarized in Table 7. Laboratory sample custody will be performed in accordance with the laboratory's Quality Assurance Manual

2.4. Analytical Methods (B4)

The following section details aspects of the analytical requirements, ensuring that appropriate analytical methods are employed. Table 6 summarizes the analytical methods to be used by the contract laboratory. Table 7 displays the required container type, sample volume, preservation, and holding time for each parameter according to the previously referenced methods. The laboratory will provide sample containers from a commercial supplier. All sample containers will be new and pre-cleaned by the supplier. In addition, the contract laboratory will provide sample labels for each bottle and add the required preservative for each parameter, where feasible.

The analytical data results and intra-laboratory QA/QC results will be submitted by the contract laboratory to the Field Manager or other designated contact person within a specified time frame from the completion of each sampling event.

Table 7 Guidelines for Sample Container Preparation and Preservation

Parameter	Container	Recommended Sample Volume	Preservation	Holding Time
Coliform Bacteria	Pre-Sterilized Polyethylene or Glass	200 ml	Add $Na_2S_2O_7$ [1] Refrigerate to 4°C	6 hours[2]
NH_3 and nitrate-nitrite	Polyethylene or Glass	1000 ml	Add H_2SO_4, pH<2 Refrigerate to 4°C	28 days
BOD_5	Polyethylene or Glass	1000 ml	Refrigerate to 4°C	48 hours
Iron	Polyethylene or Glass	500 ml	Add HNO_3, pH<2 Refrigerate to 4°C	180 days
Manganese	Polyethylene or Glass	500 ml	Add HNO_3, pH<2 Refrigerate to 4°C	180 days

1. Sodium Thiosulfate ($Na_2S_2O_7$) prevents continuation of bacteriocidal action.
2. The maximum allowable holding time for bacteria samples is 30 hours with a regulatory goal of 6 hours when practical.

2.5. Quality Control (B5)

All field operations personnel are responsible for ensuring that proper procedures are followed for sample collection and handling, sample preservation, and sample custody of the delivered samples to the designated laboratory. If noncompliance issues arise, an investigation and corrective action report prepared by the responsible supervising field personnel will be submitted to the Project Manager. The accuracy and precision of all data measurements must be quantifiable. Analytical procedures used for data analysis must be performed according to approved standard methods. Data measurements should be recorded in a controlled environment in which a quality control program can be maintained.

Field quality will also be assessed through the collection of field duplicate samples and equipment rinse blank samples. Field duplicates will be collected at a frequency of one for every group of 10 samples. Rinse blank samples will be collected at a frequency of one for each day of sampling or one for every group of 20 samples.

The contract laboratory is responsible for implementing its QA/QC Manual, which is an internal quality assurance plan for laboratory procedures. The contract lab is responsible for the accuracy and reliability of analytical methods and final data reports. If noncompliance issues arise, an investigation and corrective action report will be prepared and submitted from the Laboratory Manager to the Project Manager. The contract lab is responsible for providing data qualifiers and/or case narratives to inform the Project Manager of any analytical exceptions that fall outside of routine method protocols. Analytical quality control will be performed in accordance with the laboratory QA/QC Manual, the specified analytical methods, and as discussed under the Quality Objectives and Criteria Section of this QAPP.

2.6. Instrument/Equipment Testing, Inspection, and Maintenance (B6)

All field and laboratory instruments/equipment shall be routinely maintained according to manufacturer instructions and accepted procedures associated with the selected analytical methods, SOPs and the laboratory's QA/QC Manual, as applicable. Field instruments and equipment shall be tested and inspected prior to sampling events. An adequate supply of spare parts shall be maintained as necessary for equipment maintenance.

2.7. Instrument/Equipment Calibration and Frequency (B7)

Calibration procedures for field and laboratory instruments/equipment will follow manufacturer instructions and accepted procedures associated with the selected analytical methods, SOPs and the laboratory's QA/QC Manual, as applicable. In order to maintain field precision and accuracy, the instruments will be calibrated to known standards.

2.8. Inspection/Acceptance of Supplies and Consumables (B8)

All supplies and consumables for field and laboratory activities will be inspected by the field operations teams and laboratory managers, respectively, to guarantee their usability. Supplies or consumables found to be deficient for the needs of the project will not be used.

2.9. Non-direct Measurements (B9)

Non-direct measurements will not be used in implementation of the monitoring program.

2.10. Data Management (B10)

Data generated through field and laboratory activities will be used for developing models and reports. Reporting formats will vary depending on the purpose for which the data has been assembled, but will include such items as field books, field calibration and measurement records, electronic data downloaded from field instruments, laboratory analytical results and QC reports. The Project Manager or designee has the responsibility of maintaining all documents and data generated during field programs and received from the laboratory. The Laboratory Technical Director has the same responsibility for laboratory data and information.

Field and laboratory documents will be kept in the project files. All electronic files will be backed up on a regular basis. At the conclusion of the project all relevant information, project files and electronic data will be turned over to the Project Manager. Paper and electronic files will be retained for a minimum period of three years following archiving.

3 Assessment and Oversight (Group C)

The U.S. EPA QAPP Guidance Group C Assessment and Oversight elements are addressed in this section.

3.1. Assessment and Response Actions (C1)

The sampling team will be evaluated to determine if sampling protocol is followed. Quality control and noncompliance issues related to field activities will require an investigation and corrective action conducted under the supervision of the Project Manager.

Laboratories contracted for data analysis shall maintain internal quality assurance programs described in their quality assurance plans. When the possibility of quality control problems or noncompliance issues arise that may affect the usability of data, an investigation and corrective action will be conducted by the Laboratory Technical Director and communicated to the Project Manager.

3.2. Reports to Management (C2)

Periodic summary reports will be prepared by the Project Engineer in charge of Quality Assurance, if necessary, to inform the Project Manager of the project status. The reports will include:

- Periodic assessment of measurement data accuracy, precision, and completeness;
- Results of performance audits and/or systems audits;
- Significant Quality Assurance/Quality Control problems and recommended corrective action;
- Status of corrective action implementation to any problems previously identified.

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4 Data Validation and Usability (Group D)

The U.S. EPA QAPP Guidance Group D Data Validation and Usability elements are addressed in this section. The purpose of these elements is to determine if the data meet the project's Data Quality Objectives (validation) and to evaluate the data against the method, procedural and/or contractual requirements (verification). Data validation, verification, and usability assessment will be conducted as outlined in this QAPP.

The data generated from the sampling program will be subjected to a multi-tiered review process described below. This process includes:

- A review of the data at the bench and field levels;
- A secondary review of field records by the Field Manager and analytical results within the laboratory by the lab QA/QC Manager to verify the data against method and SOP requirements;
- A review of the verified data by the Project Manager or designee for reasonableness and to identify obvious data anomalies;
- A validation by an objective third party, if necessary; and
- An assessment of the data by project team members for its usability to meet the project goals.

4.1. Data Review, Verification and Validation (D1)

All environmental measurement data collected by project staff will be subjected to quality control checks before being utilized in the interpretive reporting. A data generation system that incorporates reviews at several steps in the process is designed to protect the integrity of the data and reduce the number of data that do not meet the Data Quality Objectives (DQOs) or the project goals. This section describes the requirements of each review step that will be used in this project.

4.1.1. Data Verification Requirements

Data verification will occur at the field and laboratory level. This section describes the requirements of the data verification.

Field Activities Data Verification. The Field Manager will be responsible for ensuring that the samples are collected and handled according to the specified procedures. Sample collection verification will include confirming that the samples were collected with the proper equipment at the appropriate locations with the appropriate frequency. Sample handling verification will include confirming that the samples were stored in the appropriate containers with the correct preservative, that the samples were stored at the proper temperature during transport from the field to the laboratory, and that all of the appropriate information is logged on the chain-of-custody records.

Lab Activities Data Verification. The laboratory QA/QC Manager will be responsible for verification of laboratory-generated data, although the laboratory SOPs for each method may require some components of the verification to also be conducted at the bench level. Laboratory verification will include assessing that the procedures used to generate the data are consistent with the method requirements as specified in the laboratory's SOPs and that the QA/QC requirements for each method are met. Examples of method requirements include verifying the calibration and data reduction procedures. However, these requirements vary by analyte and are presented in more detail in the laboratory QA/QC Manual.

4.1.2. Data Review Requirements

The Field Manager will perform data reviews that consist of screening the field data sheets and laboratory data sheets according to established criteria listed in this section. If the established screening criteria are not met, an additional review of available laboratory data (e.g., quality control checks, relevant laboratory bench sheets) may be conducted. Investigation of the issue will be documented and the data will be discarded or flagged appropriately, identifying the limitations of the data.

Field Data Sheet Reviews. The following criteria may be used to screen the physical parameter measurements recorded by the field crews:
- temperature readings – check for reasonableness of values
- pH readings – check for reasonableness of values
- dissolved oxygen readings –compare concentrations to percent saturation

Laboratory Data Sheet Reviews. The following criteria will be used to screen the analytical measurements performed by the contract laboratory:
- equipment blanks –values should be less than detection limits
- method blanks –values should be less than detection limits
- field blanks – are values less than detection limits
- review of all analytical results – check for reasonableness of values

4.1.3. Data Validation Requirements

Data validation is typically performed by someone independent of the project activity and not associated with the organization responsible for producing the dataset. However, the data validator needs to be familiar with both the data validation requirements and the project objectives. A scientist/engineer not directly involved in the project administration, project management, field or laboratory operations will conduct the data validation. There are four requirements in the data validation process as follows:

- Inspect the data verification and review records to ensure that no oversights were made during that process.
- Evaluate the data against the project DQOs. If data do not meet one or more of the DQOs, the data validation process will include an investigation into causes and an assessment of the impact of the noncompliant data on project objectives.
- Evaluate the data in the context of the project's overall objectives.
- Communicate the data validation results to the rest of the project team.

4.2. Verification and Validation Methods (D2)

All environmental measurement data and samples collected by project staff will be subjected to quality control prior to being entered into the project database. This is a multi-step process where the laboratory QA/QC Manager will have primary responsibility for verifying the data and a third party, preferably one who is not involved in data collection or analysis, conducts the data validation. These steps are described in more detail in the following sections.

4.2.1. Data Verification

This section describes the procedures that will be utilized in this project for verifying the data against method, procedural and/or contractual requirements.

Field Activities Data Verification. Individual crew leaders will verify the completion of their field data sheets and chain-of-custody forms. In addition, crew leaders will also verify the proper calibration and operation of their multi-parameter instruments. At the completion of each monitored event, the Field Manager will review all field data sheets, calibration sheets, and chain-of-custody forms for accuracy and completeness. The Field Manager will also verify that monitoring QA objectives for all accuracy, precision, completeness, and adherence to the required collection techniques are being met.

Laboratory Analytical Results Verification. Individual analysts will verify the completion of the appropriate analytical test and required bench sheets. The laboratory Technical Director or designee will review calculations and inspect laboratory bench sheets and log books daily to verify their accuracy, completeness, and adherence to the specified analytical method protocols. Calibration and QC data will be examined daily by the individual analyst. The laboratory Technical Director or designee will verify that all instrument systems are operating within control limits and that QA objectives for accuracy, precision, completeness, and adherence to the required detection limits are being met.

A summary of reportable QA/QC results and any non-conformance issues will be included in the laboratory deliverable to the Field or Project Manager.

4.2.2. Data Validation

This section describes the process that will be used to validate the data generated for this project. The first requirement is to inspect the data verification results and review records to ensure that no oversights were made during that process. A complete set of field and laboratory information will be provided to the data validator for this task.

The primary objective of the data validation in this project is to evaluate the data conformance with the project DQOs. These DQOs include criteria for accuracy, precision, completeness, and compliance with required detection limits. The components described under the Data Management Section of this QAPP will provide the necessary information to make this evaluation. The following must be reviewed as part of the measurement data and analytical data validation activities:

- field measurement data,
- field sample collection information,
- sample custody records,
- laboratory analytical results,
- data review information and/or laboratory case narrative,
- quality control data.

The data validator will conduct a systematic review of the data for compliance with the established quality control criteria based on duplicate, replicate, spiked, control, and blank data results provided by the laboratory. In addition, quality assurance evaluations of data accuracy, precision, and completeness will be performed on the field measurement data and the laboratory analytical results for each monitored event. The data validation qualifiers listed in Table 8 will be used when validating the data:

Table 8 Data Validation Qualifiers

Qualifier	Definition
U	The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.
J	The associated value is an estimated quantity.
R	The data are unusable (note: analyte may or may not be present)
UJ	The material was analyzed for, but was not detected. The associated value is an estimated level.
B	Chemical was detected in the field blank at a concentration equal to or greater than the ML, or greater than one-fifth the level in the associated sample, whichever is greater.
D	Out of control field duplicate based on RPD control limit

If quality control checks or objectives were not met, an investigation of the non-conformance may be initiated by the data validator with the project team personnel, such as the Field Manager, the laboratory QA/QC Manager, and the Project Manager. The non-conformance will be documented and the affected data set will be flagged appropriately, identifying any limitations.

Another objective of the data validation is to evaluate the data within the context of the project goals. These goals include providing datasets that can be used to develop model inputs, to calibrate and validate the models, and to ensure consistency among different sources of data. Suitable datasets for the modeling portion of this project will be based on the data quality assessment described above as well as an assessment of the spatial and temporal extent of the sample collection. Comparability with other sources of data will be evaluated by comparing and, if necessary, plotting the data with previously collected data to identify outliers or anomalous values.

The data validation results will be communicated to the project team in the form of a summary table that lists the validation tasks and the associated results and conclusions. If the validated dataset includes non-compliant data, this data will be addressed in a memo that accompanies the summary table. Data qualifiers assigned to the data during validation will be maintained in the project database to ensure communication of validation results with current and future data users.

4.3. Reconciliation with User Requirements (D3)

Once all field measurements and analytical data have been reviewed, quality control measures assessed, and any problems addressed, the measurement and analytical data will be assessed by the Project Manager or designee.

The assessment of the information generated from the monitoring program will be initiated by entering all analytical data and field measurement data into the project database. Other data (such as precipitation, flow data, velocity data, stage data, field notes, and information on any sampling anomalies) may be appended. All of these data will be evaluated and any relationships or correlations will be noted. The compilation of all information surrounding a sampling and/or monitoring event will be available to facilitate reconciliation with user requirements.

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5 References

Illinois Environmental Protection Agency (IEPA). 2004. Illinois 2004 Section 303(d) List. Bureau of Water, Watershed Management Section. November 2004. IEPA/BOW/04-005 [online] http://www.epa.state.il.us/water/watershed/reports/303d-report/303d-2004.pdf

United States Environmental Protection Agency (EPA), 1998. *EPA Guidance for Quality Assurance Project Plans*, EPA QA/G-5. Washington , DC.

United States Environmental Protection Agency (EPA), 2002. *Guidance on Environmental Verification and Data Validation*. EPA QA/G-8. Washington, DC.

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Appendix A

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I. Introduction

This standard operating procedure (SOP) is applicable to the collection of representative liquid samples, both aqueous and non-aqueous, from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface. These typically applicable procedures have been adapted from the U.S. EPA Environmental Response Team Surface Water Sampling SOP No. 2013, dated 11/17/94 and may be varied or changed as required, dependent upon site conditions or equipment and procedural limitations. The actual procedures used should be documented in the field notes, especially if changes are made.

There are two primary interferences or potential problems with representative surface water sampling. These include cross contamination of samples and improper sample collection. Following proper decontamination procedures and minimizing disturbance of the sample site will eliminate these problems as follows:

- Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Refer to the Equipment Cleaning SOP.
- Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed area.

In order to collect a representative sample, the hydrology and morphometry of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sampling locations and depths. In addition, water quality indicator data may be collected, if necessary, in impoundments to determine if stratification is present. Measurements such as dissolved oxygen, pH, temperature, and redox potential can indicate if strata exist which would affect analytical results. Measurements should be collected at sufficiently sized intervals (e.g., 1 meter) from the substrate to the surface using the appropriate instrument (e.g., Hydrolab).

II. Materials

The following materials shall be available, as required, during surface water sampling. Back-up field instruments/equipment should be available, if required.

- Personal protective equipment (as necessary);
- Cleaning equipment (as required in the Standard Operating Procedure for Equipment Cleaning);
- Appropriate sampling apparatus and accessories (e.g., Kemmerer, weighted bottle, or Dip sampler, sample containers, sampling line, weights, messengers);
- Appropriate sample bottles, preservatives (if required) and sample bottle labels;
- Ziploc^{R}-type bags;
- Insulated coolers, ice, and appropriate packing material;
- Chain of Custody records and custody seals;
- Field data sheets, field log book, waterproof pen, camera and film;

- Decontamination equipment;
- Maps/plot plan, survey stakes/flags/buoys and anchors;

III. Preparations

- Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.
- Obtain the necessary sampling and monitoring equipment to suit the task. Consider sample volume, depth, deployment circumstances (shore, wading, boat, currents), type of sample, sampler composition materials, and analyses to be conducted.
- Decontaminate or pre-clean equipment and ensure that it is in working order.
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
- Perform a general site survey.
- Use stakes, flagging, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. If also collecting sediment samples, this procedure may disturb the bottom and cause interferences with collection of representative water samples.

IV. General Sample Collection Procedures

1. Record pertinent data on the field log (see attached Surface Water Sampling Field Log, or equivalent).

2. Label all sample containers with the date, time, site location, sampling personnel, and other requested information.

3. Don appropriate personal protective equipment (as necessary).

4. For coliform bacteria samples, use a sterile sample bottle and store the bottle cap in a sterile plastic bag to prevent contamination during sampling.

5. Clean all sampling equipment prior to sample collection according to the procedures in the Standard Operating Procedure for Equipment Cleaning.

6. At designated surface water sampling locations, thoroughly rinse the sampler in the water body prior to collecting the first sample.

7. For samples requiring field filtering, use a pump and in-line disposable filter, if possible to collect the sample directly into the sample container.

8. If field preservation is required, place appropriate preservative into the sample container prior to sample collection. Note the preservative and preservative column on the sample container and sampling log.

9. If any quality control samples are specified, they will be collected in the following manner:

- Duplicate samples should be collected at the same time or immediately following one another in accordance with the above procedures. If blind duplicate samples are specified, one of the duplicate samples should be labeled so that it does not identify the other sample of the duplicate pair to the laboratory on the chain-of-custody (COC). For example, one sample of the duplicate pair would be labeled following the normal protocol, while the second would be labeled with a sample ID of "DUPLICATE" and a blank line placed in the location, date and time boxes of the sample label. It is important that the duplicate pair samples are identified separately in the field notes with information including location, sample ID (as entered on the sample container label and COC), sample date and time so that analytical results can be paired after received from the laboratory.
- Rinse (or equipment) blanks should be collected from a final distilled/deionized water rinse of the specified sampling equipment after that piece of equipment has been cleaned in accordance with appropriate specified cleaning procedures.
- Field blanks, such as samples of water or reagents used to clean sampling equipment, should be collected directly into the sample bottle from the appropriate source container.

10. Record sample collection information on the field log and store the samples in an iced cooler as described in the Standard Operating Procedure for the Shipping and Handling of Samples.

11. Handle, pack, and ship samples according to the procedures in Standard Operating Procedure for the Shipping and Handling of Samples.

V. Equipment-Specific Sample Collection Procedures

Kemmerer Bottle. A Kemmerer bottle may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

1. Use a properly cleaned Kemmerer bottle. Set the sampling device so that the sampling end pieces (upper and lower stoppers) are pulled away from the sampling tube (body), allowing the substance to be sampled to pass through this tube.

2. Lower the pre-set sampling device to the pre-determined depth. Avoid bottom disturbance.

3. When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device.

4. Retrieve the sampler and discharge from the bottom drain the first 10-20 mL to clear any potential contamination of the valve.

5. Transfer the sample to the appropriate sample container, as necessary, and cap securely.

Weighted Bottle Sampler. A weighted bottle sampler may be used in situations similar to those outlined for the Kemmerer bottle, but for near surface samples. Sampling procedures are as follows:

1. Use a thoroughly cleaned weighted bottle sampler with clean and/or disposable sample containers. For coliform bacteria samples, use a sterile sample bottle with the special sample bottle holder and store the bottle cap in a sterile plastic bag to prevent contamination.

3. Upon arrival at each field site, thoroughly rinse the sampler in the stream prior to collecting the first sample.

4. At the designated sampling location, carefully lower the weighted bottle sampler, allowing the sampler to fully submerse and fill with water. Coliform samples will be collected just below the surface of the stream at the center of flow.

5. Retrieve the sampler, transfer the sample to the appropriate sample container, as necessary, and cap securely.

Dip Sampler

A dip sampler is useful in situations where a sample is to be recovered from locations (e.g., outfall pipe, sump manhole, along a pond or lagoon bank) where direct access is limited. The long handle (or line if sampling from a bridge or other structure directly above the water body) on such a device allows access from a safe location. Sampling procedures are as follows:

1. Assemble the device in accordance with the manufacturer's instructions.

2. Thoroughly clean the sampler prior to use and use only clean sample containers.

3. Upon arrival at each field site, thoroughly rinse the sampler in the stream prior to collecting the first sample.

4. Extend the device to the sample location and fill the sample container by dipping and/or submersion.

5. Retrieve the sampler, transfer the sample to the appropriate sample container, as necessary, and cap securely.

Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be used to collect water samples from the surface directly into the sample bottle. This method may not be appropriate for sampling lagoons or other impoundments where contact with contaminants is a concern. When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation. The procedures are as follows:

1. Using adequate protective clothing, access the sampling station by appropriate means.

2. For shallow stream stations, collect the sample under the water surface while pointing the sample container upstream. The container must be upstream of the collector. Avoid disturbing the substrate.

3. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and boat wakes.

VI. Disposal Methods

If required, all water generated during equipment cleaning procedures will be collected and contained on site for determination of proper treatment or disposal. In addition, personal protective equipment (e.g., gloves, disposable clothing) and other disposable equipment resulting from cleaning and sampling procedures will be placed in plastic bags and appropriately contained for proper disposal.

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SURFACE WATER SAMPLING FIELD LOG

Project Name: Project Code: Page __ of __

Date	Time	Sample ID	Sample Location	Equipment Used	Samplers	Comments

Notes:

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I. Introduction

This standard operating procedure (SOP) is applicable to the collection of representative data (stream dimensions and water velocity) for use in determining discharge in streams and open channels. These typically applicable procedures have been adapted from the USGS *Techniques in Water Resources Investigations*, Book 3, Chapter A8: Discharge Measurements at Gaging Stations (http://water.usgs.gov/pubs/twri/twri3a8/pdf/TWRI_3-A8.pdf) and the *Open Channel Profiling Handbook*, January 1989 (Rev. May 1, 1990), Marsh-McBirney, Inc. The procedures herein may be varied or changed as required, dependent upon site conditions or equipment and procedural limitations. The actual procedures used should be employed in consultation of the more detailed procedures found in the USGS discharge measurement guidance document and the actual procedures used should be documented in the field notes, especially any changes made.

II. Materials

The following materials shall be available, as required, during collection of surface water flow data. Back-up field instruments/equipment should be available, if required.

- Personal protective equipment (as necessary);
- Boat and/or waders;
- Cleaning equipment (see the Standard Operating Procedure for Equipment Cleaning);
- Flowmeter/velocimeter and appropriate accessories (e.g., Marsh-McBirney Flo-Mate 2000, Pigmy-Gurly velocimeter, profiling/wading rod, boat/bridge board with suspension cable and weight, operation manuals);
- Protractor and compass;
- Measuring tape and/or measuring wheel;
- Field data sheets, field log book, waterproof pen, camera and film;
- Maps/plot plan, survey stakes/flags/buoys and anchors;

III. Preparations

- Determine the extent of the sampling effort, the methods to be employed, and the types and amounts of equipment and supplies needed.
- Obtain the necessary sampling and monitoring equipment to suit the task. Consider stream morphometry (width, depths, channels) and deployment circumstances (bridges, shoreline, wading, boats, obstructions, currents).
- Decontaminate or pre-clean equipment and ensure that it is in working order.
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
- Perform a general site survey.
- Use stakes, flagging, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

IV. Flow Measurement Procedures

The methods of determining cross-sectional area and velocity must be selected prior to the field event. Data required for use in calculation of stream flow includes measurements of cross-sectional area (water depth and transect segment width), water velocity, flow angle, and transect angle. The mid-section method of computing cross-sectional area for discharge measurements is recommended by USGS and there are a number of different methods for measuring velocity. The two methods of velocity measurement that follow are frequently used for normal stream conditions:

- Six tenths Depth Method (0.6 depth below the water surface) uses observed velocity at this depth as the mean velocity in the vertical. This method gives extremely reliable results whenever the water depth is between 0.3 and 2.5 feet. It is also quicker to measure so is good for times of rapidly changing water level (stage).
- Two Point Method (0.2 and 0.8 depth below the water surface) averages velocities observed at these relative depths at each location and this average is used as the same mean velocity in the vertical. This method gives more consistent and accurate results than any of the other methods except the vertical-velocity curve method. The two point method is generally not used at depths less than 2.5 feet because the current meter settings would be too close to the water surface and stream bed for dependable results.

Flow measurement data collection using wading techniques are preferred by USGS, if conditions permit. Wading measurements offer the advantage over measurements from bridges (or other techniques such as cableways, not discussed herein) in that it is usually possible to select the best of several available cross-sections for the measurement.

When a stream cannot be waded, bridges may be used to obtain flow measurements (though cableway measurements are usually better, if available). No set rule can be given for choosing between the upstream or downstream side of the bridge to collect flow data. The advantages of using the upstream side of the bridge are:

- Hydraulic characteristics at the upstream side of bridge openings usually are more favorable.
- Approaching drift can be seen and be more easily avoided.
- The streambed at the upstream side of the bridge is not likely to scour as badly as at the downstream side.

The advantages of using the downstream side of the bridge are:

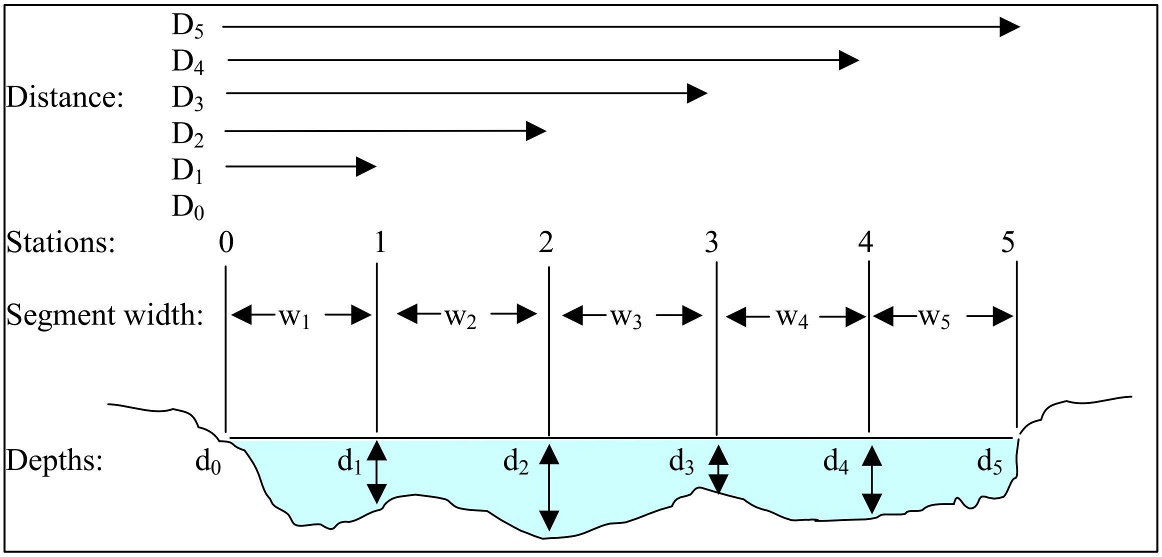
- Vertical angles are more easily measured because the sounding line will move away from the bridge.
- The flow lines of the stream may be straightened out by passing through a bridge opening with piers (see points under step 2 below).

To accomplish flow data collection using the methods selected, a transect of measurement stations across a stream is set up and marked before collecting section depth, width, and velocity data using the following steps:

1. Follow appropriate safety procedures and use personal protective equipment as necessary.
2. Select the transect site location following as many of the following considerations as possible:

- The channel should have as much straight run as possible – at least such that the length upstream from the profile should be twice the downstream length.
- The channel should be free of flow disturbances. Look for protruding pipe joints, sudden changes in diameter, contributing sidestreams, outgoing sidestreams, or obstructions.
- The flow should be free of swirls, eddies, vortices, backward flow, or dead zones.
- Avoid areas immediately downstream from sharp bends or obstructions.
- Avoid converging or diverging flow (approach to a flume) and vertical drops.
- Avoid areas immediately downstream from a sluice gate or where the channel empties into a body of stationary water.

3. Determine the width of the stream starting and ending at the stream's edges. Use a measuring wheel on a bridge or string a measuring tape between stakes if wading or in a boat.
4. Record the angle of the transect with respect to the stream channel and direction of flow. The transect should most preferably be at right angles to the direction of flow to avoid having to correct for the angle of the transect when calculating discharge.
5. Mark/record the partial section locations (measurement recording stations) of the measurement transect. These should be spaced so that no partial section contains more than 10 percent of the total flow. The ideal measurement would have less than 5 percent of the flow in any one partial section. Equal width partial sections across the transect are not recommended. Make the width of the partial sections less as depths and velocities become greater.
6. Assemble the appropriate equipment for the velocity and depth measurements.
7. Prepare the measurement note sheets to include the following information:
   - Name of stream and exact location of transect site.
   - Date, party, type of meter suspension, type of meter.
   - Measurement data (depth, width, position location, velocity, flow angle, time measurements were started and ended).
   - Bank of stream that was the starting point. Identify the stream bank by either LEW or REW (left edge of water or right edge of water, respectively) when facing downstream.
   - Gage height measurement and corresponding times.
   - Other pertinent information regarding site conditions and accuracy of the measurement.
8. Begin recording depth, width (transect distance) and velocity measurements at each station of the transect, successively, according to the remaining steps below and in reference to the figure that follows.



w = width of segment
D = distance from stream's edge
d = depth of water

9. Record distance (D1, D2, D3 …) from steam's edge at initial station (measurement point 0) to each successive station (1, 2, 3, …).
10. Record the water depth (d0, d1, d2, d3, …) at each measurement point, including the edge of the water at each end of the transect.
11. Measure velocity (0.2 depth & 0.8 depth – or – 0.6 depth below water surface) at each station and record the reading and associated meter depth position (0.2, 0.6, 0.8). Follow manufacturer instructions for operation of the meter.

    Note: If wading, stand in a position that least affects the velocity of the water passing the meter sensor (sufficiently downstream or to the side of the sensor – approximately an arm's length). Avoid standing in the water if feet and legs would occupy a considerable percentage of the cross section of a narrow stream (use a plank or other support). Keep the wading rod in a vertical position and the velocity sensor parallel to the direction of flow.
12. Measure and record the angle of flow with respect to the transect and direction of flow, especially if the flow is not at right angles to the transect.

V. Discharge Calculation

The USGS-preferred midpoint method of determining discharge uses the products of the partial areas of the stream cross-section (segment) and their respective average velocities (Q = A * V). It is assumed that the velocity measurement at each station represents the mean velocity in a partial rectangular area. The area extends laterally from half the distance from the preceding station to half the distance to the next and vertically from the water surface to the sounded depth. The cross-section is defined by depths at the station locations (d_1, d_2, …, d_n). There are two cases in the calculation, as follows:

For segments in the middle of the transect:

$Q_{middle\text{-}segment} = (D_{n+1} - D_{n-1})/2 * d_n * V_n$

For segments at the end of the transect:

$Q_{first\text{-}end\text{-}segment} = (D_{n+1} - D_n)/2 * d_n * V_n$
$Q_{last\text{-}end\text{-}segment} = (D_n - D_{n-1})/2 * d_n * V_n$

- $Q = A * V$ (discharge = area * velocity; where)
- $A = w * d$ (area = width * depth; where)
- $w = D_{n-1} - D_{n+1}$ or $D_{n+1} - D_n$ or $D_n - D_{n-1}$
  (segment width = distance between alternate or adjacent stations; and)

Sum the segment discharges to get the total discharge for the river at a particular location

VI. Other considerations for less than ideal site conditions:

Non-perpendicularity:

Ideally, the cross-section is perpendicular to the stream channel, which has a straight run of sufficient length, and the stream flow is perpendicular to the cross-section. However, this is not always possible in the real world.

Angle of flow measurements should be collected and incorporated into the discharge calculation when flow is not perpendicular to the stream cross-section (insufficient straight run length of channel, presence of swirls, eddies, etc.).

Calculation of discharge should consider only the velocity component vector that is parallel to the stream channel (perpendicular to the ideal cross-section). This can be obtained by multiplying the velocity reading by the cosine of the flow angle (V * cos(a)). If the cross-section measurements are taken from a bridge that is not perpendicular to the stream channel, then correction for the angle of the bridge is also necessary.

Backwater and reverse flow:

Backwater areas or areas to shallow to measure are usually assigned a velocity of zero. Velocity values in areas of flow reversal (from eddies, or lake seiche effects near river mouths) must be assigned the opposite sign (if downstream velocities are positive, upstream velocities are negative).

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Flow Monitoring Datasheet

Site: ____

Crew: ____________________ Date: ____________________

Staff Gage Reading (ft): __________ Begin Time: ____________________

Tape Down (ft): __________ End Time: ____________________

Equipment Used:

Transect Starting Point is on (circle one): left bank facing downstream right bank facing downstream

Bridge measurements are from (circle one): upstream side downstream side

Distance Starting Point to Nearest Edge of Water (ft): __________

Distance Ending Point to Nearest Edge of Water (ft): __________

Depth at Left Edge of Water (facing downstream): __________

Depth at Right Edge of Water (facing downstream): __________

Observations:

Transect Point No.	Transect Tape Reading (ft)	Water Depth (ft)	0.8D Velocity (ft/s) (if Depth >2.5 ft)	0.2D Velocity (ft/s) (if Depth >2.5 ft)	0.6D Velocity (ft/s) (if Depth <2.5 ft)	Angle coeff.	Notes

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I. Introduction

The equipment cleaning procedures described in this document include pre-field, in-field, and post-field cleaning of sampling equipment. The sampling equipment may consist of surface water sampling devices; water testing instruments; or other activity-specific sampling equipment. All non-disposable sampling equipment will be cleaned after completion of each sampling event. If appropriate, cleaning procedures will be monitored through the analysis of rinse blank samples as described in the project QAPP. Equipment cleaning areas will be located within or adjacent to a specific work area as necessary.

II. Materials

The following materials will be available during equipment cleaning, as needed:

- Personal protection equipment (as necessary);
- Distilled/deionized water;
- Non-phosphate detergent (Alconox, Liquinox, or equivalent);
- Tap water;
- Appropriate cleaning solvent (e.g., methanol, nitric acid);
- High-pressure hot water/steam cleaning unit;
- Wash basins;
- Brushes;
- Polyethylene sheeting;
- Aluminum foil;
- Plastic overpack drum, garbage can, or stainless steel tubes (for bladder or other pumps);
- Large heavy-duty garbage bags;
- Spray bottles (to hold tap water, distilled/deionized water, methanol, or nitric acid); and
- Disposable and/or heavy duty reusable (PVC, latex or nitrile) gloves.

III. Storage of Equipment

All cleaned sampling equipment will be stored in a clean environment and, if appropriate, the equipment will be covered/sealed with aluminum foil.

IV. Safety Procedures During Equipment Cleaning

1. Personnel will wear the following personal protection equipment as necessary, when cleaning sampling equipment (e.g., Kemmerer sampler, split-spoon sampler, trowels) and larger equipment (e.g., drill rig, augers):

    - Safety glasses, goggles, or a splash shield; and
    - PVC, latex, or nitrile outer gloves,

- Coated Tyvek® disposable coveralls or rainsuit, optional for small equipment cleaning; and
- Chemical resistant over boots, optional for small equipment cleaning.

2. All solvent rinsing if required, will be conducted in an adequately ventilated area.

3. All solvents transported into the field will be stored and packaged in appropriate containers with care taken to avoid exposure to extreme heat.

4. Handling of solvents will be consistent with the manufacturer's Material Safety Data Sheets (MSDS).

V. Field Cleaning Procedures

Cleaning Station

If a designated field equipment cleaning station location is required, it will be established to conduct all cleaning at each work area of the Site. The field equipment cleaning station will be located away from the immediate work area to minimize adverse impacts from work activities on the cleaning procedures, but close enough so the sampling teams can minimize equipment handling and transport.

Cleaning of Smaller Sampling Equipment

Cleaning of smaller sampling equipment (e.g., Kemmerer samplers, sample composite vessels, split-spoon samplers, bailers, trowels) will be conducted according to the following sequential procedure:

- Non-phosphate detergent (Alconox, Liquinox, or equivalent) and tap water wash;
- Tap water rinse;
- Solvent rinse, if required (e.g., methanol for organic constituent analysis, nitric acid for inorganic constituent analysis); and
- Triple distilled/deionized water rinse.

The first step, non-phosphate detergent and tap water scrub, is intended to remove all visible particulate matter and residual oil and grease. This may be preceded by a steam cleaning to facilitate soils removal. The tap water rinse is necessary to remove all soapy residues. The need for a specific solvent used for the solvent rinse, if required in the QAPP, will depend upon what the sample will be analyzed for. The final rinse of distilled/deionized water will be repeated three times. The equipment will then be allowed to air dry.

Collection and Disposal of used Solvents, Residuals and Rinse Solutions

All solvents, residuals, and rinse waters generated during the cleaning of equipment on-site will be collected, containerized, and stored on-site until arrangements can be made for proper disposal.

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I. Introduction

This standard operating procedure (SOP) is applicable to the collection of representative sediment oxygen demand (SOD) data from streams, rivers, lakes, ponds, lagoons, and surface impoundments. These typically applicable procedures have been adapted from the Ohio EPA Sediment Sampling Guide and Methodologies (OEPA, 2001), and may be varied or changed as required, dependent upon site conditions or equipment and procedural limitations. The actual procedures used should be documented in the field notes, especially if changes are made.

In order to collect representative SOD data, the hydrology and morphometry of a stream or impoundment should be determined prior to sampling. This will aid in determining appropriate sampling locations (see Section II).

SOD is measured using a dark chamber (resembling a large, inverted bowl) that isolates a known area of sediment and a known volume of water. A pump and tubing are used to form a closed system loop to circulate the volume of water over the area of sediment and ensure complete mixing. A dissolved oxygen (DO) probe in the chamber provides a continuous display of the DO concentration inside the chamber, which is recorded every five minutes for two hours or until the DO drops by 2 mg/L.

By using a dark chamber, photosynthesis does not affect the DO of the water in the chamber, and respiration and SOD are the only influences in the DO chamber. The effects of respiration are quantified by filling a blank SOD chamber or dark bottle with a known volume of water from the same location as the measurement chamber and measuring the DO at the beginning and end of the SOD test. The change in DO in the blank chamber or dark bottle provides an estimate of the amount of DO consumed by algal respiration in the water column.

The rate of change of DO in the chamber is determined by plotting the DO recorded in the chamber every five minutes. A regression analysis is then performed on the dataset. The rate of change of DO in the chamber is equal to the slope of the regression. The respiration rate measured in the dark bottle is subtracted from this rate. The corrected value is then divided by the area of the underlying sediment, resulting in an SOD value expressed as grams of oxygen consumed per square meter per day (g/m2/day) at the ambient temperature. To provide for standardization, temperatures are usually corrected to 20 degrees Celsius using a temperature correction factor.

II. Site Selection

SOD should be evaluated when any of the following conditions exist:

- Reaches having extensive low velocity pools (less than 0.25 fps).
- Reaches having diurnal DO swings greater than 100%.
- Reaches having extensive sludge deposits.

Sites should be selected based on a field evaluation that includes:

- Stream velocity; less than 0.25 fps (Velz, 1970), i.e., pools.
- Discharger location.

- Accessibility.
- Presence and extent of sludge deposits. Sludge deposits present the greatest impact of sediment types on instream DO. Sites for SOD measurement should include sludge deposits, if present, or locations with hydraulic characteristics conducive to sludge deposition.

III. Materials

The following materials shall be available, as required, during SOD surveys. Back-up field instruments/equipment should be available, if required.

- Personal protective equipment (as necessary).
- Cleaning equipment (as required in the Standard Operating Procedure for Equipment Cleaning).
- SOD chambers (benthic respirometer) and accessories (mixing pump with tubing and fittings, battery with connecting cables, rheostat for adjusting pump velocity).
- DO Meters – YSI Model 56 DO meter for each chamber, YSI Model 57 DO meter for algal production outside chamber, chart recorder.
- Primary productivity bottles, rope.
- Turbidimeter and accessories.
- Pyranograph and photometer with submersible sensor.
- Sediment sampling equipment (scoop, ponar dredge, etc.).
- Field data sheets, field log book, waterproof pen, camera and film.
- Miscellaneous supplies: Maps/plot plan, extra rope, bungee cords, survey stakes/flags/buoys, anchors and safety equipment.

IV. Preparations

- Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.
- Decontaminate or pre-clean equipment and ensure that it is in working order.
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
- Perform a general site survey.
- Use stakes, flagging, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. If also collecting sediment samples, this procedure may disturb the bottom and cause interferences with collection of representative water samples.

V. SOD Instrument Setup and Measurement Procedures

Benthic Respirometer – Instrument Setup

1. Measure and record on SOD data sheet: water velocity at 0.2 feet above sediments, SOD chamber number.

2. Calibrate DO meter. Record DO concentration near water surface.

3. Place chamber in sediments. If sediments are disturbed, wait several minutes before proceeding.

4. Purge all air from the mixing pump and tubing by running the pump for a sufficient time period with tubing ends under water.

5. Attach the mixing pump inlet and outlet tubing to the SOD chamber fittings. Turn on pump to begin mixing water and verify that no air is trapped within chamber.

6. Insert the DO probe in the chamber. Verify that no air bubbles are introduced inside the chamber via the probe.

7. If possible, regulate water velocity within chamber to approximate stream velocity near the sediments outside the chamber. If a rheostat is used in-line with the pump, the rheostat settings will need to be calibrated to velocity using the pump and tubing, a bucket and a flowmeter.

8. Install a similar respirometer next to the first one, but seal the bottom with a plastic lid, excluding all sediment (for quality control "blank" measurements). This chamber will measure the respiration oxygen demand of the water column, to be subtracted from the DO change measured by the first SOD chamber. If only one chamber is available, use the DO change measured in the dark productivity bottles to make this correction.

9. Start the DO meter.

10. Record the starting time, date, site data, meter number and, if using a non-auto-recording DO meter, manually record the DO and temperature readings on the SOD field data sheet. Write the values at 5 minute intervals initially, and alter the interval depending on the rate of oxygen uptake.

11. Retrieve chamber after DO concentration has decreased by 2 mg/l or after two hours.

VI. Calculations

The following equation is used to determine the SOD:

SOD = 1.44 * (V/A)*(b1-b2) where:

SOD	=	sediment oxygen demand, in g/m2/day
1.44	=	conversion factor, converts results to g/m2/day
V	=	volume of chamber, in liters
A	=	area of chamber, in square meters (A=p*r2)
b1	=	rate of change of DO inside the SOD chamber, in mg/L/minute
b2	=	rate of change of DO inside the "blank" SOD chamber or dark productivity bottles, in mg/L/minute

To facilitate the comparison of results among different sites, the SOD should be converted to 20^{o}C by using the following equation:

SOD20 = SODT/(1.065T-20) where:

SODT	=	SOD at original temperature, in g/m2/day

SOD20 = SOD at 20^{o}C, in g/m2/day
T = Ambient temperature, in ^{o}C

VII Disposal Methods

If required, all water generated during equipment cleaning procedures will be collected and contained for determination of proper treatment or disposal. In addition, personal protective equipment (e.g., gloves, disposable clothing) and other disposable equipment resulting from cleaning and sampling procedures will be placed in plastic bags and appropriately contained for proper disposal.

VIII. References

Ohio EPA. 2001. Sediment Sampling Guide and Methodologies, 2nd Edition. Division of Surface Water, Columbus, Ohio. Nov. 2001

Velz, Clarence. 1970. Applied Stream Sanitation. Wiley Interscience. New York, NY.

I. Introduction

Water quality parameters, such as water temperature, dissolved oxygen and pH are routinely measured during surface water investigations. Instantaneous measurements may be recorded using individual probes or multi-sensor sondes, as available and appropriate for each situation. These probes should be calibrated daily using manufacturer procedures. Collection of continuous data is most commonly performed using a data sonde with internal batteries and memory capacity that can be deployed for extended periods to record data over a range of conditions. The primary limiting factor for extended deployment duration is usually degradation of data quality because of biofouling of the sensor surfaces. The rate of biofouling is related to productivity of the water where monitoring is being conducted. In general, a sonde should be downloaded, checked for reading stability (drift), and recalibrated at a frequency of no more than seven to ten days. An initial check within this time period may allow for modification of subsequent visits, depending on the magnitude of drift observed. The calibration and maintenance log for the above referenced meters is included as an attachment to this Standard Operating Procedure.

II. Materials

The following materials, as required, shall be available for installation of and field visits to the continuous monitoring station(s):

- Personal protective equipment (as necessary);
- Perforated PVC housing(s) for extended deployment installations;
- Fence post(s) and pounder for extended deployment installations;
- Attachment hardware for extended deployment installations;
- Data probes or sonde;
- Manufacturer's operating manuals for each instrument;
- Calibration solutions appropriate for each instrument;
- Tools and equipment necessary for field maintenance of instruments;
- Laptop computer for setup and downloading sondes (as necessary);
- Clean container;
- pH calibration buffer solution within and bracketing expected range of measurements;
- Cleaning equipment (as required in the Standard Operating Procedure for Equipment Cleaning);
- Distilled/deionized water; and
- Appropriate forms and field notebook.

III. Procedures for Instantaneous Field Water Quality Measurements

1. Calibrate and operate all meters in accordance with manufacturer’s operating manuals.
2. For in-situ surface water measurements place probe(s) at the designated location in the water body, allow instrument readings to stabilize, and record the readings for each parameter:
3. If measuring ex-situ samples, collect a water sample from the designated location in the designated container, insert probes into container and record readings (especially temperature

and pH readings) as soon as possible after collecting the sample to minimize inaccuracies from the changing temperature of the sample as it equilibrates to ambient temperature.

4. Rinse probes off in distilled/deionized water, if required.
5. Log results and observations in field notebook.

IV. Procedures for Extended Sonde Deployment and Continuous Measurements

Installation. Installation of the data sonde is accomplished using a perforated PVC housing attached to a fence post or other structure, if present and appropriate. The goal of the installation is to place the sensors in a location that is representative of the water column (e.g. mid-channel, mid-depth, middle of flow volume). It is important to consider water level fluctuations, obstructions, and debris that may be present during wet or dry weather conditions and plan the installation accordingly to maximize the collection of accurate data. After an appropriate location is identified, install the perforated PVC housing in the stream channel.

Data Sonde Set-up and Calibration. The dissolved oxygen and pH sensors are calibrated according to manufacturer specifications prior to installation. Temperature is usually a factory-calibrated parameter. A logging file is created in the sonde for the storage of data according to manufacturer specifications. Start date and time is specified to ensure that data logging occurs when the sonde is deployed. Specify the sampling interval/data recording frequency. After calibration and logging file set-up, remove calibration chamber and attach the weighted strainer. Place the sonde into the protective housing. Secure the cap to the housing. Record deployment time in field notes.

Field Maintenance. The data sonde should be maintained at a minimum frequency of every seven to ten days. The current readings should be checked to evaluate drift, the logging file should be downloaded, the sonde should be cleaned and recalibrated, and the sonde should be redeployed. Each of these activities is described below.

The readings being reported by the sensors are checked for drift by comparing to known values. Dissolved oxygen is compared to a winkler titration and pH readings are compared to calibration solutions. The procedure is as follows:

1. Collect a water sample using a 5-gallon bucket, taking care to minimize turbulence. Keep sample out of direct sunlight.

2. Remove sonde from housing, connect to laptop, and place sensors in sample bucket. NOTE: take care to minimize disturbance to sensors;

3. Record current dissolved oxygen reading;

4. Conduct a Winkler titration to determine dissolved oxygen concentration of sample. Perform this step with an aliquot of the water collected in step 1 and as near as possible to the same time the sonde DO reading is recorded. Treat both sample aliquots identically otherwise, collect;

5. Calculate relative percent difference (RPD) between Winkler and sonde dissolved oxygen readings using the formula noted below. The acceptance criterion for this comparison is an RPD of 20% or less.

$$RPD=\left|\frac{(Abs(Winkler\ D.O.-Sonde\ D.O.))}{(Winkler\ D.O.+Sonde\ D.O\ /\ 2)}\right|*100$$

6. Record result in the field notebook;
7. Repeat process for the pH sensors;
8. Download logging file to laptop;
9. Gently clean the sensors to remove biofilms according to manufacturer specifications;
10. Recalibrate sensors;
11. Set up logging file;
12. Redeploy sonde, record date and time in field notes.

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FIELD INSTRUMENT CALIBRATION AND MAINTENANCE LOG
Temperature, pH and Dissolved Oxygen Meters

Instrument	Temperature	pH	D.O.
Manufacturer			
Model			
Identification No.			

Date	Time	Initials	Temp	pH			D.O.	Battery	Comments
			°C	4	7	10		Check	

.

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I. Handling

1. Fill in sample label (see attachment). Use indelible waterproof marking pen and include:
   - Sample Identification code (if possible, should reflect site name, sample location and sample interval)
   - Sample type (e.g., soil, sediment, water, vapor);
   - Project code;
   - Analysis required;
   - Date sampled;
   - Time sampled;
   - Name or initials of person who collected the sample;
   - Mode of collection (composite or grab); and
   - Preservation added, if applicable.
2. Check the caps on the sample containers so that they are tightly sealed.
3. Cover the label and sample container cap with clear packing tape to secure the label and cap onto the container, if necessary.
4. Place a signed custody seal label (see attachment) over the cap such that the cap cannot be removed without breaking the custody seal, if required.

II. Packing

1. If using a laboratory-supplied transpack, follow the laboratory's instructions for packing. Generally, repack the transpack in the same way in which the empty containers were received. If using a standard cooler, follow the instructions below.
2. Using packaging tape, secure the outside and inside the drain plug at the bottom of the cooler that is used for sample transport.
3. Place 1 to 2 inches of vermiculite or other cushioning material at the bottom of the cooler.
4. Place the sealed container upright in the cooler.
5. Place additional cushioning material around the sides of each sample container.
6. Place frozen gel cold packs on top of sample containers. If ice is used, repackage ice in small Ziploc® - type plastic bags and place loosely in the cooler. Do not pack cold packs or ice so tightly that it may prevent the addition of sufficient cushioning material.
7. Fill the remaining space in the cooler with vermiculite or other cushioning material.

8. Place the chain-of-custody forms (see attachment) in a large Ziploc® type bag and tape the forms to the inside of the cooler lid.

9. Close the cooler lid and fasten with packaging tape.

10. Wrap strapping or packaging tape around both ends of the cooler at least twice.

11. Mark the cooler on the outside with the following information: return address, "Fragile" labels (see attachment) on the top and on one side, and arrows indicating "This Side Up" (see attachment) on two adjacent sides.

12. Place custody seal evidence tape (see attachment) over front right and back left of the cooler lid and cover with clear plastic tape.

III. Shipping

1. Environmental samples will be shipped according to 40 CFR 761.65 (i)(3) and in accordance with current and applicable D.O.T. standards.

2. All samples will be delivered by an express carrier, allowing for sufficient time for analysis to be performed within the applicable holding time periods.

3. The following chain-of-custody procedures will apply to sample shipping:

   - Relinquish the sample containers to the laboratory via express carrier. The signed and dated forms should be taped inside the top of the cooler. The express carrier will not be required to sign the chain-of-custody forms.
   - When the samples are received by the laboratory, the laboratory personnel shall complete the chain-of-custody forms by signing and dating to acknowledge receipt of samples. The internal temperature of the shipping container is measured and recorded. The sample identification numbers on the containers are then checked to ensure that they are consistent with the chain of custody forms

Sample Shipping Label

	Limno-Tech, Inc. **734-332-1200**
Client/Source:	☐ **Grab** ☐ **Composite**
Site Name:	**Date:**
Sample #	**Time:**
Analysis:	**Preservatives:**
	Collected by:

Sample Custody Seal Label

Limno-Tech, Inc. **501 Avis Drive** **Ann Arbor, MI 48108**	Sealed by: ______________________ Date: _________Time: ______________

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Sample Chain of Custody Form

Limno-Tech, Inc.
Excellence in Environmental Engineering Since 1975

Check Originating Office

☐ Corporate Office
501 Avis Drive
Ann Arbor, MI 48108
(734) 332-1200 (phone)
(734)332-1212 (fax)

☐ Kalamazoo Field Office
2980 Business One Drive
Kalamazoo, MI 49001
(616) 226-0190 (phone)
(616) 226-0192 (fax)

CHAIN OF CUSTODY RECORD

Proj. No.	Project Name				
Samplers: *(Signature)*					

Sta. No.	Date	Time	COMP	GRAB	Station Location	Number of Containers							Remarks

Relinquished by: *(Signature)*	Date	Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date	Time	Relinquished by: *(Signature)*
Relinquished by: *(Signature)*	Date	Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date	Time	Relinquished by: *(Signature)*
Relinquished by: *(Signature)*	Date	Time	Received for Laboratory by: *(Signature)*	Date	Time	Remarks:	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

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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

Date / Time	Temp [°C]	DO [mg/l]
8/27/2005 19:15	23.42	4.33
8/27/2005 19:30	23.41	4.28
8/27/2005 19:45	23.41	4.28
8/27/2005 20:00	23.41	4.26
8/27/2005 20:15	23.41	4.25
8/27/2005 20:30	23.41	4.25
8/27/2005 20:45	23.41	4.23
8/27/2005 21:00	23.41	4.23
8/27/2005 21:15	23.4	4.22
8/27/2005 21:30	23.4	4.22
8/27/2005 21:45	23.39	4.21
8/27/2005 22:00	23.38	4.21
8/27/2005 22:15	23.37	4.2
8/27/2005 22:30	23.36	4.2
8/27/2005 22:45	23.36	4.19
8/27/2005 23:00	23.34	4.19
8/27/2005 23:15	23.33	4.2
8/27/2005 23:30	23.32	4.17
8/27/2005 23:45	23.32	4.18
8/28/2005 0:00	23.31	4.19
8/28/2005 0:15	23.29	4.17
8/28/2005 0:30	23.28	4.16
8/28/2005 0:45	23.27	4.17
8/28/2005 1:00	23.25	4.15
8/28/2005 1:15	23.24	4.16
8/28/2005 1:30	23.22	4.14
8/28/2005 1:45	23.2	4.15
8/28/2005 2:00	23.19	4.15
8/28/2005 2:15	23.17	4.15
8/28/2005 2:30	23.15	4.13
8/28/2005 2:45	23.13	4.12
8/28/2005 3:00	23.1	4.12
8/28/2005 3:15	23.09	4.11
8/28/2005 3:30	23.07	4.13
8/28/2005 3:45	23.04	4.11
8/28/2005 4:00	23.02	4.11
8/28/2005 4:15	23.01	4.1
8/28/2005 4:30	22.97	4.09
8/28/2005 4:45	22.95	4.12
8/28/2005 5:00	22.93	4.11
8/28/2005 5:15	22.9	4.1
8/28/2005 5:30	22.87	4.1
8/28/2005 5:45	22.86	4.07
8/28/2005 6:00	22.83	4.05
8/28/2005 6:15	22.8	4.07
8/28/2005 6:30	22.77	4.08
8/28/2005 6:45	22.75	4.04
8/28/2005 7:00	22.73	4.04
8/28/2005 7:15	22.7	4.03
8/28/2005 7:30	22.68	4.03
8/28/2005 7:45	22.66	4.03
8/28/2005 8:00	22.65	4.03
8/28/2005 8:15	22.64	4.03
8/28/2005 8:30	22.63	4.02
8/28/2005 8:45	22.63	4.01
8/28/2005 9:00	22.63	3.99
8/28/2005 9:15	22.63	3.96
8/28/2005 9:30	22.64	3.93
8/28/2005 9:45	22.66	3.91
8/28/2005 10:00	22.69	3.88
8/28/2005 10:15	22.71	3.83
8/28/2005 10:30	22.74	3.81
8/28/2005 10:45	22.75	3.79
8/28/2005 11:00	22.78	3.74
8/28/2005 11:15	22.8	3.77
8/28/2005 11:30	22.86	3.76
8/28/2005 11:45	22.98	3.74
8/28/2005 12:00	23.04	3.86
8/28/2005 12:15	23.09	3.89
8/28/2005 12:30	23.21	3.94
8/28/2005 12:45	23.31	3.91
8/28/2005 13:00	23.44	4.05
8/28/2005 13:15	23.58	4.14
8/28/2005 13:30	23.78	4.21
8/28/2005 13:45	23.97	4.33
8/28/2005 14:00	24.15	4.43
8/28/2005 14:15	24.26	4.43
8/28/2005 14:30	24.26	4.42
8/28/2005 14:45	24.33	4.45
8/28/2005 15:00	24.33	4.44
8/28/2005 15:15	24.3	4.46
8/28/2005 15:30	24.29	4.46
8/28/2005 15:45	24.32	4.44
8/28/2005 16:00	24.27	4.44
8/28/2005 16:15	24.21	4.46
8/28/2005 16:30	24.2	4.4
8/28/2005 16:45	24.22	4.42
8/28/2005 17:00	24.23	4.37
8/28/2005 17:15	24.23	4.36
8/28/2005 17:30	24.25	4.33
8/28/2005 17:45	24.25	4.32
8/28/2005 18:00	24.28	4.32
8/28/2005 18:15	24.26	4.28
8/28/2005 18:30	24.27	4.27
8/28/2005 18:45	24.26	4.28
8/28/2005 19:00	24.27	4.31
8/28/2005 19:15	24.27	4.3
8/28/2005 19:30	24.27	4.33
8/28/2005 19:45	24.26	4.35
8/28/2005 20:00	24.25	4.35
8/28/2005 20:15	24.25	4.39
8/28/2005 20:30	24.24	4.38
8/28/2005 20:45	24.24	4.41
8/28/2005 21:00	24.24	4.4
8/28/2005 21:15	24.23	4.42
8/28/2005 21:30	24.22	4.39
8/28/2005 21:45	24.2	4.35
8/28/2005 22:00	24.18	4.36
8/28/2005 22:15	24.16	4.33
8/28/2005 22:30	24.14	4.32
8/28/2005 22:45	24.13	4.29
8/28/2005 23:00	24.09	4.27
8/28/2005 23:15	24.06	4.26
8/28/2005 23:30	24.04	4.24
8/28/2005 23:45	24.02	4.2

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Date / Time	Temp [°C]	DO [mg/l]
8/28/2005 9:45	23.2	3.93
8/28/2005 10:00	23.21	3.92
8/28/2005 10:15	23.23	3.97
8/28/2005 10:30	23.24	3.93
8/28/2005 10:45	23.3	4
8/28/2005 11:00	23.32	4
8/28/2005 11:15	23.38	4.01
8/28/2005 11:30	23.44	4.06
8/28/2005 11:45	23.5	4.07
8/28/2005 12:00	23.55	4.07
8/28/2005 12:15	23.66	4.08
8/28/2005 12:30	23.75	4.15
8/28/2005 12:45	23.85	4.15
8/28/2005 13:00	23.96	4.19
8/28/2005 13:15	24.04	4.22
8/28/2005 13:30	24.11	4.19
8/28/2005 13:45	24.25	4.22
8/28/2005 14:00	24.31	4.2
8/28/2005 14:15	24.41	4.24
8/28/2005 14:30	24.51	4.26
8/28/2005 14:45	24.59	4.29
8/28/2005 15:00	24.7	4.3
8/28/2005 15:15	24.68	4.31
8/28/2005 15:30	24.76	4.3
8/28/2005 15:45	24.78	4.31
8/28/2005 16:00	24.81	4.31
8/28/2005 16:15	24.81	4.3
8/28/2005 16:30	24.83	4.32
8/28/2005 16:45	24.84	4.3
8/28/2005 17:00	24.84	4.28
8/28/2005 17:15	24.83	4.27
8/28/2005 17:30	24.82	4.24
8/28/2005 17:45	24.8	4.19
8/28/2005 18:00	24.79	4.19
8/28/2005 18:15	24.76	4.15
8/28/2005 18:30	24.74	4.16
8/28/2005 18:45	24.71	4.11
8/28/2005 19:00	24.67	4.08
8/28/2005 19:15	24.66	4.05
8/28/2005 19:30	24.63	4.06
8/28/2005 19:45	24.6	4.02
8/28/2005 20:00	24.57	4.05
8/28/2005 20:15	24.56	4.05
8/28/2005 20:30	24.55	4
8/28/2005 20:45	24.53	4
8/28/2005 21:00	24.52	3.99
8/28/2005 21:15	24.49	3.97
8/28/2005 21:30	24.49	3.98
8/28/2005 21:45	24.47	3.97
8/28/2005 22:00	24.46	3.95
8/28/2005 22:15	24.44	3.95
8/28/2005 22:30	24.44	3.94
8/28/2005 22:45	24.43	3.95
8/28/2005 23:00	24.41	3.94
8/28/2005 23:15	24.4	3.96
8/28/2005 23:30	24.4	3.93
8/28/2005 23:45	24.37	3.9
8/29/2005 0:00	24.37	3.92
8/29/2005 0:15	24.36	3.88
8/29/2005 0:30	24.35	3.88
8/29/2005 0:45	24.34	3.88
8/29/2005 1:00	24.33	3.86
8/29/2005 1:15	24.31	3.87
8/29/2005 1:30	24.3	3.85
8/29/2005 1:45	24.29	3.82
8/29/2005 2:00	24.28	3.85
8/29/2005 2:15	24.27	3.84
8/29/2005 2:30	24.26	3.82
8/29/2005 2:45	24.23	3.81
8/29/2005 3:00	24.23	3.79
8/29/2005 3:15	24.21	3.79
8/29/2005 3:30	24.2	3.8
8/29/2005 3:45	24.19	3.77
8/29/2005 4:00	24.17	3.81
8/29/2005 4:15	24.15	3.76
8/29/2005 4:30	24.12	3.77
8/29/2005 4:45	24.11	3.77
8/29/2005 5:00	24.08	3.75
8/29/2005 5:15	24.06	3.74
8/29/2005 5:30	24.04	3.76
8/29/2005 5:45	24.01	3.76
8/29/2005 6:00	23.98	3.74
8/29/2005 6:15	23.95	3.74
8/29/2005 6:30	23.92	3.74
8/29/2005 6:45	23.92	3.73
8/29/2005 7:00	23.88	3.72
8/29/2005 7:15	23.86	3.7
8/29/2005 7:30	23.84	3.69
8/29/2005 7:45	23.82	3.69
8/29/2005 8:00	23.8	3.68
8/29/2005 8:15	23.78	3.68
8/29/2005 8:30	23.75	3.67
8/29/2005 8:45	23.75	3.67
8/29/2005 9:00	23.73	3.67
8/29/2005 9:15	23.72	3.69
8/29/2005 9:30	23.71	3.7
8/29/2005 9:45	23.71	3.72
8/29/2005 10:00	23.7	3.71
8/29/2005 10:15	23.7	3.7
8/29/2005 10:30	23.71	3.75
8/29/2005 10:45	23.71	3.7
8/29/2005 11:00	23.74	3.71

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Date / Time	Temp [°C]	DO [mg/l]
8/29/2005 16:15	24.48	2.72
8/29/2005 16:30	24.44	2.73
8/29/2005 16:45	24.4	2.7
8/29/2005 17:00	24.37	2.68
8/29/2005 17:15	24.34	2.63
8/29/2005 17:30	24.33	2.62
8/29/2005 17:45	24.29	2.59
8/29/2005 18:00	24.27	2.61
8/29/2005 18:15	24.26	2.51
8/29/2005 18:30	24.25	2.5
8/29/2005 18:45	24.24	2.47
8/29/2005 19:00	24.23	2.48
8/29/2005 19:15	24.21	2.46
8/29/2005 19:30	24.19	2.45
8/29/2005 19:45	24.18	2.43
8/29/2005 20:00	24.16	2.42
8/29/2005 20:15	24.15	2.42
8/29/2005 20:30	24.13	2.4
8/29/2005 20:45	24.12	2.39
8/29/2005 21:00	24.1	2.41
8/29/2005 21:15	24.08	2.42
8/29/2005 21:30	24.07	2.38
8/29/2005 21:45	24.06	2.35
8/29/2005 22:00	24.05	2.31
8/29/2005 22:15	24.03	2.31
8/29/2005 22:30	24	2.34
8/29/2005 22:45	24	2.3
8/29/2005 23:00	23.99	2.27
8/29/2005 23:15	23.97	2.25
8/29/2005 23:30	23.95	2.24
8/29/2005 23:45	23.93	2.24
8/30/2005 0:00	23.91	2.22
8/30/2005 0:15	23.9	2.21
8/30/2005 0:30	23.88	2.21
8/30/2005 0:45	23.86	2.2
8/30/2005 1:00	23.84	2.21
8/30/2005 1:15	23.83	2.18
8/30/2005 1:30	23.81	2.15
8/30/2005 1:45	23.79	2.15
8/30/2005 2:00	23.77	2.16
8/30/2005 2:15	23.75	2.16
8/30/2005 2:30	23.74	2.18
8/30/2005 2:45	23.71	2.17
8/30/2005 3:00	23.7	2.15
8/30/2005 3:15	23.68	2.16
8/30/2005 3:30	23.65	2.19
8/30/2005 3:45	23.63	2.2
8/30/2005 4:00	23.6	2.19
8/30/2005 4:15	23.58	2.19
8/30/2005 4:30	23.56	2.19
8/30/2005 4:45	23.55	2.18
8/30/2005 5:00	23.53	2.17
8/30/2005 5:15	23.5	2.17
8/30/2005 5:30	23.47	2.18
8/30/2005 5:45	23.45	2.18
8/30/2005 6:00	23.42	2.2
8/30/2005 6:15	23.4	2.18
8/30/2005 6:30	23.37	2.18
8/30/2005 6:45	23.36	2.19
8/30/2005 7:00	23.33	2.22
8/30/2005 7:15	23.3	2.26
8/30/2005 7:30	23.28	2.33
8/30/2005 7:45	23.26	2.29
8/30/2005 8:00	23.24	2.28
8/30/2005 8:15	23.22	2.27
8/30/2005 8:30	23.2	2.29
8/30/2005 8:45	23.18	2.3
8/30/2005 9:00	23.17	2.32
8/30/2005 9:15	23.14	2.36
8/30/2005 9:30	23.12	2.36
8/30/2005 9:45	23.1	2.34
8/30/2005 10:00	23.1	2.36
8/30/2005 10:15	23.1	2.32
8/30/2005 10:30	23.09	2.33
8/30/2005 10:45	23.1	2.34
8/30/2005 11:00	23.09	2.38
8/30/2005 11:15	23.1	2.42
8/30/2005 11:30	23.12	2.44
8/30/2005 11:45	23.13	2.45
8/30/2005 12:00	23.14	2.45
8/30/2005 12:15	23.16	2.46
8/30/2005 12:30	23.19	2.47
8/30/2005 12:45	23.19	2.45
8/30/2005 13:00	23.22	2.47
8/30/2005 13:15	23.25	2.49
8/30/2005 13:30	23.27	2.51
8/30/2005 13:45	23.29	2.52
8/30/2005 14:00	23.29	2.53
8/30/2005 14:15	23.29	2.52
8/30/2005 14:30	23.26	2.5
8/30/2005 14:45	23.23	2.49
8/30/2005 15:00	23.21	2.47
8/30/2005 15:15	23.2	2.45
8/30/2005 15:30	23.16	2.45
8/30/2005 15:45	23.14	2.43
8/30/2005 16:00	23.1	2.44
8/30/2005 16:15	23.09	2.37
8/30/2005 16:30	23.06	2.4
8/30/2005 16:45	23.05	2.36
8/30/2005 17:00	23.03	2.4
8/30/2005 17:15	23.02	2.4
8/30/2005 17:30	22.97	2.41
8/30/2005 17:45	22.95	2.4
8/30/2005 18:00	22.94	2.34
8/30/2005 18:15	22.93	2.29
8/30/2005 18:30	22.9	2.24
8/30/2005 18:45	22.86	2.19
8/30/2005 19:00	22.84	2.15
8/30/2005 19:15	22.81	2.11

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Date / Time	Temp [°C]	DO [mg/l]
8/29/2005 17:00	24.22	3.66
8/29/2005 17:15	24.23	3.82
8/29/2005 17:30	24.29	3.91
8/29/2005 17:45	24.21	3.76
8/29/2005 18:00	24.2	3.8
8/29/2005 18:15	24.2	3.79
8/29/2005 18:30	24.2	3.84
8/29/2005 18:45	24.2	3.83
8/29/2005 19:00	24.22	3.87
8/29/2005 19:15	24.22	3.9
8/29/2005 19:30	24.22	3.88
8/29/2005 19:45	24.21	3.8
8/29/2005 20:00	24.22	3.88
8/29/2005 20:15	24.22	3.89
8/29/2005 20:30	24.22	3.83
8/29/2005 20:45	24.21	3.84
8/29/2005 21:00	24.21	3.85
8/29/2005 21:15	24.21	3.81
8/29/2005 21:30	24.21	3.86
8/29/2005 21:45	24.2	3.85
8/29/2005 22:00	24.19	3.83
8/29/2005 22:15	24.18	3.85
8/29/2005 22:30	24.18	3.83
8/29/2005 22:45	24.17	3.84
8/29/2005 23:00	24.15	3.8
8/29/2005 23:15	24.14	3.82
8/29/2005 23:30	24.13	3.8
8/29/2005 23:45	24.11	3.82
8/30/2005 0:00	24.1	3.78
8/30/2005 0:15	24.09	3.8
8/30/2005 0:30	24.07	3.78
8/30/2005 0:45	24.05	3.77
8/30/2005 1:00	24.04	3.73
8/30/2005 1:15	24.04	3.79
8/30/2005 1:30	24.02	3.76
8/30/2005 1:45	23.99	3.74
8/30/2005 2:00	23.98	3.71
8/30/2005 2:15	23.96	3.67
8/30/2005 2:30	23.95	3.68
8/30/2005 2:45	23.93	3.64
8/30/2005 3:00	23.91	3.62
8/30/2005 3:15	23.9	3.65
8/30/2005 3:30	23.87	3.63
8/30/2005 3:45	23.85	3.59
8/30/2005 4:00	23.82	3.62
8/30/2005 4:15	23.81	3.59
8/30/2005 4:30	23.79	3.55
8/30/2005 4:45	23.77	3.57
8/30/2005 5:00	23.75	3.55
8/30/2005 5:15	23.73	3.46
8/30/2005 5:30	23.72	3.5
8/30/2005 5:45	23.69	3.47
8/30/2005 6:00	23.67	3.44
8/30/2005 6:15	23.64	3.43
8/30/2005 6:30	23.62	3.37
8/30/2005 6:45	23.6	3.33
8/30/2005 7:00	23.57	3.44
8/30/2005 7:15	23.55	3.47
8/30/2005 7:30	23.53	3.56
8/30/2005 7:45	23.49	3.58
8/30/2005 8:00	23.46	3.57
8/30/2005 8:15	23.43	3.55
8/30/2005 8:30	23.4	3.53
8/30/2005 8:45	23.38	3.54
8/30/2005 9:00	23.36	3.59
8/30/2005 9:15	23.32	3.67
8/30/2005 9:30	23.3	3.67
8/30/2005 9:45	23.27	3.68
8/30/2005 10:00	23.25	3.69
8/30/2005 10:15	23.23	3.74
8/30/2005 10:30	23.21	3.75
8/30/2005 10:45	23.19	3.74
8/30/2005 11:00	23.18	3.73
8/30/2005 11:15	23.16	3.74
8/30/2005 11:30	23.16	3.71
8/30/2005 11:45	23.15	3.69
8/30/2005 12:00	23.15	3.63
8/30/2005 12:15	23.15	3.64
8/30/2005 12:30	23.15	3.59
8/30/2005 12:45	23.16	3.63
8/30/2005 13:00	23.17	3.6
8/30/2005 13:15	23.19	3.59
8/30/2005 13:30	23.2	3.58
8/30/2005 13:45	23.22	3.61
8/30/2005 14:00	23.23	3.54
8/30/2005 14:15	23.25	3.53
8/30/2005 14:30	23.24	3.52
8/30/2005 14:45	23.23	3.48
8/30/2005 15:00	23.23	3.44
8/30/2005 15:15	23.23	3.41
8/30/2005 15:30	23.24	3.4
8/30/2005 15:45	23.23	3.37
8/30/2005 16:00	23.22	3.35
8/30/2005 16:15	23.21	3.39
8/30/2005 16:30	23.17	3.36
8/30/2005 16:45	23.16	3.4
8/30/2005 17:00	23.14	3.37
8/30/2005 17:15	23.11	3.32
8/30/2005 17:30	23.08	3.29
8/30/2005 17:45	23.05	3.21
8/30/2005 18:00	23.02	3.22
8/30/2005 18:15	22.98	3.2
8/30/2005 18:30	22.95	3.24
8/30/2005 18:45	22.92	3.21
8/30/2005 19:00	22.9	3.25
8/30/2005 19:15	22.88	3.24
8/30/2005 19:30	22.85	3.26
8/30/2005 19:45	22.83	3.23

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Date / Time	Temp [°C]	DO [mg/l]
8/29/2005 10:45	24.95	2.69
8/29/2005 11:00	24.94	2.69
8/29/2005 11:15	24.92	2.63
8/29/2005 11:30	24.93	2.63
8/29/2005 11:45	24.94	2.59
8/29/2005 12:00	24.98	2.6
8/29/2005 12:15	24.99	2.57
8/29/2005 12:30	25.03	2.6
8/29/2005 12:45	25.07	2.63
8/29/2005 13:00	25.14	2.64
8/29/2005 13:15	25.26	2.64
8/29/2005 13:30	25.29	2.7
8/29/2005 13:45	25.34	2.69
8/29/2005 14:00	25.47	2.71
8/29/2005 14:15	25.77	3.08
8/29/2005 14:30	25.76	2.96
8/29/2005 14:45	26	3.28
8/29/2005 15:00	25.89	2.97
8/29/2005 15:15	26.07	3.26
8/29/2005 15:30	26.06	3.18
8/29/2005 15:45	26.09	3.13
8/29/2005 16:00	26.29	3.46
8/29/2005 16:15	26.34	3.46
8/29/2005 16:30	26.29	3.39
8/29/2005 16:45	26.28	3.28
8/29/2005 17:00	26.42	3.51
8/29/2005 17:15	26.15	3.05
8/29/2005 17:30	26.2	3.17
8/29/2005 17:45	26.31	3.28
8/29/2005 18:00	26.39	3.57
8/29/2005 18:15	26.33	3.6
8/29/2005 18:30	26.07	3.17
8/29/2005 18:45	26.01	3.58
8/29/2005 19:00	25.9	3.22
8/29/2005 19:15	25.83	3.01
8/29/2005 19:30	25.79	3.09
8/29/2005 19:45	25.72	3
8/29/2005 20:00	25.68	2.98
8/29/2005 20:15	25.62	2.92
8/29/2005 20:30	25.56	2.89
8/29/2005 20:45	25.51	2.84
8/29/2005 21:00	25.49	2.75
8/29/2005 21:15	25.44	2.71
8/29/2005 21:30	25.4	2.73
8/29/2005 21:45	25.36	2.7
8/29/2005 22:00	25.33	2.65
8/29/2005 22:15	25.31	2.73
8/29/2005 22:30	25.3	2.7
8/29/2005 22:45	25.3	2.83
8/29/2005 23:00	25.3	2.83
8/29/2005 23:15	25.28	2.81
8/29/2005 23:30	25.27	2.79
8/29/2005 23:45	25.26	2.8
8/30/2005 0:00	25.24	2.8
8/30/2005 0:15	25.25	2.84
8/30/2005 0:30	25.25	2.9
8/30/2005 0:45	25.24	2.93
8/30/2005 1:00	25.25	2.99
8/30/2005 1:15	25.24	2.97
8/30/2005 1:30	25.24	2.98
8/30/2005 1:45	25.24	2.99
8/30/2005 2:00	25.23	3
8/30/2005 2:15	25.23	3.01
8/30/2005 2:30	25.23	2.98
8/30/2005 2:45	25.22	2.97
8/30/2005 3:00	25.22	2.98
8/30/2005 3:15	25.21	2.98
8/30/2005 3:30	25.2	2.98
8/30/2005 3:45	25.19	2.92
8/30/2005 4:00	25.19	2.93
8/30/2005 4:15	25.19	2.94
8/30/2005 4:30	25.18	2.92
8/30/2005 4:45	25.17	2.97
8/30/2005 5:00	25.16	2.9
8/30/2005 5:15	25.16	2.91
8/30/2005 5:30	25.15	2.89
8/30/2005 5:45	25.13	2.84
8/30/2005 6:00	25.12	2.82
8/30/2005 6:15	25.11	2.81
8/30/2005 6:30	25.11	2.82
8/30/2005 6:45	25.08	2.85
8/30/2005 7:00	25.07	2.85
8/30/2005 7:15	25.06	2.87
8/30/2005 7:30	25.06	2.82
8/30/2005 7:45	25.04	2.8
8/30/2005 8:00	25.02	2.84
8/30/2005 8:15	25	2.83
8/30/2005 8:30	25.01	2.84
8/30/2005 8:45	24.98	2.87
8/30/2005 9:00	24.98	2.88
8/30/2005 9:15	24.96	2.86
8/30/2005 9:30	24.95	2.85
8/30/2005 9:45	24.95	2.91
8/30/2005 10:00	24.93	2.87
8/30/2005 10:15	24.93	2.96
8/30/2005 10:30	24.92	2.99

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Date / Time	Temp [°C]	DO [mg/l]
8/30/2005 17:45	24.97	4.27
8/30/2005 18:00	25.02	4.25
8/30/2005 18:15	25.01	4.29
8/30/2005 18:30	24.98	4.28
8/30/2005 18:45	24.95	4.18
8/30/2005 19:00	24.95	4.23
8/30/2005 19:15	24.92	4.14
8/30/2005 19:30	24.92	4.14
8/30/2005 19:45	24.9	4.17
8/30/2005 20:00	24.89	4.12
8/30/2005 20:15	24.86	4.17
8/30/2005 20:30	24.85	4.11
8/30/2005 20:45	24.85	4.1
8/30/2005 21:00	24.84	4.08
8/30/2005 21:15	24.81	4.13
8/30/2005 21:30	24.81	4.12
8/30/2005 21:45	24.79	4.06
8/30/2005 22:00	24.78	4.07
8/30/2005 22:15	24.76	4.02
8/30/2005 22:30	24.74	4.01
8/30/2005 22:45	24.73	3.99
8/30/2005 23:00	24.7	4.01
8/30/2005 23:15	24.7	4
8/30/2005 23:30	24.68	3.93
8/30/2005 23:45	24.67	3.97
8/31/2005 0:00	24.65	3.93
8/31/2005 0:15	24.62	3.9
8/31/2005 0:30	24.59	3.91
8/31/2005 0:45	24.57	3.94
8/31/2005 1:00	24.55	3.91
8/31/2005 1:15	24.52	3.92
8/31/2005 1:30	24.49	3.88
8/31/2005 1:45	24.46	3.9
8/31/2005 2:00	24.43	3.89
8/31/2005 2:15	24.39	3.83
8/31/2005 2:30	24.36	3.88
8/31/2005 2:45	24.33	3.87
8/31/2005 3:00	24.32	3.82
8/31/2005 3:15	24.29	3.86
8/31/2005 3:30	24.27	3.84
8/31/2005 3:45	24.25	3.89
8/31/2005 4:00	24.23	3.84
8/31/2005 4:15	24.21	3.88
8/31/2005 4:30	24.19	3.86
8/31/2005 4:45	24.15	3.88
8/31/2005 5:00	24.13	3.87
8/31/2005 5:15	24.11	3.84
8/31/2005 5:30	24.1	3.86
8/31/2005 5:45	24.07	3.89
8/31/2005 6:00	24.03	3.81
8/31/2005 6:15	24.03	3.88
8/31/2005 6:30	23.99	3.83
8/31/2005 6:45	23.96	3.88
8/31/2005 7:00	23.93	3.88
8/31/2005 7:15	23.9	3.89
8/31/2005 7:30	23.88	3.84
8/31/2005 7:45	23.86	3.87
8/31/2005 8:00	23.86	3.91
8/31/2005 8:15	23.84	3.94
8/31/2005 8:30	23.86	4.01
8/31/2005 8:45	23.88	4.06
8/31/2005 9:00	23.94	4.08
8/31/2005 9:15	23.97	4.12
8/31/2005 9:30	23.99	4.11
8/31/2005 9:45	24.03	4.13
8/31/2005 10:00	24.08	4.05
8/31/2005 10:15	24.08	4.02
8/31/2005 10:30	24.16	4.09
8/31/2005 10:45	24.45	4.34
8/31/2005 11:00	24.58	4.35
8/31/2005 11:15	24.65	4.37
8/31/2005 11:30	25.07	4.55
8/31/2005 11:45	24.87	4.45
8/31/2005 12:00	25.07	4.69
8/31/2005 12:15	25.56	4.82
8/31/2005 12:30	25.47	4.84
8/31/2005 12:45	25.44	4.76
8/31/2005 13:00	25.25	4.76
8/31/2005 13:15	25.28	4.88
8/31/2005 13:30	25.41	5.04
8/31/2005 13:45	25.63	5.19
8/31/2005 14:00	25.73	5.29
8/31/2005 14:15	25.77	5.36
8/31/2005 14:30	25.71	5.26
8/31/2005 14:45	25.74	5.34
8/31/2005 15:00	25.95	5.52
8/31/2005 15:15	25.95	5.42
8/31/2005 15:30	26.16	5.6
8/31/2005 15:45	26.11	5.52
8/31/2005 16:00	26.13	5.5
8/31/2005 16:15	26.2	5.62
8/31/2005 16:30	26.24	5.69
8/31/2005 16:45	26.13	5.53
8/31/2005 17:00	26.06	5.46
8/31/2005 17:15	25.99	5.4
8/31/2005 17:30	25.96	5.43
8/31/2005 17:45	25.86	5.45
8/31/2005 18:00	25.8	5.33
8/31/2005 18:15	25.74	5.28
8/31/2005 18:30	25.71	5.19
8/31/2005 18:45	25.68	5.17
8/31/2005 19:00	25.67	5.11
8/31/2005 19:15	25.66	5.21
8/31/2005 19:30	25.67	5.16
8/31/2005 19:45	25.64	5.16
8/31/2005 20:00	25.63	5.24
8/31/2005 20:15	25.62	5.22
8/31/2005 20:30	25.6	5.2
8/31/2005 20:45	25.58	5.13
8/31/2005 21:00	25.54	5.17
8/31/2005 21:15	25.52	5.14
8/31/2005 21:30	25.49	5.09
8/31/2005 21:45	25.44	5.11
8/31/2005 22:00	25.4	5.05
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
9/1/2005 3:30	24.62	4.66
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

North Fork Kaskaskia River Watershed
Final Approved TMDL

Prepared for Illinois Environmental Protection Agency

September 2006

North Fork Kaskaskia River (IL_OKA-01): Manganese, dissolved oxygen, pH, iron, fecal coliform

North Fork Kaskaskia River (IL_OKA-02): Manganese, dissolved oxygen, pH, iron

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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).

Two segments of the North Fork Kaskaskia River (Segments IL_OKA-01 and IL_OKA-02) 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

1 PROBLEM IDENTIFICATION

The impairments in waters of the North Fork Kaskaskia River 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). TMDLs are currently only being developed for pollutants that have numerical water quality standards; those causes that have a numeric water quality standard and which are the focus of this report are shown below in bold font.

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 manganese loads from watershed sources such as stream bank erosion would also serve to reduce phosphorus loads to the river.

North Fork Kaskaskia River	
Assessment Unit ID	IL_OKA-01
Length (miles)	10.11
Listed For	**Dissolved oxygen, pH, manganese, iron, fecal coliform,** total phosphorus
Use Support[1]	Aquatic life (N), Fish consumption (F), Public and food processing water supplies (N), Primary contact (N), Secondary contact (X)

[1]F = Fully supporting, N=not supporting, X= not assessed

North Fork Kaskaskia River	
Assessment Unit ID	IL_OKA-02
Length (miles)	15.31
Listed For	**Dissolved oxygen, pH, manganese, iron,** total phosphorus
Use Support[1]	Aquatic life (N), Fish consumption (X), Public and food processing water supplies (N), Primary contact (X), Secondary contact (X)

[1]F=fully supporting, N=not supporting, X=not assessed

As discussed in the Stage 1 Report, available data were reviewed to confirm the impairments and sources. Since the Stage 1 Report was written, fecal coliform has been identified as another cause of impairment in the North Fork Kaskaskia River segment IL_OKA-01; fecal coliform is addressed in this TMDL. Based on a review of available data, it has been determined that the fecal coliform listing is warranted, with 18 of the 62 instream fecal coliform measurements collected between May and October exceeding the water quality standard. Potential sources include wildlife, livestock, failing septic systems and permitted dischargers.

2 REQUIRED TMDL ELEMENTS

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

North Fork Kaskaskia River (IL_OKA-01 and IL_OKA-02)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:**

    North Fork Kaskaskia River, HUC 07140202. The impairments of concern addressed in this TMDL are dissolved oxygen, pH, manganese, iron, and fecal coliform. Potential sources contributing to the listing of this segment of the North Fork Kaskaskia River include: natural background sources, streambank erosion, groundwater, river bottom sediments, runoff from lawns and agricultural lands, failing septic systems and permitted point sources.

    The North Fork Kaskaskia River 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).

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, a modeling target of 6.0 was used to consider diurnal variation and ensure that the 5.0 mg/l water quality standard is met.

    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 **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 the public water intake was discontinued on July 31, 2006, 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 **iron** as a cause of impairment in streams state that iron is a potential cause of impairment of the aquatic life use if greater than 10% of the dissolved iron samples exceed 1,000 ug/l. The IEPA guidelines (IEPA, 2006) for identifying **iron** as a cause of impairment in streams state that iron is a potential cause of impairment of the public and food processing water supply use if greater than 10% of the dissolved iron samples collected in 2001 or later exceed 300 ug/l. Because the public water intake was discontinued on July 31, 2006, the TMDL target for dissolved iron is based on the dissolved iron standard to protect the aquatic life use. The TMDL target is a dissolved iron concentration of 1,000 ug/l.

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. For fecal coliform, the target is set at meeting 200 cfu/100 ml across the entire flow regime during May through October.

3. Loading Capacity – Linking Water Quality and Pollutant Sources:

Loading capacity was determined for each impairment cause and river segment, as presented below.

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). 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. Ammonia and BOD5 are also addressed in this TMDL.

QUAL2E simulations show that SOD must be reduced by 97% during low flow conditions to meet the TMDL target for dissolved oxygen, assuming that other sources are maintained at existing loads. To achieve this, a 97% reduction of particulate organic carbon loading to the stream is required.

The load capacity is presented below:

IL_OKA-01 Load Capacity

CBOD5 Load Capacity (lbs/day)	Ammonia Load Capacity (lbs/day)	
	Summer	Winter
40.1	0.3	0.4

IL_OKA-02 Load capacity

CBOD5 Load Capacity (lbs/day)	Ammonia Load Capacity (lbs/day)
30.5	3.1

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 both segment IL_OKA-01 and IL_OKA-02.

Manganese

A load capacity calculation was completed to determine the maximum manganese loads that will maintain compliance with the total manganese standard under a range of flow conditions:

North Fork Kaskaskia River (IL_OKA-01) Flow (cfs)	Manganese load capacity (lbs/day)
10	53.6
20	107.3
40	214.6
60	321.8
80	429.1
99	536.4
149	804.6
398	2145.5

North Fork Kaskaskia River (IL_OKA-02) Flow (cfs)	Manganese load capacity (lbs/day)
5	27.0
10	53.9
20	107.9
30	161.8
40	215.7
50	269.7
75	404.5
200	1078.7

Iron

A load capacity calculation was completed to determine the maximum iron loads that will maintain compliance with the dissolved iron standard under a range of flow conditions:

North Fork Kaskaskia River (IL_OKA-01) Flow (cfs)	Iron load capacity (lbs/day)
10	53.6
20	107.3
40	214.6
60	321.8
80	429.1
99	536.4
149	804.6
398	2145.5

North Fork Kaskaskia River (IL_OKA-02) Flow (cfs)	Iron load capacity (lbs/day)
5	27.0
10	53.9
20	107.9
30	161.8
40	215.7
50	269.7
75	404.5
200	1078.7

Fecal coliform

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:

North Fork Kaskaskia River (IL_OKA-01) Flow (cfs)	Fecal load capacity (million cfu/day)
10	49,000
20	97,000
40	195,000
60	292,000
80	389,000
149	730,000
398	1,947,000

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDLs are as follows:

Dissolved oxygen

	CBOD5 LA (lbs/day)	Ammonia LA (lbs/day)
IL_OKA-01	7.7	0.2
IL_OKA-02	27.4	2.8

pH

The pH TMDL target for nonpoint sources in the North Fork Kaskaskia River watershed (segments IL_OKA-01 and Il_OKA-02) is between 6.5 and 9.0 standard units.

Manganese

North Fork Kaskaskia River (IL_OKA-01) Flow (cfs)	Manganese load allocation (lbs/day)
10	48.24
20	96.57
40	193.14
60	289.62
80	386.19
99	482.76
149	724.14
398	1930.95

North Fork Kaskaskia River (IL_OKA-02) Flow (cfs)	Manganese load allocation (lbs/day)
5	24.30
10	48.51
20	97.11
30	145.62
40	194.13
50	242.73
75	364.05
200	970.83

Iron

North Fork Kaskaskia River (IL_OKA-01) Flow (cfs)	Iron load allocation (lbs/day)
10	44.1
20	92.4
40	189.0
60	285.4
80	382.0
99	478.6
149	720.0
398	1926.8

North Fork Kaskaskia River (IL_OKA-02) Flow (cfs)	Iron load allocation (lbs/day)
5	24.3
10	48.5
20	97.1
30	145.6
40	194.1
50	242.7
75	364.1
200	970.8

Fecal coliform

Load allocations designed to achieve compliance with the above TMDL are calculated for the May-October period by the following equation:

Load allocation = load capacity – MOS – ΣWLAs

North Fork Kaskaskia River (IL_OKA-01) Flow (cfs)	Fecal load allocation (million cfu/day)
10	48,000
20	97,000
40	194,000
60	291,000
80	389,000
149	729,000
398	1,946,000

5. Wasteload Allocations (WLA):

Wasteload allocations are presented below, by impairment cause for each river segment.

Dissolved oxygen

Wasteload allocations for the two permitted sewage treatment plants (Patoka STP and Patoka Community Unit School District) in the North Fork Kaskaskia River (IL_OKA-01) watershed were based on their existing permit limits, because results of the TMDL analysis show that they do not cause or contribute to the dissolved oxygen impairment. The CBOD5 WLA for these facilities equals 31.5 lbs/day, for periods when they are discharging. The ammonia WLA for these facilities varies seasonally based on the permit limits for the Patoka Community Unit School District. The summer ammonia WLA for this facility equals 0.08 lbs/day and the winter ammonia limit equals 0.2 lbs/day. The Patoka STP does not have an ammonia limit and therefore an ammonia WLA was not calculated for this facility.

There are no permitted point source dischargers in the segment IL_OKA-02 watershed, therefore the wasteload allocation for this segment does not need to be calculated.

pH

There are four point source dischargers in the segment IL_OKA-01 watershed: Patoka STP, Patoka Community Unit School District, Mobile Pipeline – Patoka Station and Ameren Energy – Kinmundy Power Plant. Effluent pH levels for these four point sources shall be between 6.5 and 9.0 standard units at the point of discharge.

The pH target for point sources is not applicable in segment IL_OKA-02 as there are no permitted point source dischargers in the segment IL_OKA-02 watershed.

Manganese

The manganese wasteload allocation for segment IL-OKA-01 does not need to be calculated because there are no manganese permit limits for the dischargers in this watershed. The manganese wasteload allocation for segment IL-OKA-02 does not need to be calculated because there are no point source dischargers of manganese in the watershed.

Iron

The WLA for the one point source discharger of dissolved iron (Mobile Pipeline – Patoka Station) was calculated from the current permitted flow (assuming continuous discharge) and a dissolved iron concentration consistent with the applicable water quality standards (1,000 ug/l). The WLA for this facility equals 4.17 lbs/day.

There are no permitted point source dischargers in the segment IL_OKA-02 watershed. The iron wasteload allocation for this segment does not need to be calculated.

Fecal coliform

There are two sewage treatment plants in the North Fork Kaskaskia River (IL_OKA-01) watershed, which are permitted to discharge fecal coliform. These are the Patoka STP and the Patoka Community Unit School District STP. Both of these facilities have a disinfection exemption. The WLA for these facilities 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 the dischargers exempted reach. The WLA for these facilities equals 600 million cfu/day.

There are no permitted point source dischargers in the segment IL_OKA-02 watershed. The wasteload allocation for this segment does not need to be calculated.

6. **Margin of Safety:** Both explicit and implicit margins of safety were incorporated into this TMDL, as described below.

Dissolved oxygen

The TMDL for segments IL_OKA-01 and IL_OKA-02 contains an explicit margin of safety equal to 10% of the load allocation.

	CBOD5 MOS (lbs/day)	Ammonia MOS (lbs/day)
IL_OKA-01	0.86	0.02
IL_OKA-02	3.05	0.31

pH

The pH TMDL for segments IL_OKA-01 and IL_OKA-02 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 the North Fork Kaskaskia River will be met.

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.

North Fork Kaskaskia River (IL_OKA-01) Flow (cfs)	Manganese Margin of Safety (lbs/day)
10	5.4
20	10.7
40	21.5
60	32.2
80	42.9
99	53.6
149	80.5
398	214.6

North Fork Kaskaskia River (IL_OKA-02) Flow (cfs)	Manganese Margin of Safety (lbs/day)
5	2.7
10	5.4
20	10.8
30	16.2
40	21.6
50	27.0
75	40.5
200	107.9

Iron

The iron 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 iron 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.

North Fork Kaskaskia River (IL_OKA-01) Flow (cfs)	Iron Margin of Safety (lbs/day)
10	5.4
20	10.7
40	21.5
60	32.2
80	42.9
99	53.6
149	80.5
398	214.6

North Fork Kaskaskia River (IL_OKA-02) Flow (cfs)	Iron Margin of Safety (lbs/day)
5	2.7
10	5.4
20	10.8
30	16.2
40	21.6
50	27.0
75	40.5
200	107.9

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.

7. **Seasonal Variation:** Seasonal variation is considered within the TMDL as described below:

Dissolved oxygen

The TMDL was conducted with an explicit consideration of seasonal variation. The TMDL was evaluated for a range of flow conditions that are expected to be observed throughout the year. However, dissolved oxygen problem are only predicted to occur during low flow periods. Furthermore, this TMDL requires a 97% reduction in watershed loadings of particulate organic carbon, which are expected to be delivered to the stream during wet weather conditions. Finally, this TMDL considers seasonal ammonia permit limits for the sewage treatment plants, where applicable.

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.

Iron

The TMDL was conducted with an explicit consideration of seasonal variation. The dissolved iron 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.

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.

Fecal coliform

This TMDL was conducted with an explicit consideration of seasonal variation. The 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 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 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.

   The involvement of 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:** Monitoring of the North Fork Kaskaskia River will continue to be conducted as part of IEPA's ambient monitoring program to track the effectiveness of the TMDL.

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 (Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. One public meeting was conducted in Patoka, Illinois in 2005 to present the results of the Stage 1 characterization work. A second public meeting was held in Patoka, Illinois in August 2006 to present the draft TMDL. One additional public meeting will be held at a later date to present the implementation plan.

3 WATERSHED CHARACTERIZATION

A description of the North Fork Kaskaskia River watershed to support the identification of sources contributing to the listed impairments is provided in the Stage 1 Report. 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 two impaired stream segments addressed in this report are in the North Fork Kaskaskia River watershed, located in southern Illinois, approximately 75 miles southeast of Springfield, Illinois, and 60 miles east of St. Louis, Missouri. The headwaters of the North Fork Kaskaskia River originate in Fayette County, Illinois, and this is the origin of segment IL_OKA-02. Segment IL_OKA-02 flows westward through Marion County, ending about 0.5 miles upstream of the US Route 51 overpass, where this segment flows into segment IL_OKA-01. Segment IL_OKA-01 flows westward from just east of the US Route 51 overpass, through Clinton County, to its terminus at Carlyle Lake. The project study area is predominantly agricultural (74%) and includes portions of three counties (Fayette, Marion and Clinton). Figure 1 shows a map of the North Fork Kaskaskia River watershed, and includes key features such as waterways, impaired waterbodies, and public water intakes. The three public water supply intakes shown near the Route 51 crossing of the North Fork Kaskaskia River were discontinued on July 31, 2006; the new source is Lake Carlyle. 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 Stage 1 Report provides detailed characterizations of the impaired waterways and their watersheds.

In August and October 2005, additional low-flow sampling was conducted at six locations in the North Fork Kaskaskia River watershed. Five locations on the mainstem of the creek were sampled, and one tributary (Louse Run). Sampling was planned for a second tributary, but it was dry at the time of the field sampling. Dissolved oxygen concentrations were less than 4.0 mg/l at all sampling locations, during both surveys. Manganese concentrations were observed to exceed the public and food processing water supply use and aquatic life use criteria along the length of the river (OKA-01 and OKA-02), with the lowest concentrations measured downstream. Dissolved iron concentrations also exceeded the public and food processing water supply use and aquatic life use criteria in both segments of the river, with the lowest concentration measured at the most downstream station. pH measurements were all within the 6.5 to 9.0 SU range and no violations were observed. No additional fecal coliform data were collected during this study. The data are summarized in the Stage 2 data report.

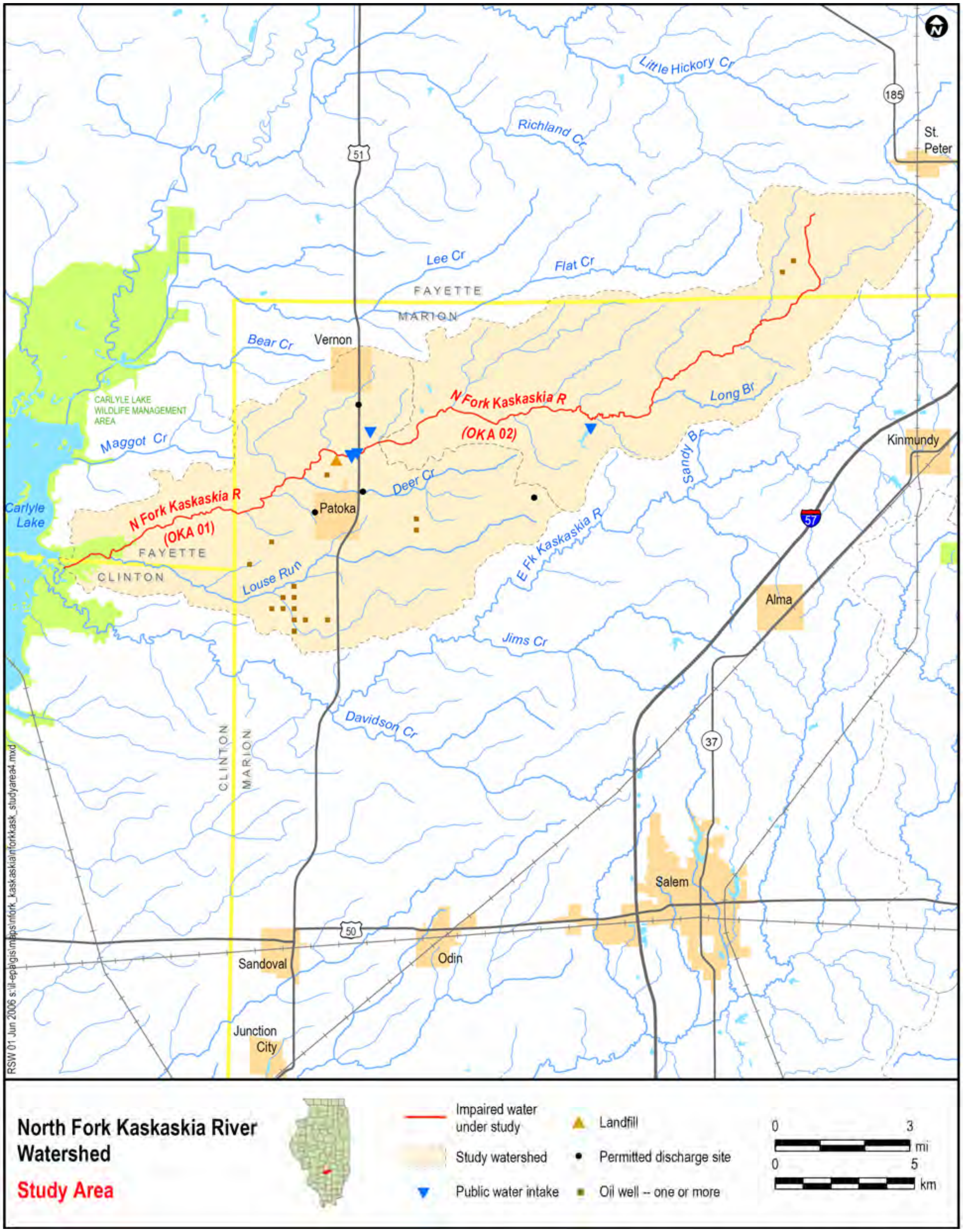

Figure 1. Base Map of the North Fork Kaskaskia River Watershed

4 DESCRIPTION OF APPLICABLE STANDARDS AND NUMERIC TARGETS

The ultimate goal of TMDL development is to achieve attainment with water quality standards. A water quality standard consists of 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 North Fork Kaskaskia River 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 dissolved oxygen, pH, manganese, iron and fecal coliform under its CWA Section 305(b) program, as summarized below.

4.2.1 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.

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 the North Fork Kaskaskia River (IL_OKA-01 and Il_OKA-02) for dissolved oxygen is appropriate based on IEPA's guidelines.

4.2.2 pH

The water quality standard for pH in Illinois waters designated for aquatic life is greater than or equal to 6.5 SU and less than or equal to 9.0 SU. 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 the North Fork Kaskaskia River (IL_OKA-01 and Il_OKA-02) for pH is appropriate based on IEPA's guidelines.

4.2.3 Manganese

The water quality standard for total 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 streams indicates impairment if more than 10% of the observations measured since 2001 exceed 150 ug/L. The water quality standard for manganese in Illinois waters designated for aquatic life is 1000 ug/l. The aquatic life guideline for streams indicates impairment if more than 10% of the observations measured in the last five years exceed 1,000 ug/l. The available data confirm the listing of the North Fork Kaskaskia River (IL_OKA-01 and Il_OKA-02) for total manganese is appropriate based on IEPA's guidelines for the aquatic life use. The data also confirm the listing based on the public and food processing water supply use; however, it should be noted that the sole public water intake on the North Fork Kaskaskia River was discontinued July 31, 2006.

4.2.4 Iron

The water quality standard for dissolved iron in Illinois waters designated as public and food processing water supplies is 300 ug/l. The public and food processing water supply guideline for streams indicates impairment if more than 10% of the observations measured since 2001 exceed 300 ug/L. The water quality standard for iron in Illinois waters designated for aquatic life is 1000 ug/l. The aquatic life guideline for streams indicates impairment if more than 10% of the observations measured in the last five years exceed 1,000 ug/l. The available data confirm the listing of the North Fork Kaskaskia River (IL_OKA-01 and Il_OKA-02) for dissolved iron is appropriate based on IEPA's guidelines for the aquatic life use. The data also confirm the listing based on the public and food processing water supply use; however, it should be noted that the sole public water intake on the North Fork Kaskaskia River was discontinued July 31, 2006.

4.2.5 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 the North Fork Kaskaskia River (IL_OKA-01).

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 criteria do not exist, surrogate parameters must be selected to represent the designated use.

4.3.1 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 the North Fork Kaskaskia River (IL_OKA-01 and IL_OKA-02), 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, a modeling target of 6.0 mg/l was used to consider diurnal variation and ensure that the 5.0 mg/l TMDL target is met.

4.3.2 pH

For the North Fork Kaskaskia River (IL_OKA-01 and IL_OKA-02), the target was set to the water quality criterion of $6.5 \leq pH \leq 9.0$.

4.3.3 Manganese

For the North Fork Kaskaskia River (IL_OKA-01 and IL_OKA-02), the target was set to the water quality criterion for total manganese of 1000 ug/l.

4.3.4 Iron

For the North Fork Kaskaskia River (IL_OKA-01 and IL_OKA-02), the target was set to the water quality criterion for dissolved iron of 1000 ug/l.

4.3.5 Fecal Coliform

For the North Fork Kaskaskia River (IL_OKA-01), the target was set to the water quality criterion for fecal coliform of 200 cfu/100ml.

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 TMDL is based on the QUAL2E model. A model was not applied for the pH TMDL. The TMDLs for manganese, iron 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 the North Fork Kaskaskia River. 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 North Fork Kaskaskia River watershed is provided in the Stage 1 Report.

Of the models discussed in the Stage 1 Report, the QUAL2E model (Brown and Barnwell, 1987) was selected to address dissolved oxygen impairments in the North Fork Kaskaskia River. 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 TMDL is based upon discussions with IEPA and their Scientific Advisory Committee. The approach consists of using data collected during two field surveys (August 2005 and October 2005) 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 (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
- Initial conditions
- Incremental inflow conditions
- Point source loads

5.1.3.1 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.

5.1.3.2 Model Segmentation

The QUAL2E model divides the river being simulated into discrete segments (called "reaches") that have constant channel geometry and hydraulic characteristics. Reaches are further divided into "computational elements", which define the interval at which results are provided. The North Fork Kaskaskia River QUAL2E model consists of five reaches, which are comprised of a varying number of computational elements. Computational elements have a fixed length of 0.5 miles. Each reach was defined such that it contains a water quality monitoring station. Model segmentation is presented below in Table 1.

Table 1. QUAL2E Segmentation

Reach	River miles	Number of computational elements	Other features
1	21.5 – 25.5	8	
2	14.5 - 21.5	14	
3	9.5 – 14.5	10	
4	4.0 – 9.5	11	
5	0.0 – 4.0	8	Louse Run

5.1.3.3 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.

5.1.3.4 Initial Conditions

Initial model conditions were based on field observations taken during the two surveys conducted in 2005. Specifically, site-specific information on creek flow, velocity, morphometry, and concentrations of BOD and ammonia were used to specify initial conditions.

5.1.3.5 Incremental Inflow Conditions

Incremental inflows were calculated from the measured flows. Observed increases in flows were added to each reach incrementally.

5.1.3.6 Point Source Loads

There are no point source dischargers considered in the modeling, as the two permitted sewage treatment plants were not discharging during the model calibration surveys. One tributary, Louse Run, was included in the model because it was flowing during the field surveys used for model calibration. Louse Run was characterized based on field observations.

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 data collected during two surveys
3. Adjusting model coefficients to provide the best comparison between model predictions and observed dissolved oxygen data.

The QUAL2E dissolved oxygen calibration for the entire length of the North Fork Kaskaskia River (IL_OKA-01 and IL_OKA-02) is discussed below.

The QUAL2E model was initially applied with the model inputs as specified above. Observed data for two dry weather surveys were used for calibration purposes. These surveys were conducted on August 31, 2005 and October 13, 2005.

QUAL2E was calibrated to match the observed dissolved oxygen concentrations measured along the mainstem of the river. Model results initially overpredicted 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 corrected during the calibration process by adjusting the following reaction rate coefficients based on data collected during the first field survey: reaeration rate, sediment oxygen demand, BOD decay rate coefficient and the rate coefficient for ammonia oxidation.

The resulting dissolved oxygen predictions compared well to the measured concentrations, as shown in Figure 2. This comparison represents an acceptable model calibration. Model verification was completed using data collected during the second field survey, leaving the rate coefficients unchanged. Again, the resulting dissolved oxygen predictions compared well to the measured concentrations. The QUAL2E model output files from the calibration and verification runs are included in Attachment 1.

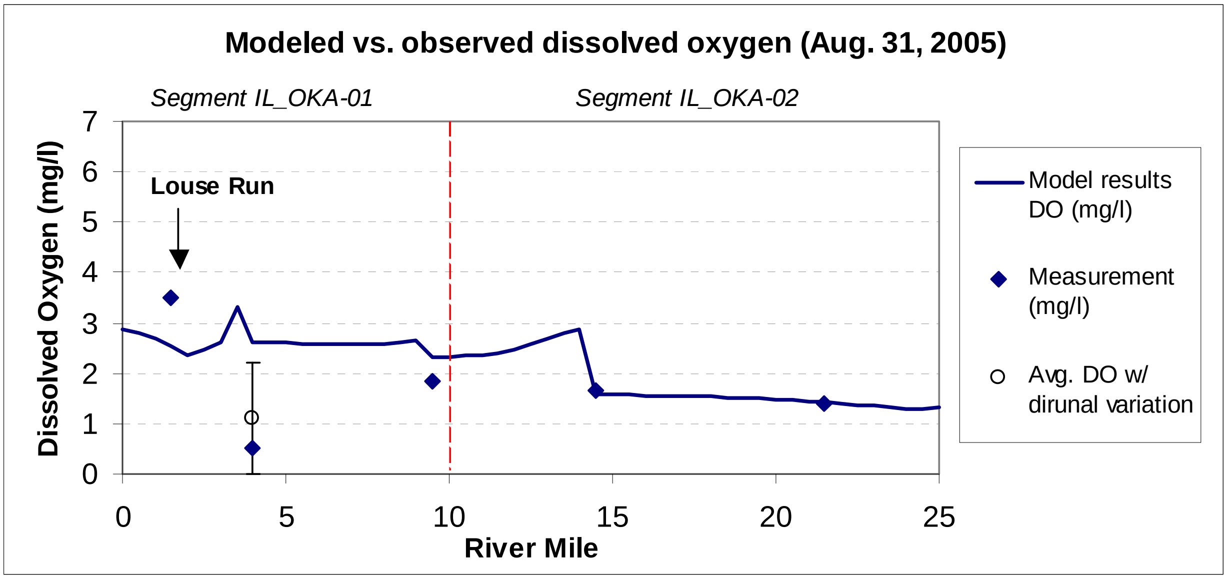

Figure 2. Survey 1 QUAL2E Calibration

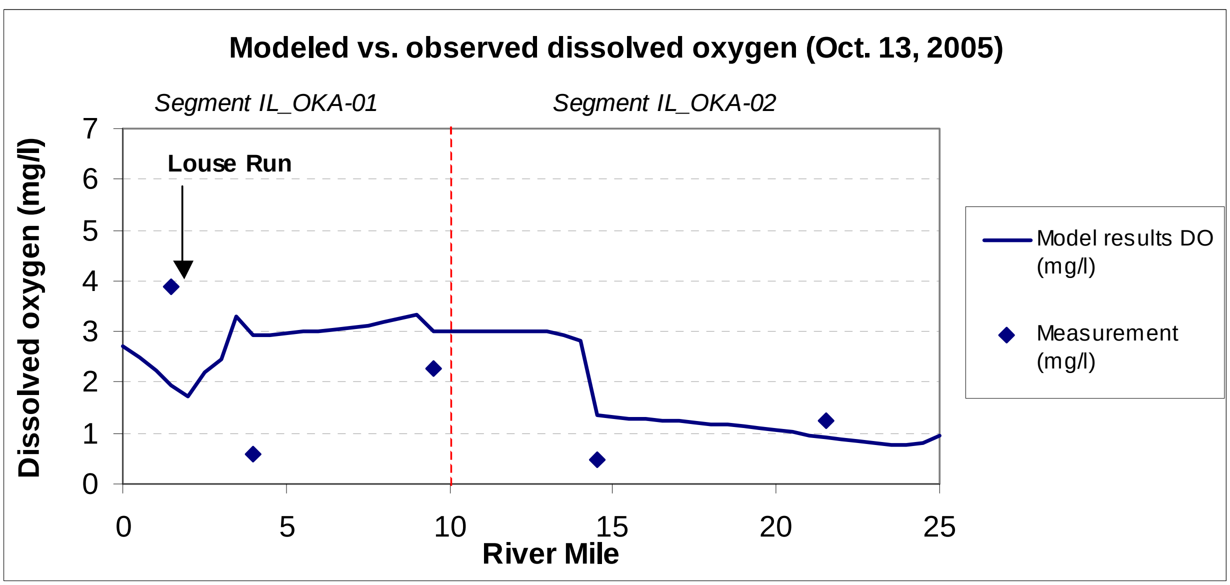

Figure 3. Survey 2 QUAL2E Verification

5.2 pH APPROACH

The pH TMDL did not require application of a model.

5.3 LOAD DURATION CURVE ANALYSIS

A load duration curve approach was used in the manganese, iron and fecal coliform analysis for the North Fork Kaskaskia River. 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.

5.3.1 Model Selection

A detailed discussion of the model selection process for the North Fork Kaskaskia River (IL_OKA-01 and IL_OKA-02) 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, iron and coliform sources and the extent of control required from these source categories to attain water quality standards.

5.3.2 Approach

The load duration curve approach uses stream flows and observed concentrations 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 in what is called a flow duration curve; 2) translating the flow duration curve 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.

5.3.3 Data inputs

This section describes the flow and water quality data used to support development of the load duration curve for total manganese, dissolved iron and fecal coliform bacteria.

5.3.3.1 Flow

Daily average flows measured at the USGS gage on East Fork Kaskaskia River near Sandoval, Illinois (05592900) were used in the analysis. Flows at this gage are available for the period 1979-2006. The flows measured at this station were adjusted for the size of the drainage area at monitoring station OKA-01. The measured East Fork Kaskaskia River flows were multiplied by 0.34 because the watershed at the North Fork Kaskaskia River sampling station OKA-01 is 66% smaller than the watershed for the East Fork Kaskaskia River gage.

5.3.3.2 Manganese

Total manganese data collected by IEPA as part of their ambient water quality monitoring program between 1990 and 2005 were used in the analysis. Total manganese data collected by Limno-Tech, Inc. during the 2005 dry weather surveys were also used in the analysis.

5.3.3.3 Iron

Dissolved iron data collected by IEPA as part of their ambient water quality monitoring program between 1990 and 2005 were used in the analysis. Dissolved iron data collected by Limno-Tech, Inc. during the 2005 dry weather surveys were also used in the analysis.

5.3.3.4 Fecal coliform

Fecal coliform data collected by IEPA between 1990 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.

5.3.4 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, iron and fecal coliform were generated by multiplying the flows in the duration curve by the water quality standard of 1000 ug/l for total manganese, 1000 ug/l for dissolved iron and 200 cfu/100 ml for fecal coliform bacteria. The load duration curves are shown with a solid line in Figures 4, 5, and 6 for manganese, iron and fecal coliform, respectively. Observed pollutant loads of manganese and iron 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, 3 and 4.

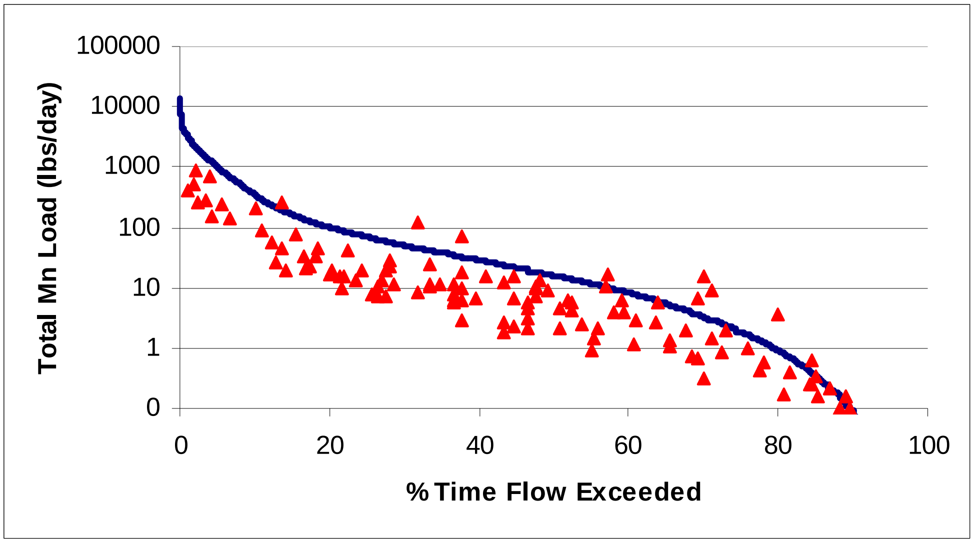

Figure 4. Load duration curve for manganese with observed loads (triangles)

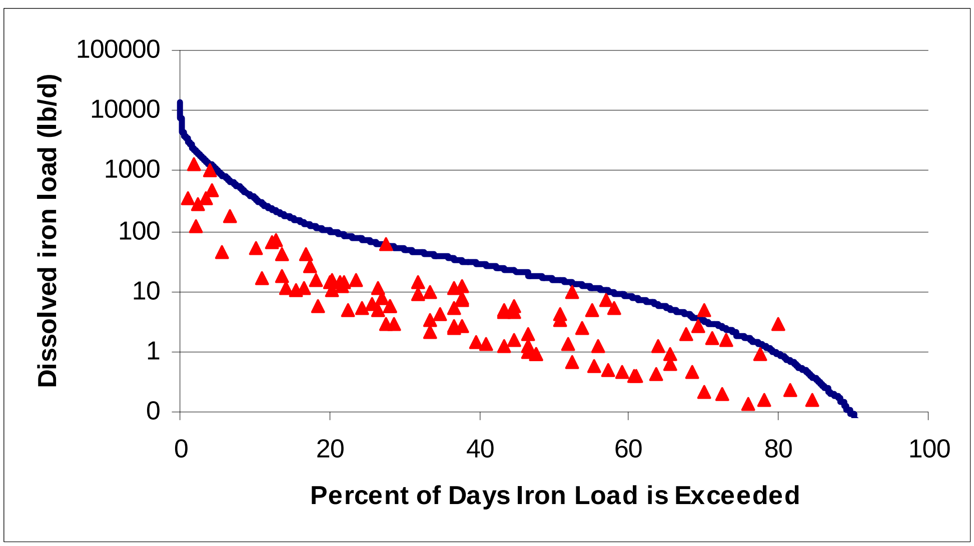

Figure 5. Load duration curve for iron with observed loads (triangles)

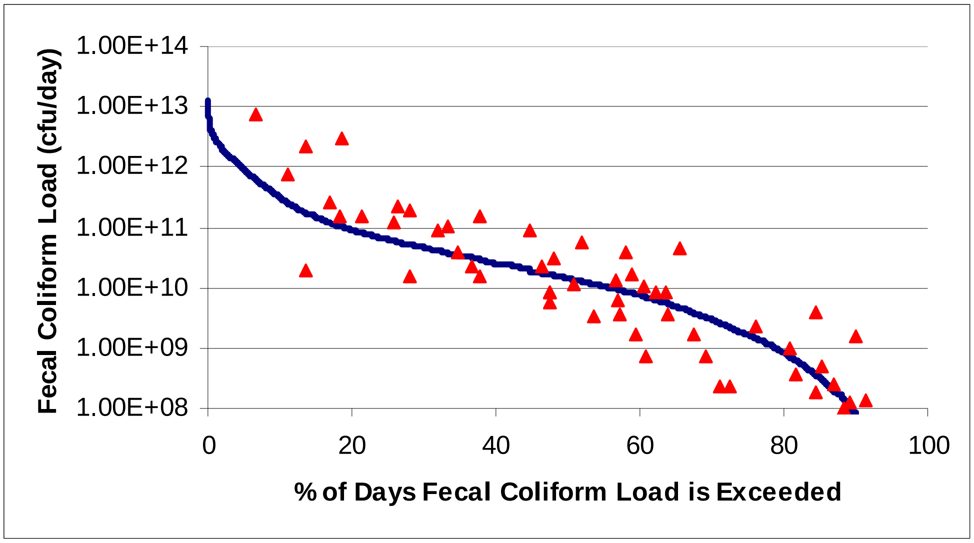

Figure 6. Load duration curve for fecal coliform with observed loads (triangles)

In Figures 4 and 6, the data show that exceedances of the manganese and fecal targets occur over the range of observed flows indicating both dry and wet weather sources contribute to observed violations of the water quality standard. For iron (Figure 5), the exceedances of the water quality target are only observed at lower flows. This indicates a potential groundwater source or iron release from the river bottom sediments during anoxic conditions. A similar process may be a factor for manganese, as greater exceedances of the target are observed at lower flows.

6 TMDL DEVELOPMENT

This section presents the development of the total maximum daily loads for the North Fork Kaskaskia River watershed for dissolved oxygen, pH, manganese, iron and fecal coliform. Included in this section are descriptions of how the total loading capacity was calculated, and a discussion on 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 TMDL

A dissolved oxygen TMDL was developed for both segments of the North Fork Kaskaskia River (IL_OKA-01 and IL_OKA-02).

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 modeling target of 6.0 mg/l[1].

QUAL2E simulations showed that, even with these 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]. To determine the loading capacity, the QUAL2E model was run repeatedly, uniformly reducing sediment oxygen demand (SOD) until model results demonstrated attainment of TMDL targets along the length of the river. The maximum SOD that results in compliance with water quality standards was used as the basis for determining the creek's loading capacity.

Model simulations determined that it was necessary to reduce sediment oxygen demand by 97 percent to meet the TMDL target for dissolved oxygen. It is difficult to accurately predict the necessary reductions in organic solids necessary to achieve specific SOD reductions; however, in a TMDL assessment relating SOD reductions for a watershed in Michigan, it was estimated that SOD rates would respond proportionally to reductions in total suspended solids (TSS) loads (Suppnick, 1992). This response appears reasonable if the appropriate solids are targeted for reduction. As such, a 97% reduction of particulate organic carbon loading to the stream (which occurs primarily during higher flow periods), is required.

[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.

Model results were used to calculate the TMDL load allocation, which is a component of the loading capacity. The load capacity was calculated as the sum of the load allocation, the wasteload allocation (section 6.1.2) and the margin of safety (section 6.1.5).

The loading capacity is presented by segment below (Tables 2 and 3). A seasonal loading capacity is presented for segment IL_OKA-01 to reflect seasonal ammonia permit limits.

Table 2. IL_OKA-01 Load Capacity

CBOD5 Load Capacity (lbs/day)	Ammonia Load Capacity (lbs/day)	
	Summer	Winter
40.1	0.3	0.4

Table 3. IL_OKA-02 Load Capacity

CBOD5 Load Capacity (lbs/day)	Ammonia Load Capacity (lbs/day)
30.5	3.1

6.1.2 Allocation

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

$$TMDL = WLA + LA + MOS$$

The following section presents the allocations for North Fork Kaskaskia River Segments IL_OKA-01 and IL_OKA-02.

6.1.2.1 North Fork Kaskaskia River (IL_OKA-01)

There are four NPDES permitted point source dischargers in the North Fork Kaskaskia River (IL_OKA-01) watershed. None of these dischargers contribute to violations observed at monitoring station OKA-01, because they all discharge downstream of this monitoring station. Sampling in summer 2005 was conducted downstream of the two sewage treatment plants that are permitted to discharge oxygen-demanding materials. The dissolved oxygen violations observed during the 2005 sampling were not due to the dischargers because they were not discharging at that time. The WLAs for the Village of Patoka sewage treatment plant (STP) and the Patoka Community Unit School District STP are therefore set at the monthly average CBOD5 and ammonia load permit limits. The Patoka STP does not have an ammonia limit; therefore the ammonia WLA was not calculated for this facility. The Patoka Community Unit School District has seasonal ammonia limits. The ammonia WLA for this facility is based on the permit limits and therefore varies seasonally.

The summer ammonia WLA for segment IL_OKA-01 equals 0.08 lbs/day and the winter ammonia limit equals 0.2 lbs/day. The CBOD5 WLA does not vary seasonally and equals 31.5 lbs/day.

The load allocation was calculated for nonpoint sources for low flow conditions because this is the period when dissolved oxygen problems have been observed. The load allocation representing low flow periods was based on the measured tributary flows to segment IL_OKA-01 and measured concentrations, because these are considered background conditions and do not significantly contribute to dissolved oxygen problems. The load allocations presented below in Table 4 were reduced by 10%, which was designed to serve as a margin of safety (discussed below). 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 oxygen demand.

Table 4. IL_OKA-01 Load Allocation

CBOD5			Ammonia		
LA (lbs/day)	Existing load (lbs/day)	% Reduction	LA (lbs/day)	Existing load (lbs/day)	% Reduction
7.7	8.6	10%	0.22	0.24	10%

6.1.2.2 North Fork Kaskaskia River (IL_OKA-02)

There are no NPDES permitted point source dischargers in the North Fork Kaskaskia River (IL_OKA-02) watershed. Therefore the WLA for this segment is not calculated.

The load allocation was calculated for nonpoint sources for low flow conditions because this is the period when dissolved oxygen problems have been observed. The load allocation representing low flow periods was based on estimated inflows to segment IL_OKA-02 and measured concentrations, because these are considered background conditions and do not significantly contribute to dissolved oxygen problems. The load allocations presented below in Table 5 were reduced by 10%, which was applied to the margin of safety (discussed below). 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 oxygen demand.

Table 5. IL_OKA-02 Load Allocation

CBOD5			Ammonia		
LA (lbs/day)	Existing load (lbs/day)	% Reduction	LA (lbs/day)	Existing load (lbs/day)	% Reduction
27.4	30.5	10%	2.8	3.1	10%

6.1.3 Critical Conditions

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. A review of available dissolved oxygen data for the North Fork Kaskaskia River showed that low dissolved oxygen occurs during low flow conditions (flows at monitoring station OKA-01< 36 cfs). To effectively consider critical conditions, this TMDL is based upon the flows measured during the October 13, 2005 low flow survey (~1 cfs) and temperatures measured during the warmer August survey.

6.1.4 Seasonality

The TMDL was conducted with an explicit consideration of seasonal variation. The TMDL was evaluated for a range of flow conditions that are expected to be observed throughout the year. Dissolved oxygen problems are only predicted to occur during low flow periods and so this TMDL focuses on the critical low flow period. Furthermore, this TMDL requires a 97% reduction in watershed particulate organic carbon loadings, which are expected to be delivered to the stream during wet weather conditions. Finally, this TMDL considers seasonal ammonia permit limits for the sewage treatment plants, where applicable.

6.1.5 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 dissolved oxygen TMDL 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 QUAL2E water quality model predicted values and the observed values. In particular, model predictions of dissolved oxygen concentrations correctly predict the presence of standards violations for all ten measurements across two surveys. The average error in predicted dissolved oxygen concentration is less than 0.5 mg/l. 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 CBOD5 and ammonia loads allocated to the margin of safety are presented in Tables 6 and 7.

Table 6. IL_OKA-01 Margin of Safety

CBOD5 MOS (lbs/day)	Ammonia MOS (lbs/day)
0.86	0.02

Table 7. IL_OKA-02 Margin of Safety

CBOD5 MOS (lbs/day)	Ammonia MOS (lbs/day)
3.05	0.31

6.2 pH TMDL

A pH TMDL was developed for both segments of the North Fork Kaskaskia River (IL_OKA-01 and IL_OKA-02).

6.2.1 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.

Within the North Fork Kaskaskia River watershed, 3 of 107 (3%) pH measurements taken between 1990 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 upstream up all point source dischargers, therefore point sources are not a potential source. Naturally acidic soils in the watershed, described in the Stage 1 report are the only obvious potential source contributing to low instream pH.

6.2.2 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:

$$TMDL = WLA + LA + MOS$$

Within the IL_OKA-01 watershed, the pH target for nonpoint sources equals 6.5 – 9.0 SU. The pH target for the four point source dischargers with pH permit limits equals 6.5 – 9.0 standard units. These point source dischargers are:

Patoka STP

Patoka Community Unit School District

Mobile Pipeline – Patoka Station

Ameren Energy – Kinmundy Power Plant

For segment IL_OKA-02, the pH target for nonpoint sources equals 6.5 – 9.0 standard units. The pH target for point sources is not applicable, as there are no permitted dischargers in this segment's watershed.

The Margin of Safety for these two segments is discussed in section 6.2.5.

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. TMDL development utilizing this approach applies to the full range of environmental 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 pH allocations will be applicable for all seasons to ensure the target is met throughout the year.

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. 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 the North Fork Kaskaskia River will be met.

6.3 MANGANESE TMDL

A load capacity calculation approach was applied to support development of a manganese TMDL for the North Fork Kaskaskia River.

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 for the watershed. The allowable loading capacity was computed by multiplying flow at the downstream end of each segment by the manganese water quality standard (1000 ug/l) for the aquatic life use. The manganese loading capacity is presented in Table 8.

Table 8. North Fork Kaskaskia River Manganese Loading Capacity

North Fork Kaskaskia River Flow (cfs)	IL_OKA-01 Load Capacity (lbs/day)
10	53.6
20	107.3
40	214.6
60	321.8
80	429.1
99	536.4
149	804.6
398	2145.5

North Fork Kaskaskia River Flow (cfs)	IL_OKA-02 Load Capacity (lbs/day)
5	27.0
10	53.9
20	107.9
30	161.8
40	215.7
50	269.7
75	404.5
200	1078.7

6.3.2 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:

$$TMDL = WLA + LA + MOS$$

There are no permitted dischargers in the watershed for the upstream North Fork Kaskaskia River segment (IL_OKA-02) and none of the four permitted facilities that discharge within the IL_OKA-01 watershed have permit limits for manganese. The WLA for the two segments does not need to be calculated.

The remainder of the loading capacity is given to the load allocation for nonpoint sources and to the margin of safety, as presented in Tables 9 and 10. 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 manganese load.

The required reduction was estimated by comparing the maximum of the observed manganese concentrations to the 1,000 ug/l standard for the aquatic life use over a range of flows. Because the data on which these reduction calculations were based were collected at station OKA-01, which is upstream of all point source dischargers, the percent reductions are for nonpoint sources only. For both segments, up to a 78% reduction in current loads is needed at lower flows, while no reductions are needed at higher flows (Tables 9 and 10).

Table 9. Manganese TMDL for Segment IL_OKA-01

N.F. Kaskaskia River Flow (cfs)	Current Load (lbs/day)	Load Capacity (lbs/day)	MOS (10%) (lbs/day)	WLA (lbs/day)	Load allocation (lbs/day)	% Reduction needed to meet aquatic life use standard
10	239.4	53.6	5.36	0.0	48.24	78
20	278.9	107.3	10.73	0.0	96.57	62
40	109.4	214.6	21.46	0.0	193.14	0
60	164.1	321.8	32.18	0.0	289.62	0
80	557.8	429.1	42.91	0.0	386.19	23
99	134.1	536.4	53.64	0.0	482.76	0
149	490.8	804.6	80.46	0.0	724.14	0
398	1158.6	2145.5	214.55	0.0	1930.95	0

Table 10. Manganese TMDL for Segment IL_OKA-02

N.F. Kaskaskia River Flow (cfs)	Current Load (lbs/day)	Load Capacity (lbs/day)	MOS (10%) (lbs/day)	WLA (lbs/day)	Load allocation (lbs/day)	% Reduction needed to meet aquatic life use standard
5	120.4	27.0	2.70	0.00	24.30	78
10	140.2	53.9	5.39	0.00	48.51	62
20	55.0	107.9	10.79	0.00	97.11	0
30	82.5	161.8	16.18	0.00	145.62	0
40	280.5	215.7	21.57	0.00	194.13	23
50	67.4	269.7	26.97	0.00	242.73	0
75	246.8	404.5	40.45	0.00	364.05	0
200	582.5	1078.7	107.87	0.00	970.83	0

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. TMDL development utilizing the load-duration approach applies to the full range of flow conditions, including the low and moderate flow periods when the manganese concentrations were observed to exceed the standard (Figure 4); 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 IRON TMDL

A load capacity calculation approach was applied to support development of an iron TMDL for the North Fork Kaskaskia River.

6.4.1 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 for the watershed. The allowable loading capacity was computed by multiplying flow by the water quality standard (1,000 ug/l) for the aquatic life use. The dissolved iron loading capacity is presented in Table 11.

Table 11. North Fork Kaskaskia River Dissolved Iron Loading Capacity

North Fork Kaskaskia River Flow (cfs)	IL_OKA-01 Load Capacity (lbs/day)
10	53.6
20	107.3
40	214.6
60	321.8
80	429.1
99	536.4
149	804.6
398	2145.5

North Fork Kaskaskia River Flow (cfs)	IL_OKA-02 Load Capacity (lbs/day)
5	27.0
10	53.9
20	107.9
30	161.8
40	215.7
50	269.7
75	404.5
200	1078.7

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:

$$TMDL = WLA + LA + MOS$$

There is one facility that is permitted to discharge iron within the IL_OKA-01 watershed. This is the Mobile Pipeline-Patoka Station, which has a permit to discharge hydrostatic test effluent. The WLA for this segment was calculated using the discharger's permitted flow rates and a concentration consistent with meeting water quality standards (1,000 ug/l). The WLA for segment IL_OKA-01 equals 4.17 lbs/day. The remainder of the loading capacity is given to the load allocation for nonpoint sources and to the margin of safety, as presented in Table 12. 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 dissolved iron load.

There are no permitted dischargers in the watershed for the upstream North Fork Kaskaskia River segment (IL_OKA-02). The WLA for this segment therefore equals zero. The remainder of the loading capacity is given to the load allocation for nonpoint sources and to the margin of safety, as presented in Table 13. 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 dissolved iron load.

To estimate the percent reduction needed to meet the TMDL target, the maximum observed dissolved iron concentration was compared to the 1,000 ug/l standard over a range of flows. Because the data on which these reduction calculations were based were collected at station OKA-01, which is upstream of all point source dischargers, the percent reductions are for nonpoint sources only. For both of the listed segments, a 69% reduction in current iron load is needed at the low flows, but no reductions are needed at higher flows (Tables 12 and 13).

Table 12. Dissolved Iron TMDL for North Fork Kaskaskia River (IL-OKA-01)

North Fork Kaskaskia River Flow (cfs)	Current load (lbs/day)	Load capacity (lbs/day)	MOS (10%) (lbs/day)	Wasteload allocation (lbs/day)	Load allocation (lbs/day)	% reduction needed to meet aquatic life standard
10	171.6	53.6	5.36	4.17	44.1	69
20	38.6	107.3	10.73	4.17	92.4	0
40	214.6	214.6	21.46	4.17	189.0	0
60	96.5	321.8	32.18	4.17	285.4	0
80	145.9	429.1	42.91	4.17	382.0	0
99	150.2	536.4	53.64	4.17	478.6	0
149	128.7	804.6	80.46	4.17	720.0	0
398	1759.3	2145.5	214.55	4.17	1926.8	0

Table 13. Dissolved Iron TMDL for the North Fork Kaskaskia River (IL-OKA-02)

North Fork Kaskaskia River Flow (cfs)	Current load (lbs/day)	Load capacity (lbs/day)	MOS (10%) (lbs/day)	Wasteload allocation (lbs/day)	Load allocation (lbs/day)	% reduction needed to meet aquatic life standard
5	86.3	27.0	2.70	0	24.3	69
10	19.4	53.9	5.39	0	48.5	0
20	107.9	107.9	10.79	0	97.1	0
30	48.5	161.8	16.18	0	145.6	0
40	73.4	215.7	21.57	0	194.1	0
50	75.5	269.7	26.97	0	242.7	0
75	64.7	404.5	40.45	0	364.1	0
200	884.6	1078.7	107.87	0	970.8	0

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 the load-duration approach applies to the full range of flow conditions; including the low flow periods when the dissolved iron concentrations were observed to exceed the standard (Figure 5); therefore critical conditions were addressed during TMDL development.

6.4.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The dissolved iron 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.

6.4.5 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. The iron 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 iron 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%. The10% 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.

6.5 FECAL COLIFORM TMDL

A load capacity calculation approach was applied to support development of a fecal coliform TMDL for the North Fork Kaskaskia River Segment IL_OKA-01.

6.5.1 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 for the watershed. The allowable loading capacity was computed by multiplying flow by 200 cfu/100 ml. The fecal coliform loading capacity is presented in Table 14.

Table 14. North Fork Kaskaskia River Fecal Coliform Loading Capacity

North Fork Kaskaskia River Flow (cfs)	Load Capacity (million cfu/day)
10	49,000
20	97,000
40	195,000
60	292,000
80	389,000
99	487,000
149	730,000
199	973,000
398	1,947,000

6.5.2 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:

$$TMDL = WLA + LA + MOS$$

The WLA for the two sewage treatment plants in the watershed for segment IL_OKA-01 was calculated using their permitted flow rates and a concentration consistent with meeting 200 cfu/100 ml at the downstream end of their exempted reach. Wasteload allocations for these facilities are presented in Table 15. The total WLA for these facilities equals approximately 600 million cfu/day.

Table 15. Point Source Dischargers and WLAs

NPDES ID	Facility name	Disinfection exemption?	Average Design Flow (MGD)	Permit expiration date	WLA (million cfu/day)
ILG58022	Patoka STP	Year-round	0.072	12/31/2007	545
IL0024376	Patoka Community Unit School District	Year-round	0.006	6/30/2006	45

The remainder of the loading capacity is given to the load allocation for nonpoint sources, as presented in Table 16. 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.

To estimate the percent reduction needed to meet the water quality target, the maximum observed fecal coliform concentrations were compared to the 200 cfu/100 ml target over a range of flows. Because the data on which these reduction calculations were based were collected at station OKA-01, which is upstream of all point source dischargers, the percent reductions are for nonpoint sources only. Between 66% and 96% reduction in current loads are needed over the full range of flows (Table 16).

Table 16. Fecal Coliform TMDL for North Fork Kaskaskia River Segment IL_OKA-01[1]

North Fork Kaskaskia River Flow (cfs)	Current Load (million cfu/day)	Load Capacity (million cfu/day)	WLA (million cfu/day)	Load allocation (million cfu/day)	% reduction needed to met TMDL target
10	876,000	49,000	600	48,000	94%
20	489,000	97,000	600	97,000	80%
40	759,000	195,000	600	194,000	74%
60	8,322,000	292,000	600	291,000	96%
80	4,672,000	389,000	600	389,000	92%
149	2,153,000	730,000	600	729,000	66%
398	23,360,000	1,947,000	600	1,946,000	92%

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

6.5.3 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 6 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.

6.5.4 Seasonality

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 in any given point in the season where the standard applies.

6.5.5 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 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.

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 Wednesday, March 16, 2005 in Patoka, Illinois at the Village Civic Center. In addition to the meeting's sponsors, 12 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.

In August 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 Thursday, August 17, 2006 in Patoka, Illinois at the Village Civic Center. In addition to the meeting's sponsors, 3 individuals attended the meeting. Attendees registered and listened to a presentation on the Stage Three findings by Limno-Tech, Inc. and Baetis, who presented the North Fork Kaskaskia River and East Fork Kaskaskia River TMDLs together. This was followed by a general question and answer session.

Another public meeting will be scheduled at a later date to present the implementation plan.

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. QUAL2E) to define the load-response relationship and define the maximum allowable pollutant load that the waterbodies 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.

REFERENCES

Brown, L.C., and T.O. Barnwell, Jr. 1987. The Enhanced Stream Water Quality Models QUAL2E and QUAL2E UNCAS: Documentation and User Manual. EPA/600/3-87/007. May 1987.

Illinois Environmental Protection Agency (IEPA), 2006. Illinois Integrated Water Quality Report and Section 303(d) list-2006. Illinois EPA Bureau of Water. April 2006. IEPA/BOW/04-005 http://www.epa.state.il.us/water/watershed/reports/303d-report/2006/303d-report.pdf

Suppnick, J.D., *1992.* A Nonpoint Source Pollution Load Allocation for Sycamore Creek, In: Ingham County Michigan. Proceedings of the Surface Water Quality and Ecology Symposium, Water Environment Federation, 1992. pp. 294-302.

U.S. Environmental Protection Agency (EPA), 1991. *Guidance for Water Quality-based Decisions: The TMDL Process.* EPA 440/4-91-001. Office of Water, Washington, DC.

Attachment 1

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                                               * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                                                      Version 3.22  --  May 1996
         $$$ (PROBLEM TITLES) $$$

         CARD TYPE                        QUAL-2E PROGRAM TITLES
         TITLE01            NF Kaskaskia River TMDL
         TITLE02            Calibration run, Survey 1 Aug. 31, 2005
         TITLE03   NO       CONSERVATIVE MINERAL   I
         TITLE04   NO       CONSERVATIVE MINERAL  II
         TITLE05   NO       CONSERVATIVE MINERAL III
         TITLE06  YES       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      D-ULT BOD CONV K COEF  =       0.23000
         INPUT METRIC            =     0.00000      UTPUT METRIC           =       0.00000
         NUMBER OF REACHES       =     5.00000      UMBER OF JUNCTIONS     =       0.00000
         NUM OF HEADWATERS       =     1.00000      UMBER OF POINT LOADS   =       2.00000
         TIME STEP (HOURS)       =     1.00000      NTH. COMP. ELEMENT (MI)=       0.50000
         MAXIMUM ROUTE TIME (HRS)=    60.00000      IME INC. FOR RPT2 (HRS)=       1.00000
         LATITUDE OF BASIN (DEG) =    38.50000      ONGITUDE OF BASIN (DEG)=      89.00000
         STANDARD MERIDIAN (DEG) =     0.00000      AY OF YEAR START TIME  =     243.00000
         EVAP. COEF.,(AE)        =     0.00068      VAP. COEF.,(BE)        =       0.00027
         ELEV. OF BASIN (ELEV)   =   520.00000      UST 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) =    13.3000       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
         THETA( 4)       SOD RATE         1.000     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
         $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$
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        CARD TYPE           REACH ORDER AND IDENT               R. MI/KM               R. MI/KM
        STREAM REACH     1.0   RCH= Hdwtr, incl NF      FR        25.5     TO           21.5
        STREAM REACH     2.0   RCH= Incl NFK-6          FR        21.5     TO           14.5
        STREAM REACH     3.0   RCH= Incl NFK-5          FR        14.5     TO            9.5
        STREAM REACH     4.0   RCH= DeerCk to ds N      FR         9.5     TO            4.0
        STREAM REACH     5.0   RCH= Louse Run to m    h FR         4.0     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.        8.          1.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
        FLAG FIELD       2.       14.          2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
        FLAG FIELD       3.       10.          2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
        FLAG FIELD       4.       11.          7.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.
        FLAG FIELD       5.        8.          2.2.2.6.2.2.2.5.0.0.0.0.0.0.0.0.0.0.0.0.
        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     0.015     0.000     0.750     0.000    0.020
        HYDRAULICS       2.     100.00     0.015     0.000     0.750     0.000    0.020
        HYDRAULICS       3.     100.00     0.018     0.000     1.770     0.000    0.020
        HYDRAULICS       4.     100.00     0.045     0.000     1.060     0.000    0.020
        HYDRAULICS       5.     100.00     0.003     0.000     4.870     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 BULB  WET BULB     ATM                SOLAR RA
D
                        REACH    ELEVATION    COEF      COVER      TEMP      TEMP     PRESSURE     WIND   ATTENUATI
ON
        TEMP/LCD         1.        595.00     0.06      0.10      72.00     63.00      29.23       5.40      1.00
        TEMP/LCD         2.        520.00     0.06      0.10      72.00     63.00      29.23       5.40      1.00
        TEMP/LCD         3.        520.00     0.06      0.10      72.00     63.00      29.23       5.40      1.00
        TEMP/LCD         4.        445.00     0.06      0.10      72.00     63.00      29.23       5.40      1.00
        TEMP/LCD         5.        445.00     0.06      0.10      72.00     63.00      29.23       5.40      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.       0.05      0.00      0.050        1.       0.35     0.000         0.00000
        REACT COEF       2.       0.05      0.00      0.050        1.       0.35     0.000         0.00000
        REACT COEF       3.       0.05      0.00      0.050        1.       0.20     0.000         0.00000
        REACT COEF       4.       0.05      0.00      0.050        1.       0.33     0.000         0.00000
        REACT COEF       5.       0.05      0.00      0.050        1.       0.07     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.      0.00      0.00     0.10      0.00     2.00      0.00      0.00    0.00
        N AND P COEF           2.      0.00      0.00     0.10      0.00     2.00      0.00      0.00    0.00
        N AND P COEF           3.      0.00      0.00     0.10      0.00     2.00      0.00      0.00    0.00
        N AND P COEF           4.      0.00      0.00     0.10      0.00     2.00      0.00      0.00    0.00
        N AND P COEF           5.      0.00      0.00     0.10      0.00     2.00      0.00      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
        ALGAE/OTHER            1.     50.00      1.00      0.01      0.00     0.00      0.00      0.00
        ALGAE/OTHER            2.     50.00      1.00      0.01      0.00     0.00      0.00      0.00
        ALGAE/OTHER            3.     50.00      1.00      0.01      0.00     0.00      0.00      0.00
        ALGAE/OTHER            4.     50.00      1.00      0.01      0.00     0.00      0.00      0.00
        ALGAE/OTHER            5.     50.00      1.00      0.01      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.     70.70      1.40      1.00      0.00     0.00      0.00      0.00    0.00
        INITIAL COND-1         2.     70.70      1.65      1.00      0.00     0.00      0.00      0.00    0.00
        INITIAL COND-1         3.     71.78      1.85      1.00      0.00     0.00      0.00      0.00    0.00
        INITIAL COND-1         4.     73.58      0.50      3.20      0.00     0.00      0.00      0.00    0.00
        INITIAL COND-1         5.     78.80      3.50      3.20      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
          $$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$
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        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      0.00      0.00      0.00      0.00      0.00
        INITIAL COND-2        2.      0.00      0.00      0.00      0.00      0.00      0.00      0.00
        INITIAL COND-2        3.      0.00      0.00      0.00      0.00      0.00      0.00      0.00
        INITIAL COND-2        4.      0.00      0.00      0.00      0.00      0.00      0.00      0.00
        INITIAL COND-2        5.      0.00      0.00      0.00      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.      BOD       CM-1      CM-2      CM-3      ANC
     COLI
        INCR INFLOW-1         1.      0.000     70.70     6.00      1.00      0.00      0.00      0.00      0.00
     0.00
        INCR INFLOW-1         2.      0.000     70.70     6.00      1.00      0.00      0.00      0.00      0.00
     0.00
        INCR INFLOW-1         3.      1.130     71.78     6.00      5.00      0.00      0.00      0.00      0.00
     0.00
        INCR INFLOW-1         4.      0.145     73.58     6.00     10.00      0.00      0.00      0.00      0.00
     0.00
        INCR INFLOW-1         5.      0.000     78.80     6.00      3.20      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      0.20      0.00      0.00      0.00      0.00
        INCR INFLOW-2         2.      0.00      0.00      0.30      0.00      0.00      0.00      0.00
        INCR INFLOW-2         3.      0.00      0.00      0.51      0.00      0.00      0.00      0.00
        INCR INFLOW-2         4.      0.00      0.00      0.07      0.00      0.00      0.00      0.00
        INCR INFLOW-2         5.      0.00      0.00      0.08      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
        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
        HDWTR-NFK       1.         NFK River       0.20     70.70      1.40      1.00      0.00      0.00      0.0
   0
        ENDATA10        0.                         0.00      0.00      0.00      0.00      0.00      0.00      0.0
   0
          $$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS,
                         COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

        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      0.20      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      C
   M-3
                        ORDER
        POINTLD-1        1.        Patoka           0.00      0.00      0.00      0.00      0.00      0.00      0.00      0
   .00
        POINTLD-1        2.       Louse Run         0.00      0.14     73.58      2.30      1.00      0.00      0.00      0
   .00
        ENDATA11         0.                         0.00      0.00      0.00      0.00      0.00      0.00      0.00      0
   .00
          $$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS,
                         COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

                        POINT
        CARD TYPE       LOAD      ANC     COLI      CHL-A     ORG-N     NH3-N     NO2-N     NO3-N     ORG-P     DIS-P
                        ORDER
        POINTLD-2        1.       0.00 0.00E+00     0.00      0.00      0.00      0.00      0.00      0.00      0.00
        POINTLD-2        2.       0.00 0.00E+00     0.00      0.00      0.24      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 TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:

ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
1	43
2	0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

DAILY NET SOLAR RADIATION = 2332.973 BTU/FT-2 (633.100 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 12.9

HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	0.00	9	0.00	17	279.22
2	0.00	10	0.00	18	298.88
3	0.00	11	0.00	19	297.82
4	0.00	12	1.18	20	276.15
5	0.00	13	52.69	21	235.87
6	0.00	14	122.22	22	180.60
7	0.00	15	186.72	23	115.35
8	0.00	16	240.68	24	45.59

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
NITRIFICATION INHIBITION	1	51
NITRIFICATION INHIBITION	2	50
NITRIFICATION INHIBITION	3	48
NITRIFICATION INHIBITION	4	40
NITRIFICATION INHIBITION	5	14
NITRIFICATION INHIBITION	6	11
NITRIFICATION INHIBITION	7	0
NITRIFICATION INHIBITION	8	0

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 1

QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.22 -- May 1996

***** 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
1	1	1	25.50	25.00	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
2	1	2	25.00	24.50	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
3	1	3	24.50	24.00	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
4	1	4	24.00	23.50	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
5	1	5	23.50	23.00	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09

6	1	6	23.00	22.50	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
7	1	7	22.50	22.00	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
8	1	8	22.00	21.50	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
9	2	1	21.50	21.00	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
10	2	2	21.00	20.50	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
11	2	3	20.50	20.00	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
12	2	4	20.00	19.50	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
13	2	5	19.50	19.00	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
14	2	6	19.00	18.50	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
15	2	7	18.50	18.00	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
16	2	8	18.00	17.50	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
17	2	9	17.50	17.00	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
18	2	10	17.00	16.50	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
19	2	11	16.50	16.00	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
20	2	12	16.00	15.50	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
21	2	13	15.50	15.00	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
22	2	14	15.00	14.50	0.20	0.00	0.00	0.015	2.037	0.750	17.778	35.20	50.89	13.33	0.09
23	3	1	14.50	14.00	0.31	0.00	0.11	0.018	1.698	1.770	9.824	45.91	35.28	17.39	0.22
24	3	2	14.00	13.50	0.43	0.00	0.11	0.018	1.698	1.770	13.371	62.48	44.65	23.67	0.22
25	3	3	13.50	13.00	0.54	0.00	0.11	0.018	1.698	1.770	16.918	79.05	54.01	29.94	0.22
26	3	4	13.00	12.50	0.65	0.00	0.11	0.018	1.698	1.770	20.465	95.63	63.37	36.22	0.22
27	3	5	12.50	12.00	0.76	0.00	0.11	0.018	1.698	1.770	24.011	112.20	72.74	42.50	0.22
28	3	6	12.00	11.50	0.88	0.00	0.11	0.018	1.698	1.770	27.558	128.77	82.10	48.78	0.22
29	3	7	11.50	11.00	0.99	0.00	0.11	0.018	1.698	1.770	31.105	145.35	91.46	55.06	0.22
30	3	8	11.00	10.50	1.10	0.00	0.11	0.018	1.698	1.770	34.652	161.92	100.83	61.33	0.22
31	3	9	10.50	10.00	1.22	0.00	0.11	0.018	1.698	1.770	38.198	178.49	110.19	67.61	0.22
32	3	10	10.00	9.50	1.33	0.00	0.11	0.018	1.698	1.770	41.745	195.07	119.55	73.89	0.22
33	4	1	9.50	9.00	1.34	0.00	0.01	0.045	0.679	1.060	28.159	78.80	79.94	29.85	0.36
34	4	2	9.00	8.50	1.36	0.00	0.01	0.045	0.679	1.060	28.435	79.57	80.67	30.14	0.36
35	4	3	8.50	8.00	1.37	0.00	0.01	0.045	0.679	1.060	28.712	80.35	81.40	30.43	0.36
36	4	4	8.00	7.50	1.38	0.00	0.01	0.045	0.679	1.060	28.988	81.12	82.13	30.73	0.36
37	4	5	7.50	7.00	1.40	0.00	0.01	0.045	0.679	1.060	29.264	81.89	82.85	31.02	0.36
38	4	6	7.00	6.50	1.41	0.00	0.01	0.045	0.679	1.060	29.541	82.67	83.58	31.31	0.36
39	4	7	6.50	6.00	1.42	0.00	0.01	0.045	0.679	1.060	29.817	83.44	84.31	31.61	0.36
40	4	8	6.00	5.50	1.44	0.00	0.01	0.045	0.679	1.060	30.093	84.21	85.04	31.90	0.36

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 2

QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.22 -- May 1996

***** 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
41	4	9	5.50	5.00	1.45	0.00	0.01	0.045	0.679	1.060	30.370	84.99	85.77	32.19	0.36
42	4	10	5.00	4.50	1.46	0.00	0.01	0.045	0.679	1.060	30.646	85.76	86.50	32.48	0.36
43	4	11	4.50	4.00	1.47	0.00	0.01	0.045	0.679	1.060	30.922	86.53	87.23	32.78	0.36
44	5	1	4.00	3.50	1.47	0.00	0.00	0.003	10.185	4.870	100.958	1298.00	292.24	491.67	0.09
45	5	2	3.50	3.00	1.47	0.00	0.00	0.003	10.185	4.870	100.958	1298.00	292.24	491.67	0.09
46	5	3	3.00	2.50	1.47	0.00	0.00	0.003	10.185	4.870	100.958	1298.00	292.24	491.67	0.09
47	5	4	2.50	2.00	1.62	0.14	0.00	0.003	10.185	4.870	110.883	1425.60	318.44	540.00	0.09
48	5	5	2.00	1.50	1.62	0.00	0.00	0.003	10.185	4.870	110.883	1425.60	318.44	540.00	0.09
49	5	6	1.50	1.00	1.62	0.00	0.00	0.003	10.185	4.870	110.883	1425.60	318.44	540.00	0.09
50	5	7	1.00	0.50	1.62	0.00	0.00	0.003	10.185	4.870	110.883	1425.60	318.44	540.00	0.09
51	5	8	0.50	0.00	1.62	0.00	0.00	0.003	10.185	4.870	110.883	1425.60	318.44	540.00	0.09

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 3

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
1	1	7.98	1	0.40	0.06	0.00	0.05	0.00	0.00	0.09	0.00	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2	7.89	1	0.41	0.07	0.00	0.05	0.00	0.00	0.09	0.00	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	3	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.09	0.00	1.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	4	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.09	0.00	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	5	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.09	0.00	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	6	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.09	0.00	1.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	7	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.09	0.00	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	8	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.10	0.00	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.10	0.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.10	0.00	1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	3	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.10	0.00	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	4	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.10	0.00	1.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.10	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	6	7.87	1	0.41	0.07	0.00	0.05	0.00	0.00	0.10	0.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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  2   7   7.87  1   0.41  0.07  0.00  0.05  0.00  0.00  0.10  0.00  1.61  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  2   8   7.87  1   0.41  0.07  0.00  0.05  0.00  0.00  0.10  0.00  1.62  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  2   9   7.87  1   0.41  0.07  0.00  0.05  0.00  0.00  0.10  0.00  1.62  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  2  10   7.87  1   0.41  0.07  0.00  0.05  0.00  0.00  0.10  0.00  1.63  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  2  11   7.87  1   0.41  0.07  0.00  0.05  0.00  0.00  0.10  0.00  1.63  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  2  12   7.87  1   0.41  0.07  0.00  0.05  0.00  0.00  0.10  0.00  1.63  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  2  13   7.87  1   0.41  0.07  0.00  0.05  0.00  0.00  0.10  0.00  1.64  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  2  14   7.87  1   0.41  0.07  0.00  0.05  0.00  0.00  0.10  0.00  1.64  0.00  0.00  0.00  0.00  0
.00   0.00  0.00


  3   1   7.94  1   0.32  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.16  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  3   2   7.95  1   0.23  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.13  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  3   3   7.94  1   0.23  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.10  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  3   4   7.93  1   0.23  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.07  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  3   5   7.92  1   0.23  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.04  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  3   6   7.92  1   0.23  0.07  0.00  0.05  0.00  0.00  0.12  0.00  2.02  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  3   7   7.91  1   0.23  0.07  0.00  0.05  0.00  0.00  0.12  0.00  2.01  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  3   8   7.91  1   0.23  0.07  0.00  0.05  0.00  0.00  0.12  0.00  2.00  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  3   9   7.90  1   0.23  0.07  0.00  0.05  0.00  0.00  0.12  0.00  2.00  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  3  10   7.90  1   0.23  0.07  0.00  0.05  0.00  0.00  0.12  0.00  2.00  0.00  0.00  0.00  0.00  0
.00   0.00  0.00


  4   1   7.89  1   0.31  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.13  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  4   2   7.88  1   0.38  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.12  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  4   3   7.88  1   0.38  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.11  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  4   4   7.88  1   0.38  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.11  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  4   5   7.88  1   0.38  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.10  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  4   6   7.88  1   0.38  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.10  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  4   7   7.88  1   0.38  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.11  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  4   8   7.88  1   0.38  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.11  0.00  0.00  0.00  0.00  0
.00   0.00  0.00

          STREAM QUALITY SIMULATION                                                OUTPUT PA
GE NUMBER     4
          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  DE
CAY   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

  4   9   7.88  1   0.38  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.11  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  4  10   7.88  1   0.38  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.12  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
  4  11   7.88  1   0.38  0.07  0.00  0.05  0.00  0.00  0.13  0.00  2.12  0.00  0.00  0.00  0.00  0
.00   0.00  0.00


  5   1   7.88  1   0.23  0.07  0.00  0.05  0.00  0.00  0.14  0.00  2.31  0.00  0.00  0.00  0.00  0
.00   0.00  0.00
```

```
  5   2   7.88   1   0.08   0.07   0.00   0.05   0.00   0.00   0.13   0.00   2.12   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
  5   3   7.88   1   0.08   0.07   0.00   0.05   0.00   0.00   0.13   0.00   2.06   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
  5   4   7.89   1   0.08   0.07   0.00   0.05   0.00   0.00   0.13   0.00   2.03   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
  5   5   7.88   1   0.08   0.07   0.00   0.05   0.00   0.00   0.13   0.00   2.09   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
  5   6   7.88   1   0.08   0.07   0.00   0.05   0.00   0.00   0.13   0.00   2.14   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
  5   7   7.88   1   0.08   0.07   0.00   0.05   0.00   0.00   0.13   0.00   2.17   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
  5   8   7.88   1   0.08   0.07   0.00   0.05   0.00   0.00   0.14   0.00   2.20   0.00   0.00   0.00   0.00   0
.00   0.00   0.00



          STREAM QUALITY SIMULATION                                                                 OUTPUT PA
GE NUMBER     5
          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   C
OLI            CHLA
               DEG-F                              MG/L   MG/L   MG/L   MG/L   MG/L   MG/L   MG/L   MG/L   MG/L   MG/L #/1
00ML           UG/L

  1   1        78.18  0.00   0.00   0.00   1.32   0.88   0.00   0.17   0.01   0.02   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  1   2        79.29  0.00   0.00   0.00   1.30   0.78   0.00   0.14   0.01   0.05   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  1   3        79.45  0.00   0.00   0.00   1.30   0.68   0.00   0.12   0.01   0.07   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  1   4        79.48  0.00   0.00   0.00   1.32   0.60   0.00   0.10   0.01   0.09   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  1   5        79.48  0.00   0.00   0.00   1.35   0.53   0.00   0.09   0.01   0.11   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  1   6        79.48  0.00   0.00   0.00   1.38   0.47   0.00   0.07   0.00   0.12   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  1   7        79.48  0.00   0.00   0.00   1.40   0.41   0.00   0.06   0.00   0.14   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  1   8        79.48  0.00   0.00   0.00   1.43   0.36   0.00   0.05   0.00   0.15   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00


  2   1        79.45  0.00   0.00   0.00   1.45   0.32   0.00   0.04   0.00   0.15   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2   2        79.44  0.00   0.00   0.00   1.47   0.28   0.00   0.04   0.00   0.16   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2   3        79.44  0.00   0.00   0.00   1.48   0.25   0.00   0.03   0.00   0.17   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2   4        79.44  0.00   0.00   0.00   1.50   0.22   0.00   0.02   0.00   0.17   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2   5        79.44  0.00   0.00   0.00   1.51   0.19   0.00   0.02   0.00   0.18   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2   6        79.44  0.00   0.00   0.00   1.52   0.17   0.00   0.02   0.00   0.18   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2   7        79.44  0.00   0.00   0.00   1.53   0.15   0.00   0.01   0.00   0.18   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2   8        79.44  0.00   0.00   0.00   1.54   0.13   0.00   0.01   0.00   0.19   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2   9        79.44  0.00   0.00   0.00   1.55   0.11   0.00   0.01   0.00   0.19   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2  10        79.44  0.00   0.00   0.00   1.56   0.10   0.00   0.01   0.00   0.19   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2  11        79.44  0.00   0.00   0.00   1.56   0.09   0.00   0.01   0.00   0.19   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2  12        79.44  0.00   0.00   0.00   1.57   0.08   0.00   0.01   0.00   0.19   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2  13        79.44  0.00   0.00   0.00   1.57   0.07   0.00   0.00   0.00   0.20   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00
  2  14        79.44  0.00   0.00   0.00   1.58   0.06   0.00   0.00   0.00   0.20   0.20   0.00   0.00   0.00.00E
+00   0.00     0.00


  3   1        78.66  0.00   0.00   0.00   2.89   1.68   0.00   0.16   0.01   0.15   0.31   0.00   0.00   0.00.00E
+00   0.00     0.00
```

```
  3  2    78.50  0.00  0.00  0.00  2.80  2.33  0.00  0.21  0.01  0.14  0.36  0.00  0.00  0.00.00E
+00  0.00  0.00
  3  3    78.61  0.00  0.00  0.00  2.68  2.63  0.00  0.23  0.01  0.15  0.39  0.00  0.00  0.00.00E
+00  0.00  0.00
  3  4    78.73  0.00  0.00  0.00  2.57  2.76  0.00  0.23  0.01  0.17  0.41  0.00  0.00  0.00.00E
+00  0.00  0.00
  3  5    78.84  0.00  0.00  0.00  2.48  2.80  0.00  0.23  0.01  0.19  0.43  0.00  0.00  0.00.00E
+00  0.00  0.00
  3  6    78.92  0.00  0.00  0.00  2.41  2.79  0.00  0.22  0.01  0.21  0.44  0.00  0.00  0.00.00E
+00  0.00  0.00
  3  7    78.98  0.00  0.00  0.00  2.37  2.75  0.00  0.21  0.01  0.22  0.45  0.00  0.00  0.00.00E
+00  0.00  0.00
  3  8    79.03  0.00  0.00  0.00  2.34  2.69  0.00  0.20  0.01  0.24  0.45  0.00  0.00  0.00.00E
+00  0.00  0.00
  3  9    79.07  0.00  0.00  0.00  2.33  2.63  0.00  0.19  0.01  0.25  0.46  0.00  0.00  0.00.00E
+00  0.00  0.00
  3 10    79.11  0.00  0.00  0.00  2.33  2.55  0.00  0.18  0.01  0.27  0.46  0.00  0.00  0.00.00E
+00  0.00  0.00


  4  1    79.28  0.00  0.00  0.00  2.66  2.43  0.00  0.16  0.01  0.29  0.46  0.00  0.00  0.00.00E
+00  0.00  0.00
  4  2    79.33  0.00  0.00  0.00  2.62  2.40  0.00  0.14  0.01  0.30  0.46  0.00  0.00  0.00.00E
+00  0.00  0.00
  4  3    79.35  0.00  0.00  0.00  2.59  2.37  0.00  0.13  0.01  0.31  0.45  0.00  0.00  0.00.00E
+00  0.00  0.00
  4  4    79.36  0.00  0.00  0.00  2.58  2.33  0.00  0.12  0.01  0.32  0.45  0.00  0.00  0.00.00E
+00  0.00  0.00
  4  5    79.36  0.00  0.00  0.00  2.58  2.30  0.00  0.11  0.01  0.33  0.44  0.00  0.00  0.00.00E
+00  0.00  0.00
  4  6    79.36  0.00  0.00  0.00  2.58  2.27  0.00  0.10  0.01  0.33  0.44  0.00  0.00  0.00.00E
+00  0.00  0.00
  4  7    79.36  0.00  0.00  0.00  2.58  2.24  0.00  0.09  0.01  0.34  0.44  0.00  0.00  0.00.00E
+00  0.00  0.00
  4  8    79.36  0.00  0.00  0.00  2.59  2.21  0.00  0.08  0.01  0.34  0.43  0.00  0.00  0.00.00E
+00  0.00  0.00

         STREAM QUALITY SIMULATION                                                        OUTPUT PA
GE NUMBER     6
         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   C
OLI       CHLA
          DEG-F                        MG/L  MG/L  MG/L  MG/L  MG/L  MG/L  MG/L  MG/L  MG/L  MG/L #/1
00ML      UG/L

  4  9    79.37  0.00  0.00  0.00  2.60  2.18  0.00  0.08  0.01  0.35  0.43  0.00  0.00  0.00.00E
+00  0.00  0.00
  4 10    79.37  0.00  0.00  0.00  2.62  2.16  0.00  0.07  0.00  0.35  0.43  0.00  0.00  0.00.00E
+00  0.00  0.00
  4 11    79.37  0.00  0.00  0.00  2.63  2.13  0.00  0.07  0.00  0.35  0.42  0.00  0.00  0.00.00E
+00  0.00  0.00


  5  1    79.39  0.00  0.00  0.00  3.33  1.57  0.00  0.04  0.00  0.39  0.42  0.00  0.00  0.00.00E
+00  0.00  0.00
  5  2    79.40  0.00  0.00  0.00  2.62  0.94  0.00  0.02  0.00  0.41  0.42  0.00  0.00  0.00.00E
+00  0.00  0.00
  5  3    79.40  0.00  0.00  0.00  2.46  0.56  0.00  0.01  0.00  0.42  0.42  0.00  0.00  0.00.00E
+00  0.00  0.00
  5  4    79.30  0.00  0.00  0.00  2.37  0.36  0.00  0.01  0.00  0.39  0.41  0.00  0.00  0.00.00E
+00  0.00  0.00
  5  5    79.38  0.00  0.00  0.00  2.53  0.22  0.00  0.01  0.00  0.40  0.41  0.00  0.00  0.00.00E
+00  0.00  0.00
  5  6    79.40  0.00  0.00  0.00  2.68  0.13  0.00  0.00  0.00  0.41  0.41  0.00  0.00  0.00.00E
+00  0.00  0.00
  5  7    79.40  0.00  0.00  0.00  2.79  0.08  0.00  0.00  0.00  0.41  0.41  0.00  0.00  0.00.00E
+00  0.00  0.00
  5  8    79.40  0.00  0.00  0.00  2.87  0.05  0.00  0.00  0.00  0.41  0.41  0.00  0.00  0.00.00E
+00  0.00  0.00



         STREAM QUALITY SIMULATION                                                        OUTPUT PA
GE NUMBER     7
         QUAL-2E STREAM QUALITY ROUTING MODEL                                         Version 3.22  --
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May 1996

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
1	1	1	78.18	7.98	1.32	6.65	0.00	0.55	0.69	2.66	-0.06	-2.35	0.00	-0.05	-0.01
2	1	2	79.29	7.89	1.30	6.59	0.00	0.54	0.00	2.68	-0.05	-2.35	0.00	-0.04	-0.01
3	1	3	79.45	7.87	1.30	6.57	0.00	0.54	0.00	2.67	-0.05	-2.35	0.00	-0.04	-0.01
4	1	4	79.48	7.87	1.32	6.55	0.00	0.55	0.00	2.67	-0.04	-2.35	0.00	-0.03	-0.01
5	1	5	79.48	7.87	1.35	6.52	0.00	0.55	0.00	2.66	-0.04	-2.35	0.00	-0.03	-0.01
6	1	6	79.48	7.87	1.38	6.50	0.00	0.56	0.00	2.65	-0.03	-2.35	0.00	-0.02	-0.01
7	1	7	79.48	7.87	1.40	6.47	0.00	0.57	0.00	2.63	-0.03	-2.35	0.00	-0.02	-0.01
8	1	8	79.48	7.87	1.43	6.45	0.00	0.58	0.00	2.62	-0.02	-2.35	0.00	-0.02	-0.01
9	2	1	79.45	7.87	1.45	6.43	0.00	0.58	0.00	2.62	-0.02	-2.35	0.00	-0.01	0.00
10	2	2	79.44	7.87	1.47	6.41	0.00	0.59	0.00	2.61	-0.02	-2.35	0.00	-0.01	0.00
11	2	3	79.44	7.87	1.48	6.39	0.00	0.59	0.00	2.60	-0.02	-2.35	0.00	-0.01	0.00
12	2	4	79.44	7.87	1.50	6.37	0.00	0.59	0.00	2.59	-0.01	-2.35	0.00	-0.01	0.00
13	2	5	79.44	7.87	1.51	6.36	0.00	0.60	0.00	2.59	-0.01	-2.35	0.00	-0.01	0.00
14	2	6	79.44	7.87	1.52	6.35	0.00	0.60	0.00	2.58	-0.01	-2.35	0.00	-0.01	0.00
15	2	7	79.44	7.87	1.53	6.34	0.00	0.60	0.00	2.58	-0.01	-2.35	0.00	0.00	0.00
16	2	8	79.44	7.87	1.54	6.33	0.00	0.60	0.00	2.58	-0.01	-2.35	0.00	0.00	0.00
17	2	9	79.44	7.87	1.55	6.32	0.00	0.61	0.00	2.57	-0.01	-2.35	0.00	0.00	0.00
18	2	10	79.44	7.87	1.56	6.32	0.00	0.61	0.00	2.57	-0.01	-2.35	0.00	0.00	0.00
19	2	11	79.44	7.87	1.56	6.31	0.00	0.61	0.00	2.57	-0.01	-2.35	0.00	0.00	0.00
20	2	12	79.44	7.87	1.57	6.31	0.00	0.61	0.00	2.57	-0.01	-2.35	0.00	0.00	0.00
21	2	13	79.44	7.87	1.57	6.30	0.00	0.61	0.00	2.57	0.00	-2.35	0.00	0.00	0.00
22	2	14	79.44	7.87	1.58	6.30	0.00	0.61	0.00	2.56	0.00	-2.35	0.00	0.00	0.00
23	3	1	78.66	7.94	2.89	5.05	0.00	0.82	1.28	1.60	-0.11	-1.00	0.00	-0.07	-0.02
24	3	2	78.50	7.95	2.80	5.15	0.00	0.81	0.94	1.18	-0.15	-1.00	0.00	-0.09	-0.03
25	3	3	78.61	7.94	2.68	5.26	0.00	0.80	0.74	1.21	-0.17	-1.00	0.00	-0.10	-0.03
26	3	4	78.73	7.93	2.57	5.36	0.00	0.79	0.61	1.24	-0.18	-1.00	0.00	-0.10	-0.03
27	3	5	78.84	7.92	2.48	5.44	0.00	0.77	0.52	1.26	-0.18	-1.00	0.00	-0.10	-0.03
28	3	6	78.92	7.92	2.41	5.50	0.00	0.76	0.45	1.27	-0.18	-1.00	0.00	-0.09	-0.03
29	3	7	78.98	7.91	2.37	5.54	0.00	0.76	0.40	1.28	-0.18	-1.00	0.00	-0.09	-0.03
30	3	8	79.03	7.91	2.34	5.56	0.00	0.75	0.36	1.29	-0.18	-1.00	0.00	-0.09	-0.03
31	3	9	79.07	7.90	2.33	5.57	0.00	0.75	0.33	1.29	-0.17	-1.00	0.00	-0.08	-0.03
32	3	10	79.11	7.90	2.33	5.57	0.00	0.75	0.30	1.29	-0.17	-1.00	0.00	-0.08	-0.03

33	4	1	79.28	7.89	2.66	5.23	0.00	0.80	0.09	1.61	-0.16	-1.67	0.00	-0.07	-0.02
34	4	2	79.33	7.88	2.62	5.27	0.00	0.79	0.09	2.02	-0.16	-1.67	0.00	-0.06	-0.02
35	4	3	79.35	7.88	2.59	5.29	0.00	0.79	0.09	2.03	-0.16	-1.67	0.00	-0.06	-0.02
36	4	4	79.36	7.88	2.58	5.30	0.00	0.79	0.08	2.03	-0.16	-1.67	0.00	-0.05	-0.02
37	4	5	79.36	7.88	2.58	5.30	0.00	0.79	0.08	2.03	-0.15	-1.67	0.00	-0.05	-0.02
38	4	6	79.36	7.88	2.58	5.30	0.00	0.79	0.08	2.03	-0.15	-1.67	0.00	-0.05	-0.02
39	4	7	79.36	7.88	2.58	5.30	0.00	0.79	0.08	2.03	-0.15	-1.67	0.00	-0.04	-0.01
40	4	8	79.36	7.88	2.59	5.29	0.00	0.79	0.08	2.03	-0.15	-1.67	0.00	-0.04	-0.01

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 8

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 ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
41	4	9	79.37	7.88	2.60	5.28	0.00	0.79	0.08	2.02	-0.15	-1.67	0.00	-0.03	-0.01
42	4	10	79.37	7.88	2.62	5.26	0.00	0.79	0.08	2.02	-0.14	-1.67	0.00	-0.03	-0.01
43	4	11	79.37	7.88	2.63	5.25	0.00	0.79	0.08	2.01	-0.14	-1.67	0.00	-0.03	-0.01
44	5	1	79.39	7.88	3.33	4.55	0.00	0.86	0.00	1.06	-0.10	-0.36	0.00	-0.02	-0.01
45	5	2	79.40	7.88	2.62	5.26	0.00	0.79	0.00	0.43	-0.06	-0.36	0.00	-0.01	0.00
46	5	3	79.40	7.88	2.46	5.42	0.00	0.77	0.00	0.44	-0.04	-0.36	0.00	0.00	0.00
47	5	4	79.30	7.89	2.37	5.51	0.00	0.76	0.02	0.45	-0.02	-0.36	0.00	-0.01	0.00
48	5	5	79.38	7.88	2.53	5.35	0.00	0.78	0.00	0.43	-0.01	-0.36	0.00	0.00	0.00
49	5	6	79.40	7.88	2.68	5.20	0.00	0.80	0.00	0.42	-0.01	-0.36	0.00	0.00	0.00
50	5	7	79.40	7.88	2.79	5.09	0.00	0.81	0.00	0.41	-0.01	-0.36	0.00	0.00	0.00
51	5	8	79.40	7.88	2.87	5.01	0.00	0.82	0.00	0.41	0.00	-0.36	0.00	0.00	0.00

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                                     • • • QUAL-2E  STREAM QUALITY ROUTING MODEL • • •
                                              Version 3.22  --  May 1996
□       $$$ (PROBLEM TITLES) $$$

      CARD TYPE                            QUAL-2E PROGRAM TITLES
      TITLE01            NF Kaskaskia River TMDL
      TITLE02            Calibration Run, Survey 2 Oct. 13, 2005
      TITLE03   NO       CONSERVATIVE MINERAL   I
      TITLE04   NO       CONSERVATIVE MINERAL  II
      TITLE05   NO       CONSERVATIVE MINERAL III
      TITLE06  YES       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     D-ULT BOD CONV K COEF  =      0.23000
      INPUT METRIC           =   0.00000     UTPUT METRIC           =      0.00000
      NUMBER OF REACHES      =   5.00000     UMBER OF JUNCTIONS     =      0.00000
      NUM OF HEADWATERS      =   1.00000     UMBER OF POINT LOADS   =      2.00000
      TIME STEP (HOURS)      =   1.00000     NTH. COMP. ELEMENT (MI)=      0.50000
      MAXIMUM ROUTE TIME (HRS)= 60.00000     IME INC. FOR RPT2 (HRS)=      1.00000
      LATITUDE OF BASIN (DEG) = 38.50000     ONGITUDE OF BASIN (DEG)=     89.00000
      STANDARD MERIDIAN (DEG) =  0.00000     AY OF YEAR START TIME  =    286.00000
      EVAP. COEF.,(AE)       =   0.00068     VAP. COEF.,(BE)        =      0.00027
      ELEV. OF BASIN (ELEV)  = 520.00000     UST 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) =   11.3000     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
      THETA( 4)       SOD RATE        1.000     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
□       $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$
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        CARD TYPE            REACH ORDER AND IDENT              R. MI/KM              R. MI/KM
        STREAM REACH     1.0   RCH= Hdwtr, incl NF     FR          25.5     TO          21.5
        STREAM REACH     2.0   RCH= Incl NFK-6         FR          21.5     TO          14.5
        STREAM REACH     3.0   RCH= Incl NFK-5         FR          14.5     TO           9.5
        STREAM REACH     4.0   RCH= DeerCk to ds N     FR           9.5     TO           4.0
        STREAM REACH     5.0   RCH= Louse Run to m   h FR           4.0     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.        8.           1.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
        FLAG FIELD           2.       14.           2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
        FLAG FIELD           3.       10.           2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
        FLAG FIELD           4.       11.           7.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.
        FLAG FIELD           5.        8.           2.2.2.6.2.2.2.5.0.0.0.0.0.0.0.0.0.0.0.0.
        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     0.014     0.000     0.730     0.000     0.020
        HYDRAULICS           2.    100.00     0.014     0.000     0.730     0.000     0.020
        HYDRAULICS           3.    100.00     0.019     0.000     1.390     0.000     0.020
        HYDRAULICS           4.    100.00     0.038     0.000     1.220     0.000     0.020
        HYDRAULICS           5.    100.00     0.003     0.000     4.890     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 BULB  WET BULB     ATM                  SOLAR RA
D
                            REACH   ELEVATION     COEF      COVER     TEMP      TEMP      PRESSURE     WIND     ATTENUATI
ON
        TEMP/LCD             1.       595.00      0.06      0.10      61.00     55.00      29.43       6.50       1.00
        TEMP/LCD             2.       520.00      0.06      0.10      61.00     55.00      29.43       6.50       1.00
        TEMP/LCD             3.       520.00      0.06      0.10      61.00     55.00      29.43       6.50       1.00
        TEMP/LCD             4.       445.00      0.06      0.10      61.00     55.00      29.43       6.50       1.00
        TEMP/LCD             5.       445.00      0.06      0.10      61.00     55.00      29.43       6.50       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.      0.05      0.00      0.050        1.      0.35      0.000          0.00000
        REACT COEF           2.      0.05      0.00      0.050        1.      0.35      0.000          0.00000
        REACT COEF           3.      0.05      0.00      0.050        1.      0.25      0.000          0.00000
        REACT COEF           4.      0.05      0.00      0.050        1.      0.29      0.000          0.00000
        REACT COEF           5.      0.05      0.00      0.050        1.      0.07      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.       0.00      0.00      0.10      0.00      2.00      0.00      0.00      0.00
        N AND P COEF             2.       0.00      0.00      0.10      0.00      2.00      0.00      0.00      0.00
        N AND P COEF             3.       0.00      0.00      0.10      0.00      2.00      0.00      0.00      0.00
        N AND P COEF             4.       0.00      0.00      0.10      0.00      2.00      0.00      0.00      0.00
        N AND P COEF             5.       0.00      0.00      0.10      0.00      2.00      0.00      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
        ALGAE/OTHER              1.      50.00      1.00      0.01      0.00      0.00      0.00      0.00
        ALGAE/OTHER              2.      50.00      1.00      0.01      0.00      0.00      0.00      0.00
        ALGAE/OTHER              3.      50.00      1.00      0.01      0.00      0.00      0.00      0.00
        ALGAE/OTHER              4.      50.00      1.00      0.01      0.00      0.00      0.00      0.00
        ALGAE/OTHER              5.      50.00      1.00      0.01      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.      60.53      1.25      4.50      0.00      0.00      0.00      0.00      0.00
        INITIAL COND-1           2.      56.61      0.49      4.30      0.00      0.00      0.00      0.00      0.00
        INITIAL COND-1           3.      57.06      2.26      4.10      0.00      0.00      0.00      0.00      0.00
        INITIAL COND-1           4.      57.94      0.57      3.80      0.00      0.00      0.00      0.00      0.00
        INITIAL COND-1           5.      61.54      3.88      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
□         $$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$
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      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     0.00     0.00     0.00     0.00     0.00
      INITIAL COND-2       2.      0.00     0.00     0.00     0.00     0.00     0.00     0.00
      INITIAL COND-2       3.      0.00     0.00     0.00     0.00     0.00     0.00     0.00
      INITIAL COND-2       4.      0.00     0.00     0.00     0.00     0.00     0.00     0.00
      INITIAL COND-2       5.      0.00     0.00     0.00     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.     BOD      CM-1     CM-2     CM-3     ANC
    COLI
      INCR INFLOW-1        1.      0.000    60.53    6.00     4.50     0.00     0.00     0.00     0.00
    0.00
      INCR INFLOW-1        2.      0.000    56.61    6.00     4.30     0.00     0.00     0.00     0.00
    0.00
      INCR INFLOW-1        3.      0.790    57.06    6.00     5.00     0.00     0.00     0.00     0.00
    0.00
      INCR INFLOW-1        4.      0.323    57.94    6.00    10.00     0.00     0.00     0.00     0.00
    0.00
      INCR INFLOW-1        5.      0.000    61.54    6.00     4.50     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     0.33     0.00     0.00     0.00     0.00
      INCR INFLOW-2        2.      0.00     0.00     0.43     0.00     0.00     0.00     0.00
      INCR INFLOW-2        3.      0.00     0.00     0.24     0.00     0.00     0.00     0.00
      INCR INFLOW-2        4.      0.00     0.00     0.44     0.00     0.00     0.00     0.00
      INCR INFLOW-2        5.      0.00     0.00     0.13     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
      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
      HDWTR-NFK     1.         NFK River       0.19     60.53    1.25     4.50     0.00     0.00     0.0
    0
      ENDATA10      0.                         0.00     0.00     0.00     0.00     0.00     0.00     0.0
    0
        $$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS,
                           COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

      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     0.33     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     C
    M-3
                   ORDER
      POINTLD-1     1.        Patoka           0.00     0.00     0.00     0.00     0.00     0.00     0.00     0
    .00
      POINTLD-1     2.       Louse Run         0.00     0.32     57.92    1.74     5.10     0.00     0.00     0
    .00
      ENDATA11      0.                         0.00     0.00     0.00     0.00     0.00     0.00     0.00     0
    .00
        $$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS,
                           COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

                   POINT
      CARD TYPE    LOAD      ANC     COLI      CHL-A    ORG-N    NH3-N    NO2-N    NO3-N    ORG-P    DIS-P
                   ORDER
      POINTLD-2     1.       0.00 0.00E+00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
      POINTLD-2     2.       0.00 0.00E+00     0.00     0.00     0.41     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 TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:

ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
1	48
2	0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

DAILY NET SOLAR RADIATION = 1578.611 BTU/FT-2 (428.388 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 11.0

HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	0.00	9	0.00	17	218.96
2	0.00	10	0.00	18	233.51
3	0.00	11	0.00	19	227.38
4	0.00	12	0.00	20	201.14
5	0.00	13	12.09	21	157.28
6	0.00	14	73.80	22	99.99
7	0.00	15	135.16	23	34.19
8	0.00	16	185.10	24	0.00

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
NITRIFICATION INHIBITION	1	51
NITRIFICATION INHIBITION	2	51
NITRIFICATION INHIBITION	3	51
NITRIFICATION INHIBITION	4	51
NITRIFICATION INHIBITION	5	39
NITRIFICATION INHIBITION	6	16
NITRIFICATION INHIBITION	7	0
NITRIFICATION INHIBITION	8	0

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 1

QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.22 -- May 1996

***** 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
1	1	1	25.50	25.00	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
2	1	2	25.00	24.50	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
3	1	3	24.50	24.00	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
4	1	4	24.00	23.50	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
5	1	5	23.50	23.00	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08

6	1	6	23.00	22.50	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
7	1	7	22.50	22.00	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
8	1	8	22.00	21.50	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08

9	2	1	21.50	21.00	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
10	2	2	21.00	20.50	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
11	2	3	20.50	20.00	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
12	2	4	20.00	19.50	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
13	2	5	19.50	19.00	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
14	2	6	19.00	18.50	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
15	2	7	18.50	18.00	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
16	2	8	18.00	17.50	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
17	2	9	17.50	17.00	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
18	2	10	17.00	16.50	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
19	2	11	16.50	16.00	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
20	2	12	16.00	15.50	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
21	2	13	15.50	15.00	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08
22	2	14	15.00	14.50	0.19	0.00	0.00	0.014	2.183	0.730	18.885	36.39	53.71	13.79	0.08

23	3	1	14.50	14.00	0.27	0.00	0.08	0.019	1.608	1.390	10.299	37.79	34.53	14.32	0.19
24	3	2	14.00	13.50	0.35	0.00	0.08	0.019	1.608	1.390	13.290	48.77	42.43	18.47	0.19
25	3	3	13.50	13.00	0.43	0.00	0.08	0.019	1.608	1.390	16.282	59.75	50.32	22.63	0.19
26	3	4	13.00	12.50	0.51	0.00	0.08	0.019	1.608	1.390	19.273	70.72	58.22	26.79	0.19
27	3	5	12.50	12.00	0.59	0.00	0.08	0.019	1.608	1.390	22.264	81.70	66.12	30.95	0.19
28	3	6	12.00	11.50	0.67	0.00	0.08	0.019	1.608	1.390	25.256	92.68	74.01	35.11	0.19
29	3	7	11.50	11.00	0.75	0.00	0.08	0.019	1.608	1.390	28.247	103.65	81.91	39.26	0.19
30	3	8	11.00	10.50	0.82	0.00	0.08	0.019	1.608	1.390	31.238	114.63	89.81	43.42	0.19
31	3	9	10.50	10.00	0.90	0.00	0.08	0.019	1.608	1.390	34.229	125.61	97.70	47.58	0.19
32	3	10	10.00	9.50	0.98	0.00	0.08	0.019	1.608	1.390	37.221	136.59	105.60	51.74	0.19

33	4	1	9.50	9.00	1.01	0.00	0.03	0.038	0.804	1.220	21.837	70.33	64.09	26.64	0.34
34	4	2	9.00	8.50	1.04	0.00	0.03	0.038	0.804	1.220	22.470	72.37	65.76	27.41	0.34
35	4	3	8.50	8.00	1.07	0.00	0.03	0.038	0.804	1.220	23.104	74.41	67.44	28.19	0.34
36	4	4	8.00	7.50	1.10	0.00	0.03	0.038	0.804	1.220	23.737	76.45	69.11	28.96	0.34
37	4	5	7.50	7.00	1.13	0.00	0.03	0.038	0.804	1.220	24.371	78.49	70.78	29.73	0.34
38	4	6	7.00	6.50	1.16	0.00	0.03	0.038	0.804	1.220	25.004	80.53	72.45	30.50	0.34
39	4	7	6.50	6.00	1.19	0.00	0.03	0.038	0.804	1.220	25.637	82.57	74.12	31.28	0.34
40	4	8	6.00	5.50	1.22	0.00	0.03	0.038	0.804	1.220	26.271	84.61	75.80	32.05	0.34

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 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

 41   4   9    5.50    5.00     1.25    0.00    0.03   0.038   0.804    1.220   26.904       86.65        77.47
  32.82     0.34
 42   4  10    5.00    4.50     1.28    0.00    0.03   0.038   0.804    1.220   27.537       88.69        79.14
  33.60     0.34
 43   4  11    4.50    4.00     1.31    0.00    0.03   0.038   0.804    1.220   28.171       90.73        80.81
  34.37     0.34


 44   5   1    4.00    3.50     1.31    0.00    0.00   0.003  10.185    4.890   89.025     1149.28       260.85
  435.33    0.09
 45   5   2    3.50    3.00     1.31    0.00    0.00   0.003  10.185    4.890   89.025     1149.28       260.85
  435.33    0.09
 46   5   3    3.00    2.50     1.31    0.00    0.00   0.003  10.185    4.890   89.025     1149.28       260.85
  435.33    0.09
 47   5   4    2.50    2.00     1.63    0.32   .0.00   0.003  10.185    4.890  111.043     1433.52       318.97
  543.00    0.09
 48   5   5    2.00    1.50     1.63    0.00    0.00   0.003  10.185    4.890  111.043     1433.52       318.97
  543.00    0.09
 49   5   6    1.50    1.00     1.63    0.00    0.00   0.003  10.185    4.890  111.043     1433.52       318.97
  543.00    0.09
 50   5   7    1.00    0.50     1.63    0.00    0.00   0.003  10.185    4.890  111.043     1433.52       318.97
  543.00    0.09
 51   5   8    0.50    0.00     1.63    0.00    0.00   0.003  10.185    4.890  111.043     1433.52       318.97
  543.00    0.09



          STREAM QUALITY SIMULATION                                                                    OUTPUT PA
GE NUMBER       3
          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  DE
CAY   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    9.31   1   0.33   0.05   0.00   0.05   0.00   0.00   0.04   0.00   0.79   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  1   2    9.25   1   0.34   0.05   0.00   0.05   0.00   0.00   0.03   0.00   0.72   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  1   3    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.03   0.00   0.69   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  1   4    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.03   0.00   0.69   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  1   5    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.03   0.00   0.71   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  1   6    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.03   0.00   0.73   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  1   7    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.04   0.00   0.76   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  1   8    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.04   0.00   0.79   0.00   0.00   0.00   0.00  0
.00   0.00   0.00


  2   1    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.04   0.00   0.82   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  2   2    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.04   0.00   0.84   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  2   3    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.04   0.00   0.87   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  2   4    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.04   0.00   0.89   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  2   5    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.04   0.00   0.91   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
  2   6    9.24   1   0.34   0.05   0.00   0.05   0.00   0.00   0.04   0.00   0.93   0.00   0.00   0.00   0.00  0
.00   0.00   0.00
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   2   7   9.24   1    0.34    0.05    0.00    0.05    0.00    0.00    0.04    0.00    0.95    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   2   8   9.24   1    0.34    0.05    0.00    0.05    0.00    0.00    0.05    0.00    0.96    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   2   9   9.24   1    0.34    0.05    0.00    0.05    0.00    0.00    0.05    0.00    0.97    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   2  10   9.24   1    0.34    0.05    0.00    0.05    0.00    0.00    0.05    0.00    0.99    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   2  11   9.24   1    0.34    0.05    0.00    0.05    0.00    0.00    0.05    0.00    1.00    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   2  12   9.24   1    0.34    0.05    0.00    0.05    0.00    0.00    0.05    0.00    1.01    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   2  13   9.24   1    0.34    0.05    0.00    0.05    0.00    0.00    0.05    0.00    1.02    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   2  14   9.24   1    0.34    0.05    0.00    0.05    0.00    0.00    0.05    0.00    1.03    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00


   3   1   9.31   1    0.29    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.49    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   3   2   9.33   1    0.24    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.51    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   3   3   9.32   1    0.24    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.52    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   3   4   9.31   1    0.24    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.53    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   3   5   9.30   1    0.24    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.53    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   3   6   9.29   1    0.24    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.53    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   3   7   9.28   1    0.24    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.53    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   3   8   9.28   1    0.24    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.54    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   3   9   9.28   1    0.24    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.54    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   3  10   9.27   1    0.24    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.54    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00


   4   1   9.26   1    0.26    0.05    0.00    0.05    0.00    0.00    0.08    0.00    1.60    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   4   2   9.26   1    0.28    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.59    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   4   3   9.26   1    0.28    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.57    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   4   4   9.26   1    0.28    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.57    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   4   5   9.26   1    0.28    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.56    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   4   6   9.26   1    0.28    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.55    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   4   7   9.26   1    0.28    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.55    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   4   8   9.26   1    0.28    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.54    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00

              STREAM QUALITY SIMULATION                                                                          OUTPUT PA
GE NUMBER      4
              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   DE
CAY    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

   4   9   9.26   1    0.28    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.54    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   4  10   9.26   1    0.28    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.53    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
   4  11   9.26   1    0.28    0.05    0.00    0.05    0.00    0.00    0.07    0.00    1.53    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00


   5   1   9.25   1    0.17    0.05    0.00    0.05    0.00    0.00    0.08    0.00    1.60    0.00    0.00    0.00    0.00    0
 .00   0.00   0.00
```

```
 5   2   9.24   1    0.07   0.05   0.00   0.05   0.00   0.00   0.07   0.00   1.43   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
 5   3   9.24   1    0.07   0.05   0.00   0.05   0.00   0.00   0.06   0.00   1.36   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
 5   4   9.28   1    0.07   0.05   0.00   0.05   0.00   0.00   0.06   0.00   1.19   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
 5   5   9.25   1    0.07   0.05   0.00   0.05   0.00   0.00   0.06   0.00   1.27   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
 5   6   9.25   1    0.07   0.05   0.00   0.05   0.00   0.00   0.06   0.00   1.36   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
 5   7   9.24   1    0.07   0.05   0.00   0.05   0.00   0.00   0.07   0.00   1.44   0.00   0.00   0.00   0.00   0
.00   0.00   0.00
 5   8   9.24   1    0.07   0.05   0.00   0.05   0.00   0.00   0.07   0.00   1.49   0.00   0.00   0.00   0.00   0
.00   0.00   0.00



         STREAM QUALITY SIMULATION                                                                       OUTPUT PA
GE NUMBER     5
         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   C
OLI              CHLA
                 DEG-F                                MG/L   MG/L   MG/L   MG/L   MG/L   MG/L   MG/L    MG/L   MG/L    MG/L #/1
00ML             UG/L

  1   1          64.40   0.00   0.00   0.00   0.95   4.09   0.00   0.31   0.01   0.02   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  1   2          65.02   0.00   0.00   0.00   0.81   3.72   0.00   0.28   0.01   0.03   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  1   3          65.11   0.00   0.00   0.00   0.77   3.37   0.00   0.27   0.01   0.05   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  1   4          65.12   0.00   0.00   0.00   0.77   3.06   0.00   0.25   0.01   0.07   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  1   5          65.12   0.00   0.00   0.00   0.80   2.78   0.00   0.23   0.01   0.09   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  1   6          65.12   0.00   0.00   0.00   0.84   2.53   0.00   0.21   0.01   0.10   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  1   7          65.12   0.00   0.00   0.00   0.88   2.29   0.00   0.20   0.01   0.12   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  1   8          65.12   0.00   0.00   0.00   0.93   2.08   0.00   0.18   0.01   0.14   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00


  2   1          65.10   0.00   0.00   0.00   0.97   1.89   0.00   0.17   0.01   0.15   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2   2          65.10   0.00   0.00   0.00   1.01   1.72   0.00   0.16   0.01   0.17   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2   3          65.10   0.00   0.00   0.00   1.05   1.56   0.00   0.14   0.01   0.18   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2   4          65.10   0.00   0.00   0.00   1.09   1.42   0.00   0.13   0.01   0.19   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2   5          65.10   0.00   0.00   0.00   1.12   1.29   0.00   0.12   0.01   0.20   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2   6          65.10   0.00   0.00   0.00   1.16   1.17   0.00   0.11   0.01   0.22   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2   7          65.10   0.00   0.00   0.00   1.19   1.06   0.00   0.10   0.00   0.23   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2   8          65.10   0.00   0.00   0.00   1.21   0.96   0.00   0.09   0.00   0.23   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2   9          65.10   0.00   0.00   0.00   1.24   0.87   0.00   0.08   0.00   0.24   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2  10          65.10   0.00   0.00   0.00   1.26   0.79   0.00   0.07   0.00   0.25   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2  11          65.10   0.00   0.00   0.00   1.28   0.72   0.00   0.07   0.00   0.26   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2  12          65.10   0.00   0.00   0.00   1.30   0.65   0.00   0.06   0.00   0.27   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2  13          65.10   0.00   0.00   0.00   1.32   0.59   0.00   0.06   0.00   0.27   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00
  2  14          65.10   0.00   0.00   0.00   1.34   0.54   0.00   0.05   0.00   0.28   0.33   0.00   0.00   0.00.00E
+00   0.00       0.00


  3   1          64.46   0.00   0.00   0.00   2.81   1.71   0.00   0.09   0.00   0.21   0.30   0.00   0.00   0.00.00E
+00   0.00       0.00
```

```
  3   2       64.29   0.00    0.00    0.00    2.95    2.30    0.00    0.12    0.00    0.17    0.29    0.00    0.00    0.00.00E
+00   0.00    0.00
  3   3       64.36   0.00    0.00    0.00    3.00    2.62    0.00    0.13    0.01    0.15    0.28    0.00    0.00    0.00.00E
+00   0.00    0.00
  3   4       64.46   0.00    0.00    0.00    3.02    2.80    0.00    0.13    0.01    0.14    0.27    0.00    0.00    0.00.00E
+00   0.00    0.00
  3   5       64.54   0.00    0.00    0.00    3.02    2.90    0.00    0.13    0.01    0.13    0.27    0.00    0.00    0.00.00E
+00   0.00    0.00
  3   6       64.61   0.00    0.00    0.00    3.01    2.94    0.00    0.13    0.01    0.13    0.27    0.00    0.00    0.00.00E
+00   0.00    0.00
  3   7       64.69   0.00    0.00    0.00    3.00    2.95    0.00    0.13    0.01    0.13    0.26    0.00    0.00    0.00.00E
+00   0.00    0.00
  3   8       64.74   0.00    0.00    0.00    3.00    2.94    0.00    0.12    0.01    0.13    0.26    0.00    0.00    0.00.00E
+00   0.00    0.00
  3   9       64.77   0.00    0.00    0.00    3.00    2.92    0.00    0.12    0.01    0.13    0.26    0.00    0.00    0.00.00E
+00   0.00    0.00
  3  10       64.80   0.00    0.00    0.00    3.01    2.88    0.00    0.12    0.01    0.14    0.26    0.00    0.00    0.00.00E
+00   0.00    0.00


  4   1       64.90   0.00    0.00    0.00    3.33    2.93    0.00    0.12    0.01    0.14    0.26    0.00    0.00    0.00.00E
+00   0.00    0.00
  4   2       64.91   0.00    0.00    0.00    3.25    3.01    0.00    0.12    0.01    0.14    0.27    0.00    0.00    0.00.00E
+00   0.00    0.00
  4   3       64.92   0.00    0.00    0.00    3.18    3.09    0.00    0.12    0.01    0.15    0.27    0.00    0.00    0.00.00E
+00   0.00    0.00
  4   4       64.92   0.00    0.00    0.00    3.13    3.16    0.00    0.12    0.01    0.15    0.28    0.00    0.00    0.00.00E
+00   0.00    0.00
  4   5       64.92   0.00    0.00    0.00    3.08    3.22    0.00    0.12    0.01    0.15    0.28    0.00    0.00    0.00.00E
+00   0.00    0.00
  4   6       64.93   0.00    0.00    0.00    3.04    3.27    0.00    0.12    0.01    0.16    0.29    0.00    0.00    0.00.00E
+00   0.00    0.00
  4   7       64.93   0.00    0.00    0.00    3.01    3.32    0.00    0.12    0.01    0.16    0.29    0.00    0.00    0.00.00E
+00   0.00    0.00
  4   8       64.94   0.00    0.00    0.00    2.99    3.35    0.00    0.12    0.01    0.16    0.29    0.00    0.00    0.00.00E
+00   0.00    0.00

          STREAM QUALITY SIMULATION                                                                               OUTPUT PA
GE NUMBER      6
          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   C
OLI           CHLA
              DEG-F                             MG/L    MG/L    MG/L    MG/L    MG/L    MG/L    MG/L    MG/L    MG/L    MG/L #/1
00ML          UG/L

  4   9       64.94   0.00    0.00    0.00    2.96    3.39    0.00    0.12    0.01    0.17    0.30    0.00    0.00    0.00.00E
+00   0.00    0.00
  4  10       64.94   0.00    0.00    0.00    2.95    3.41    0.00    0.12    0.01    0.17    0.30    0.00    0.00    0.00.00E
+00   0.00    0.00
  4  11       64.94   0.00    0.00    0.00    2.94    3.43    0.00    0.12    0.01    0.17    0.30    0.00    0.00    0.00.00E
+00   0.00    0.00


  5   1       65.04   0.00    0.00    0.00    3.30    2.74    0.00    0.09    0.00    0.21    0.30    0.00    0.00    0.00.00E
+00   0.00    0.00
  5   2       65.06   0.00    0.00    0.00    2.44    1.87    0.00    0.05    0.00    0.25    0.30    0.00    0.00    0.00.00E
+00   0.00    0.00
  5   3       65.07   0.00    0.00    0.00    2.20    1.27    0.00    0.03    0.00    0.27    0.30    0.00    0.00    0.00.00E
+00   0.00    0.00
  5   4       64.75   0.00    0.00    0.00    1.72    1.42    0.00    0.07    0.00    0.25    0.32    0.00    0.00    0.00.00E
+00   0.00    0.00
  5   5       65.01   0.00    0.00    0.00    1.94    0.97    0.00    0.04    0.00    0.28    0.32    0.00    0.00    0.00.00E
+00   0.00    0.00
  5   6       65.06   0.00    0.00    0.00    2.22    0.66    0.00    0.03    0.00    0.30    0.32    0.00    0.00    0.00.00E
+00   0.00    0.00
  5   7       65.07   0.00    0.00    0.00    2.49    0.45    0.00    0.02    0.00    0.31    0.32    0.00    0.00    0.00.00E
+00   0.00    0.00
  5   8       65.07   0.00    0.00    0.00    2.72    0.31    0.00    0.01    0.00    0.31    0.32    0.00    0.00    0.00.00E
+00   0.00    0.00



          STREAM QUALITY SIMULATION                                                                               OUTPUT PA
GE NUMBER      7
          QUAL-2E STREAM QUALITY ROUTING MODEL                                                                 Version 3.22  --
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May 1996

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
1	1	1	64.40	9.31	0.95	8.36	0.00	0.44	0.57	2.79	-0.19	-2.42	0.00	-0.04	-0.01
2	1	2	65.02	9.25	0.81	8.44	0.00	0.39	0.00	2.84	-0.17	-2.42	0.00	-0.03	-0.01
3	1	3	65.11	9.24	0.77	8.47	0.00	0.37	0.00	2.85	-0.16	-2.42	0.00	-0.03	-0.01
4	1	4	65.12	9.24	0.77	8.47	0.00	0.37	0.00	2.85	-0.14	-2.42	0.00	-0.03	-0.01
5	1	5	65.12	9.24	0.80	8.44	0.00	0.38	0.00	2.84	-0.13	-2.42	0.00	-0.03	-0.01
6	1	6	65.12	9.24	0.84	8.40	0.00	0.39	0.00	2.83	-0.12	-2.42	0.00	-0.03	-0.01
7	1	7	65.12	9.24	0.88	8.36	0.00	0.41	0.00	2.82	-0.11	-2.42	0.00	-0.02	-0.01
8	1	8	65.12	9.24	0.93	8.31	0.00	0.43	0.00	2.80	-0.10	-2.42	0.00	-0.02	-0.01
9	2	1	65.10	9.24	0.97	8.27	0.00	0.44	0.00	2.79	-0.09	-2.42	0.00	-0.02	-0.01
10	2	2	65.10	9.24	1.01	8.23	0.00	0.45	0.00	2.77	-0.08	-2.42	0.00	-0.02	-0.01
11	2	3	65.10	9.24	1.05	8.19	0.00	0.47	0.00	2.76	-0.07	-2.42	0.00	-0.02	-0.01
12	2	4	65.10	9.24	1.09	8.15	0.00	0.48	0.00	2.75	-0.07	-2.42	0.00	-0.02	-0.01
13	2	5	65.10	9.24	1.12	8.12	0.00	0.49	0.00	2.73	-0.06	-2.42	0.00	-0.02	-0.01
14	2	6	65.10	9.24	1.16	8.09	0.00	0.50	0.00	2.72	-0.05	2.42	0.00	-0.02	-0.01
15	2	7	65.10	9.24	1.19	8.06	0.00	0.51	0.00	2.71	-0.05	-2.42	0.00	-0.02	-0.01
16	2	8	65.10	9.24	1.21	8.03	0.00	0.52	0.00	2.70	-0.04	-2.42	0.00	-0.01	0.00
17	2	9	65.10	9.24	1.24	8.00	0.00	0.52	0.00	2.70	-0.04	-2.42	0.00	-0.01	0.00
18	2	10	65.10	9.24	1.26	7.98	0.00	0.53	0.00	2.69	-0.04	-2.42	0.00	-0.01	0.00
19	2	11	65.10	9.24	1.28	7.96	0.00	0.54	0.00	2.68	-0.03	-2.42	0.00	-0.01	0.00
20	2	12	65.10	9.24	1.30	7.94	0.00	0.54	0.00	2.67	-0.03	-2.42	0.00	-0.01	0.00
21	2	13	65.10	9.24	1.32	7.92	0.00	0.55	0.00	2.67	-0.03	-2.42	0.00	-0.01	0.00
22	2	14	65.10	9.24	1.34	7.90	0.00	0.55	0.00	2.66	-0.03	-2.42	0.00	-0.01	0.00
23	3	1	64.46	9.31	2.81	6.50	0.00	0.81	1.08	1.86	-0.08	-1.27	0.00	-0.02	-0.01
24	3	2	64.29	9.33	2.95	6.38	0.00	0.83	0.84	1.52	-0.10	-1.27	0.00	-0.03	-0.01
25	3	3	64.36	9.32	3.00	6.32	0.00	0.83	0.69	1.51	-0.12	-1.27	0.00	-0.03	-0.01
26	3	4	64.46	9.31	3.02	6.29	0.00	0.84	0.58	1.50	-0.13	-1.27	0.00	-0.03	-0.01
27	3	5	64.54	9.30	3.02	6.28	0.00	0.84	0.50	1.50	-0.13	-1.27	0.00	-0.03	-0.01
28	3	6	64.61	9.29	3.01	6.28	0.00	0.84	0.44	1.50	-0.13	-1.27	0.00	-0.03	-0.01
29	3	7	64.69	9.28	3.00	6.28	0.00	0.84	0.40	1.50	-0.14	-1.27	0.00	-0.03	-0.01
30	3	8	64.74	9.28	3.00	6.28	0.00	0.83	0.36	1.50	-0.14	-1.27	0.00	-0.03	-0.01
31	3	9	64.77	9.28	3.00	6.27	0.00	0.83	0.33	1.50	-0.13	-1.27	0.00	-0.03	-0.01
32	3	10	64.80	9.27	3.01	6.27	0.00	0.84	0.30	1.50	-0.13	-1.27	0.00	-0.03	-0.01

33	4	1	64.90	9.26	3.33	5.93	0.00	0.86	0.22	1.54	-0.14	-1.45	0.00	-0.03	-0.01
34	4	2	64.91	9.26	3.25	6.01	0.00	0.86	0.21	1.67	-0.14	-1.45	0.00	-0.03	-0.01
35	4	3	64.92	9.26	3.18	6.08	0.00	0.85	0.20	1.69	-0.14	-1.45	0.00	-0.03	-0.01
36	4	4	64.92	9.26	3.13	6.13	0.00	0.85	0.20	1.71	-0.15	-1.45	0.00	-0.03	-0.01
37	4	5	64.92	9.26	3.08	6.18	0.00	0.84	0.19	1.72	-0.15	-1.45	0.00	-0.03	-0.01
38	4	6	64.93	9.26	3.04	6.22	0.00	0.84	0.19	1.73	-0.15	-1.45	0.00	-0.03	-0.01
39	4	7	64.93	9.26	3.01	6.25	0.00	0.84	0.18	1.74	-0.15	-1.45	0.00	-0.03	-0.01
40	4	8	64.94	9.26	2.99	6.27	0.00	0.83	0.18	1.75	-0.16	-1.45	0.00	-0.03	-0.01

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 8

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 ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
41	4	9	64.94	9.26	2.96	6.29	0.00	0.83	0.18	1.75	-0.16	-1.45	0.00	-0.03	-0.01
42	4	10	64.94	9.26	2.95	6.31	0.00	0.83	0.17	1.76	-0.16	-1.45	0.00	-0.03	-0.01
43	4	11	64.94	9.26	2.94	6.32	0.00	0.83	0.17	1.76	-0.16	-1.45	0.00	-0.03	-0.01
44	5	1	65.04	9.25	3.30	5.95	0.00	0.86	0.00	1.03	-0.13	-0.36	0.00	-0.02	-0.01
45	5	2	65.06	9.24	2.44	6.81	0.00	0.77	0.00	0.46	-0.09	-0.36	0.00	-0.01	0.00
46	5	3	65.07	9.24	2.20	7.04	0.00	0.73	0.00	0.47	-0.06	-0.36	0.00	-0.01	0.00
47	5	4	64.75	9.28	1.72	7.56	0.00	0.64	0.03	0.51	-0.07	-0.36	0.00	-0.01	0.00
48	5	5	65.01	9.25	1.94	7.31	0.00	0.69	0.00	0.49	-0.04	-0.36	0.00	-0.01	0.00
49	5	6	65.06	9.25	2.22	7.03	0.00	0.74	0.00	0.47	-0.03	-0.36	0.00	-0.01	0.00
50	5	7	65.07	9.24	2.49	6.76	0.00	0.78	0.00	0.46	-0.02	-0.36	0.00	0.00	0.00
51	5	8	65.07	9.24	2.72	6.53	0.00	0.80	0.00	0.44	-0.01	-0.36	0.00	0.00	0.00

Attachment 2

Data for Manganese Load Duration Curves			Observed Data				
North Fork Kaskaskia River at OKA-01 flow (cfs)	% of Time Exceeded	Mn load (lb/d)	Date	North Fork Kaskaskia River at OKA-01 flow (cfs)	Mn, total (ug/l)	Percentile	Mn load (lb/d)
0.0	99.99	0.00	1/11/1990	1	4463	70.07	14.9
0.0	98.87	0.00	2/14/1990	2	127	55.21	1.5
0.0	97.84	0.00	3/27/1990	11	325	27.49	19.3
0.0	96.81	0.00	5/10/1990	11	388	28.00	22.3
0.0	95.77	0.00	6/12/1990	7	281	34.84	10.9
0.0	94.74	0.00	7/19/1990	0	335	72.38	0.9
0.0	93.71	0.00	8/28/1990	0	929	87.02	0.2
0.0	92.68	0.00	10/11/1990	0	103	83.80	0.0
0.0	91.65	0.02	11/15/1990	0	802	73.01	1.9
0.0	90.62	0.06	1/24/1991	10	198	28.73	11.0
0.0	89.59	0.09	2/14/1991	160	285	5.64	245.2
0.0	88.56	0.15	3/21/1991	23	179	17.32	22.6
0.0	87.53	0.19	5/1/1991	3	580	47.49	10.8
0.0	86.50	0.24	5/30/1991	2	1600	57.14	16.3
0.1	85.47	0.32	7/17/1991	0	1566	84.55	0.6
0.1	84.44	0.39	9/19/1991	0	840	91.52	0.0
0.1	83.41	0.48	11/6/1991	2	79	55.05	0.9
0.1	82.38	0.59	12/18/1991	3	140	50.74	2.1
0.1	81.35	0.72	1/27/1992	6	83	37.73	2.8
0.2	80.32	0.87	2/26/1992	4	310	44.79	6.9
0.2	79.29	1.02	4/22/1992	43	250	12.37	57.5
0.2	78.26	1.21	5/14/1992	36	230	13.53	44.8
0.3	77.23	1.41	6/17/1992	0	610	84.35	0.2
0.3	76.20	1.59	8/18/1992	0	360	99.99	0.0
0.3	75.16	1.85	9/10/1992	3	420	51.82	6.0
0.4	74.13	2.04	11/16/1992	14	170	23.65	12.9
0.4	73.10	2.23	12/7/1992	2	200	53.69	2.6
0.5	72.07	2.60	1/11/1993	18	200	20.29	19.7
0.6	71.04	2.97	3/9/1993	33	110	14.24	19.8
0.6	70.01	3.34	4/20/1993	375	430	2.27	869.1
0.7	68.98	3.71	5/26/1993	17	170	21.48	15.4
0.8	67.95	4.08	6/10/1993	21	390	18.55	44.1
0.9	66.92	4.64	8/12/1993	29	510	15.51	79.4
0.9	65.89	5.01	9/29/1993	25	160	16.83	21.4
1.0	64.86	5.56	11/1/1993	3	400	52.32	5.6
1.1	63.83	6.12	12/7/1993	25	240	16.64	32.9
1.2	62.80	6.49	1/3/1994	8	550	33.31	23.5
1.3	61.77	7.23	2/17/1994	5	540	40.83	15.0
1.4	60.74	7.79	3/23/1994	4	490	43.43	11.8
1.6	59.71	8.53	5/23/1994	3	520	47.49	9.6
1.7	58.68	9.27	6/23/1994	6	2200	37.73	73.4
1.8	57.65	9.64	7/18/1994	0	990	87.02	0.2
1.9	56.62	10.38	9/15/1994	0	600	88.23	0.1
2.1	55.59	11.13	11/14/1994	1	3100	71.23	9.2
2.2	54.55	11.87	12/20/1994	4	100	46.42	2.0
2.4	53.52	12.98	2/2/1995	4	100	44.79	2.2
2.5	52.49	13.54	3/8/1995	433	220	1.92	514.0
2.7	51.46	14.46	4/6/1995	3	300	52.48	4.1
2.9	50.43	15.39	5/10/1995	128	210	6.68	144.5
3.1	49.40	16.50	6/20/1995	2	680	58.97	6.2
3.2	48.37	17.25	8/9/1995	4	710	44.79	15.8
3.4	47.34	18.54	9/11/1995	0	550	81.64	0.4

Data for Manganese Load Duration Curves			Observed Data				
North Fork Kaskaskia River at OKA-01 flow (cfs)	% of Time Exceeded	Mn load (lb/d)	Date	North Fork Kaskaskia River at OKA-01 flow (cfs)	Mn, total (ug/l)	Percentile	Mn load (lb/d)
3.8	46.31	20.40	10/26/1995	0	120	99.99	0.0
3.8	45.28	20.40	11/20/1995	0	180	92.01	0.0
4.1	44.25	22.25	1/10/1996	1	1800	69.21	6.7
4.5	43.22	24.11	2/8/1996	1	200	65.60	1.0
4.8	42.19	25.96	4/9/1996	6	220	39.64	6.5
4.8	41.16	25.96	5/13/1996	22	280	18.25	32.7
5.2	40.13	27.82	6/25/1996	1	960	63.84	5.9
5.5	39.10	29.67	8/12/1996	0	210	80.77	0.2
5.8	38.07	31.52	9/10/1996	0	2700	99.99	0.0
6.2	37.04	33.38	10/17/1996	0	660	90.00	0.1
6.5	36.01	35.23	11/14/1996	1	93	70.07	0.3
6.9	34.98	37.09	1/21/1997	8	270	33.31	11.5
7.6	33.94	40.80	2/13/1997	12	110	26.46	6.9
7.9	32.91	42.65	4/8/1997	19	170	20.09	17.0
8.6	31.88	46.36	5/14/1997	3	380	47.49	7.0
8.9	30.85	48.21	6/17/1997	8	250	33.31	10.7
9.6	29.82	51.92	8/4/1997	0	1200	89.13	0.2
10.0	28.79	53.78	9/16/1997	0	470	85.25	0.2
10.7	27.76	57.49	11/6/1997	0	470	78.20	0.6
11.3	26.73	61.19	12/16/1997	0	3900	80.04	3.6
12.4	25.70	66.76	2/5/1998	1	140	60.67	1.1
13.1	24.67	70.47	3/17/1998	16	180	21.91	15.7
14.1	23.64	76.03	4/8/1998	63	610	10.17	205.9
15.1	22.61	81.59	6/4/1998	11	490	28.00	28.2
16.5	21.58	89.01	7/1/1998	12	170	26.46	10.7
17.5	20.55	94.57	8/20/1998	1	380	60.93	3.0
19.3	19.52	103.84	9/24/1998	1	470	67.61	2.0
21.0	18.49	113.12	11/5/1998	7	160	36.61	5.6
22.7	17.46	122.39	12/17/1998	4	150	46.42	3.1
25.8	16.43	139.08	2/2/1999	358	130	2.39	250.7
28.9	15.40	155.77	3/10/1999	229	120	4.19	148.0
32.7	14.37	176.16	4/7/1999	276	190	3.45	282.6
37.1	13.33	200.27	5/19/1999	6	290	37.73	9.7
43.0	12.30	231.80	7/1/1999	36	1300	13.53	253.1
50.5	11.27	272.59	8/11/1999	0	620	84.55	0.2
61.2	10.24	330.08	9/9/1999	0	320	99.99	0.0
75.6	9.21	407.96	11/8/1999	0	500	99.99	0.0
93.2	8.18	502.53	12/8/1999	0	2300	99.99	0.0
115.2	7.15	621.21	1/25/2000	0	930	84.93	0.3
142.0	6.12	765.85	3/7/2000	2	190	55.88	2.1
188.1	5.09	1014.34	4/13/2000	6	180	37.73	6.0
235.5	4.06	1270.24	5/17/2000	4	270	46.42	5.5
305.0	3.03	1644.82	6/6/2000	1	410	63.53	2.6
416.0	2.00	2243.78	8/15/2000	3	300	50.74	4.5
612.0	0.97	3300.77	9/21/2000	1	180	69.21	0.7
			11/6/2000	9	2600	31.90	120.5
			12/6/2000	7	330	36.61	11.6
			1/9/2001	6	550	37.73	18.4
			2/5/2001	14	260	24.25	19.3
			4/11/2001	15	510	22.45	42.6
			5/15/2001	1	480	71.23	1.4
			8/28/2001	3	770	48.00	13.7

Data for Manganese Load Duration Curves			Observed Data				
North Fork Kaskaskia River at OKA-01 flow (cfs)	% of Time Exceeded	Mn load (lb/d)	Date	North Fork Kaskaskia River at OKA-01 flow (cfs)	Mn, total (ug/l)	Percentile	Mn load (lb/d)
			10/24/2001	2	420	58.14	4.0
			12/12/2001	11	120	27.49	7.1
			1/9/2002	3	540	49.22	9.0
			3/6/2002	18	180	20.29	17.7
			4/10/2002	39	120	12.90	25.4
			5/23/2002	7	180	36.61	6.3
			6/4/2002	2	450	59.47	3.9
			8/28/2002	0	1000	99.99	0.0
			10/29/2002	1	250	65.60	1.3
			12/23/2002	4	110	43.43	2.7
			3/10/2003	4	78	43.43	1.9
			4/2/2003	7	220	36.61	7.8
			6/17/2003	11	210	26.95	12.9
			7/29/2003	0	310	77.46	0.4
			9/9/2003	1	180	68.43	0.7
			10/21/2003	2	1000	56.83	10.4
			11/18/2003	232	540	4.14	674.9
			1/6/2004	560	140	1.19	423.2
			2/24/2004	17	110	21.69	9.8
			3/23/2004	4	230	46.42	4.7
			5/4/2004	12	120	25.70	8.0
			7/20/2004	0	590	76.03	1.0
			8/31/2004	9	180	31.90	8.3
			10/18/2004	52	310	11.03	87.4
			8/31/2005	0	1200	89.13	0.2
			10/13/2005	0	890	89.55	0.1

Attachment 3

Data for Dissolved Iron Load Duration Curves			Observed Data				
North Fork Kaskaskia River at OKA-01 flow (cfs)	% of Time Exceeded	Dis. Iron (lb/day)	Date	North Fork Kaskaskia River at OKA-01 flow (cfs)	Dis. Iron (ug/l)	Percentile	Dis. Iron load (lb/d)
0.00	99.99	0.00	1/11/1990	1	1465	70.07	4.9
0.00	98.86	0.00	2/14/1990	2	50	55.21	0.6
0.00	97.83	0.00	3/27/1990	11	50	27.49	3.0
0.00	96.80	0.00	5/10/1990	11	96	28.00	5.5
0.00	95.76	0.00	6/12/1990	7	110	34.84	4.3
0.00	94.73	0.00	7/19/1990	0	76	72.38	0.2
0.00	93.70	0.00	8/28/1990	0	125	87.02	0.0
0.00	92.67	0.00	10/11/1990	0	114	83.80	0.1
0.00	91.64	0.02	11/15/1990	0	642	73.01	1.5
0.01	90.61	0.06	1/24/1991	10	50	28.73	2.8
0.02	89.58	0.09	2/14/1991	160	54	5.64	46.5
0.03	88.55	0.15	3/21/1991	23	215	17.32	27.1
0.03	87.52	0.19	5/1/1991	3	50	47.49	0.9
0.04	86.49	0.24	5/30/1991	2	50	57.14	0.5
0.06	85.46	0.32	7/17/1991	0	50	84.55	0.0
0.07	84.43	0.39	9/19/1991	0	618	91.52	0.0
0.09	83.40	0.48	11/6/1991	2	410	55.05	4.8
0.11	82.37	0.59	12/18/1991	3	270	50.74	4.1
0.13	81.34	0.72	1/27/1992	6	360	37.73	12.0
0.16	80.31	0.87	2/26/1992	4	70	44.79	1.6
0.19	79.28	1.02	4/22/1992	43	280	12.37	64.4
0.22	78.25	1.21	5/14/1992	36	210	13.53	40.9
0.26	77.22	1.41	6/17/1992	0	50	84.35	0.0
0.30	76.19	1.59	8/18/1992	0	76	99.99	0.0
0.34	75.15	1.85	9/10/1992	3	92	51.82	1.3
0.38	74.12	2.04	11/16/1992	14	200	23.65	15.2
0.41	73.09	2.23	12/7/1992	2	190	53.69	2.4
0.48	72.06	2.60	1/11/1993	18	110	20.29	10.8
0.55	71.03	2.97	3/9/1993	33	63	14.24	11.3
0.62	70.00	3.34	4/20/1993	375	60	2.27	121.3
0.69	68.97	3.71	5/26/1993	17	160	21.48	14.5
0.76	67.94	4.08	6/10/1993	21	50	18.55	5.7
0.86	66.91	4.64	8/12/1993	29	70	15.51	10.9
0.93	65.88	5.01	9/29/1993	25	300	16.83	40.1
1.03	64.85	5.56	11/1/1993	3	700	52.32	9.7
1.13	63.82	6.12	12/7/1993	25	84	16.64	11.5
1.20	62.79	6.49	1/3/1994	8	50	33.31	2.1
1.34	61.76	7.23	2/17/1994	5	50	40.83	1.4
1.44	60.73	7.79	3/23/1994	4	50	43.43	1.2
1.58	59.70	8.53	5/23/1994	3	50	47.49	0.9
1.72	58.67	9.27	6/23/1994	6	82	37.73	2.7
1.79	57.64	9.64	7/18/1994	0	120	87.02	0.0
1.93	56.61	10.38	9/15/1994	0	50	88.23	0.0
2.06	55.58	11.13	11/14/1994	1	570	71.23	1.7
2.23	54.54	12.05	12/20/1994	4	61	46.42	1.2
2.41	53.51	12.98	2/2/1995	4	250	44.79	5.6
2.54	52.48	13.72	3/8/1995	433	550	1.92	1285.1
2.68	51.45	14.46	4/6/1995	3	50	52.48	0.7
2.85	50.42	15.39	5/10/1995	128	260	6.68	178.9
3.06	49.39	16.50	6/20/1995	2	50	58.97	0.5
3.20	48.36	17.25	8/9/1995	4	210	44.79	4.7
3.44	47.33	18.54	9/11/1995	0	330	81.64	0.2
3.78	46.30	20.40	10/26/1995	0	69	99.99	0.0
3.78	45.27	20.40	11/20/1995	0	63	92.01	0.0
4.13	44.24	22.25	1/10/1996	1	720	69.21	2.7
4.47	43.21	24.11	2/8/1996	1	180	65.60	0.9
4.81	42.18	25.96	4/9/1996	6	50	39.64	1.5
4.81	41.15	25.96	5/13/1996	22	130	18.25	15.2
5.16	40.12	27.82	6/25/1996	1	210	63.84	1.3
5.50	39.09	29.67	8/12/1996	0	50	80.77	0.0
5.84	38.06	31.52	9/10/1996	0	50	99.99	0.0
6.19	37.03	33.38	10/17/1996	0	50	90.00	0.0
6.53	36.00	35.23	11/14/1996	1	63	70.07	0.2
6.88	34.96	37.09	1/21/1997	8	230	33.31	9.8
7.56	33.93	40.80	2/13/1997	12	80	26.46	5.0

Data for Dissolved Iron Load Duration Curves

North Fork Kaskaskia River at OKA-01 flow (cfs)	% of Time Exceeded	Dis. Iron (lb/day)
7.91	32.90	42.65
8.60	31.87	46.36
8.94	30.84	48.21
9.63	29.81	51.92
9.97	28.78	53.78
10.66	27.75	57.49
11.35	26.72	61.19
12.38	25.69	66.76
13.06	24.66	70.47
14.10	23.63	76.03
15.13	22.60	81.59
16.50	21.57	89.01
17.53	20.54	94.57
19.25	19.51	103.84
20.97	18.48	113.12
22.69	17.45	122.39
25.79	16.42	139.08
29.22	15.39	157.62
32.66	14.35	176.16
37.13	13.32	200.27
42.98	12.29	231.80
50.54	11.26	272.59
61.54	10.23	331.93
75.64	9.20	407.96
93.17	8.17	502.53
115.17	7.14	621.21
142.34	6.11	767.71
188.41	5.08	1016.19
235.85	4.05	1272.10
305.30	3.02	1646.68
416.00	1.99	2243.78
618.85	0.96	3337.86

Observed Data

Date	North Fork Kaskaskia River at OKA-01 flow (cfs)	Dis. Iron (ug/l)	Percentile	Dis. Iron load (lb/d)
4/8/1997	19	140	20.09	14.0
5/14/1997	3	50	47.49	0.9
6/17/1997	8	80	33.31	3.4
8/4/1997	0	50	89.13	0.0
9/16/1997	0	52	85.25	0.0
11/6/1997	0	130	78.20	0.2
12/16/1997	0	3200	80.04	3.0
2/5/1998	1	50	60.67	0.4
3/17/1998	16	160	21.91	13.9
4/8/1998	63	160	10.17	54.0
6/4/1998	11	97	28.00	5.6
7/1/1998	12	180	26.46	11.3
8/20/1998	1	50	60.93	0.4
9/24/1998	1	470	67.61	2.0
11/5/1998	7	330	36.61	11.6
12/17/1998	4	61	46.42	1.2
2/2/1999	358	140	2.39	270.0
3/10/1999	229	390	4.19	480.9
4/7/1999	276	230	3.45	342.1
5/19/1999	6	210	37.73	7.0
7/1/1999	36	93	13.53	18.1
8/11/1999	0	420	84.55	0.2
9/9/1999	0	94	99.99	0.0
11/8/1999	0	56	99.99	0.0
12/8/1999	0	390	99.99	0.0
1/25/2000	0	200	84.93	0.1
3/7/2000	2	110	55.88	1.2
4/13/2000	6	230	37.73	7.7
5/17/2000	4	97	46.42	2.0
6/6/2000	1	67	63.53	0.4
8/15/2000	3	220	50.74	3.3
11/6/2000	9	300	31.90	13.9
12/6/2000	7	150	36.61	5.3
2/5/2001	14	69	24.25	5.1
4/11/2001	15	59	22.45	4.9
10/24/2001	2	580	58.14	5.5
12/12/2001	11	1000	27.49	59.3
3/6/2002	18	160	20.29	15.7
4/10/2002	39	340	12.90	71.9
5/23/2002	7	71	36.61	2.5
7/26/2002	0	660	77.46	0.9
8/28/2002	0	54	99.99	0.0
10/29/2002	1	120	65.60	0.6
12/23/2002	4	200	43.43	4.8
3/10/2003	4	190	43.43	4.6
4/2/2003	7	75	36.61	2.6
6/17/2003	11	130	26.95	8.0
7/29/2003	0	53	77.46	0.1
9/9/2003	1	120	68.43	0.5
10/21/2003	2	670	56.83	7.0
11/18/2003	232	820	4.14	1024.9
1/6/2004	560	120	1.19	362.7
2/24/2004	17	140	21.69	12.5
3/23/2004	4	50	46.42	1.0
5/4/2004	12	91	25.70	6.1
7/20/2004	0	80	76.03	0.1
8/31/2004	9	200	31.90	9.3
10/18/2004	52	59	11.03	16.6
10/13/2005	0	575	89.55	0.1

Attachment 4

Data for Fecal Coliform Load Duration Curve			Observed Data				
North Fork Kaskaskia River Flow at OKA-01 (cfs)	% of Time Exceeded	Fecal coliform load (cfu/day)	Date	North Fork Kaskaskia River Flow at OKA-01 (cfs)	Concentration (cfu/100ml)	Percentile	Fecal coliform load (cfu/day)
0.00	99.99	0.00E+00	5/10/1990	11	60	28.00	1.56E+10
0.00	97.83	0.00E+00	6/12/1990	7	210	34.84	3.71E+10
0.00	96.80	0.00E+00	7/19/1990	0	20	72.38	2.36E+08
0.00	95.76	0.00E+00	8/28/1990	0	240	87.02	2.42E+08
0.00	94.73	0.00E+00	10/11/1990	0	10	83.80	2.10E+07
0.00	93.70	0.00E+00	5/1/1991	3	70	47.49	5.89E+09
0.00	92.67	0.00E+00	5/30/1991	2	80	57.14	3.70E+09
0.00	91.64	1.68E+07	7/17/1991	0	30	84.55	5.30E+07
0.01	90.61	5.05E+07	9/19/1991	0	800	91.52	1.35E+08
0.02	89.58	8.41E+07	5/14/1992	36	2400	13.53	2.12E+12
0.03	88.55	1.35E+08	6/17/1992	0	2100	84.35	3.89E+09
0.03	87.52	1.68E+08	8/18/1992	0	400	99.99	0.00E+00
0.04	86.49	2.19E+08	9/10/1992	3	900	51.82	5.83E+10
0.06	85.46	2.86E+08	5/26/1993	17	360	21.48	1.48E+11
0.07	84.43	3.53E+08	6/10/1993	21	5700	18.55	2.92E+12
0.09	83.40	4.37E+08	9/29/1993	25	420	16.83	2.54E+11
0.11	82.37	5.38E+08	5/23/1994	3	100	47.49	8.41E+09
0.13	81.34	6.56E+08	6/23/1994	6	100	37.73	1.51E+10
0.16	80.31	7.91E+08	7/18/1994	0	66	87.02	6.66E+07
0.19	79.28	9.25E+08	9/15/1994	0	133	88.23	1.01E+08
0.22	78.25	1.09E+09	5/10/1995	128	2400	6.68	7.49E+12
0.26	77.22	1.28E+09	6/20/1995	2	410	58.97	1.69E+10
0.30	76.19	1.45E+09	8/9/1995	4	880	44.79	8.88E+10
0.34	75.15	1.68E+09	9/11/1995	0	112	81.64	3.58E+08
0.38	74.12	1.85E+09	10/26/1995	0	16	99.99	0.00E+00
0.41	73.09	2.02E+09	5/13/1996	22	290	18.25	1.54E+11
0.48	72.06	2.36E+09	6/25/1996	1	126	63.84	3.50E+09
0.55	71.03	2.69E+09	8/12/1996	0	260	80.77	9.62E+08
0.62	70.00	3.03E+09	9/10/1996	0	94	99.99	0.00E+00
0.69	68.97	3.36E+09	10/17/1996	0	3600	90.00	1.51E+09
0.76	67.94	3.70E+09	5/14/1997	3	102	47.49	8.58E+09
0.86	66.91	4.21E+09	6/17/1997	8	525	33.31	1.02E+11
0.93	65.88	4.54E+09	8/4/1997	0	220	89.13	1.30E+08
1.03	64.85	5.05E+09	9/16/1997	0	320	85.25	4.85E+08
1.13	63.82	5.55E+09	6/4/1998	11	710	28.00	1.85E+11
1.20	62.79	5.89E+09	7/1/1998	12	780	26.46	2.23E+11
1.34	61.76	6.56E+09	8/20/1998	1	20	60.93	7.07E+08
1.44	60.73	7.07E+09	9/24/1998	1	86	67.61	1.66E+09
1.58	59.70	7.74E+09	5/19/1999	6	1005	37.73	1.52E+11
1.72	58.67	8.41E+09	7/1/1999	36	22	13.53	1.94E+10
1.79	57.64	8.75E+09	8/11/1999	0	102	84.55	1.80E+08
1.93	56.61	9.42E+09	9/9/1999	0	181	99.99	0.00E+00
2.06	55.58	1.01E+10	5/17/2000	4	250	46.42	2.31E+10
2.23	54.54	1.09E+10	6/6/2000	1	300	63.53	8.58E+09
2.41	53.51	1.18E+10	8/15/2000	3	162	50.74	1.10E+10
2.54	52.48	1.25E+10	9/21/2000	1	42	69.21	7.07E+08
2.68	51.45	1.31E+10	5/15/2001	1	17	71.23	2.29E+08
2.85	50.42	1.40E+10	6/14/2001	2	280	60.49	1.04E+10
3.06	49.39	1.50E+10	7/31/2001	1	270	62.21	8.63E+09
3.20	48.36	1.56E+10	8/28/2001	3	370	48.00	2.99E+10
3.44	47.33	1.68E+10	10/24/2001	2	910	58.14	3.90E+10
3.78	46.30	1.85E+10	5/23/2002	7	142	36.61	2.27E+10
3.78	45.27	1.85E+10	6/4/2002	2	42	59.47	1.66E+09
4.13	44.24	2.02E+10	8/28/2002	0	70	99.99	0.00E+00
4.47	43.21	2.19E+10	10/29/2002	1	1885	65.60	4.44E+10
4.81	42.18	2.36E+10	10/21/2003	2	130	56.83	6.12E+09
4.81	41.15	2.36E+10	5/4/2004	12	400	25.70	1.21E+11
5.16	40.12	2.52E+10	6/8/2004	2	280	56.56	1.34E+10
5.50	39.09	2.69E+10	7/20/2004	0	310	76.03	2.32E+09

Data for Fecal Coliform Load Duration Curve

North Fork Kaskaskia River Flow at OKA-01 (cfs)	% of Time Exceeded	Fecal coliform load (cfu/day)
5.84	38.06	2.86E+10
6.19	37.03	3.03E+10
6.53	36.00	3.20E+10
6.88	34.96	3.36E+10
7.56	33.93	3.70E+10
7.91	32.90	3.87E+10
8.60	31.87	4.21E+10
8.94	30.84	4.37E+10
9.63	29.81	4.71E+10
9.97	28.78	4.88E+10
10.66	27.75	5.22E+10
11.35	26.72	5.55E+10
12.38	25.69	6.06E+10
13.06	24.66	6.39E+10
14.10	23.63	6.90E+10
15.13	22.60	7.40E+10
16.50	21.57	8.08E+10
17.53	20.54	8.58E+10
19.25	19.51	9.42E+10
20.97	18.48	1.03E+11
22.69	17.45	1.11E+11
25.79	16.42	1.26E+11
29.22	15.39	1.43E+11
32.66	14.35	1.60E+11
37.13	13.32	1.82E+11
42.98	12.29	2.10E+11
50.54	11.26	2.47E+11
61.54	10.23	3.01E+11
75.64	9.20	3.70E+11
93.17	8.17	4.56E+11
115.17	7.14	5.64E+11
142.34	6.11	6.97E+11
188.41	5.08	9.22E+11
235.85	4.05	1.15E+12
305.30	3.02	1.49E+12
416.00	1.99	2.04E+12
618.85	0.96	3.03E+12

Observed Data

Date	North Fork Kaskaskia River Flow at OKA-01 (cfs)	Concentration (cfu/100ml)	Percentile	Fecal coliform load (cfu/day)
8/31/2004	9	420	31.90	8.83E+10
10/18/2004	52	590	11.03	7.54E+11
5/4/2005	2	58	53.69	3.37E+09

Attachment 5

Responsiveness Summary

This responsiveness summary responds to substantive questions and comments received during the public comment period from July 20, 2006 through August 23, 2006 postmarked, including those from the August 17, 2006 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. The North Fork Kaskaskia Stage 3 TMDL report details the necessary reduction in pollutant loads to the impaired water bodies to ensure compliance with applicable water quality standards. The Illinois EPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act and regulations thereunder.

Background

The watershed targeted for TMDL development is the North Fork Kaskaskia River watershed, which originates in Fayette county and flows west into Marion county. The watershed encompasses an area of approximately 77.3 square miles. Land use in the watershed is predominately agriculture. North Fork Kaskaskia River segment OKA-01 is 10.25 miles in length and is on the *Illinois Integrated Water Quality Report and Section 303(d) List-2006* as being impaired for iron, manganese, pH, low dissolved oxygen, total fecal coliform, and total phosphorus. North Fork Kaskaskia River segment OKA-02 is 15.31 miles in length and is on the 2006 Section 303(d) List as being impaired for iron, manganese, pH, low dissolved oxygen, and total phosphorus. The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) List. Illinois EPA is currently developing TMDLs for pollutants that have numeric water quality standards. Illinois does not have a total phosphorus water quality standard that applies to streams. Therefore, a TMDL was not developed for total phosphorus for impaired segments in this watershed. The Illinois EPA contracted with Limno-Tech, Inc., to prepare a TMDL report for the North Fork Kaskaskia River watershed.

Public Meetings

Public meetings were held in the Village of Patoka on March 16, 2005, and August 17, 2006. The Illinois EPA provided public notice for both meetings by placing display ads in the Centralia Morning Sentinel, Salem Times Courier, Vandalia Leader, Farina News, and Kinmundy Express. This notice gave the date, time, location, and purpose of the meeting. The notice also provided references to obtain additional information about this specific site, the TMDL Program and other related issues. Approximately 334 individuals and organizations were also sent the public notice by first class mail. The draft TMDL Report was available for review at the Patoka Village Hall as well as the Agency's website at http://www.epa.state.il.us/public-notices .

The Stage 3 public meeting started at 6:00 p.m. on Thursday, August 17, 2006. It was attended by approximately 3 people and concluded at 6:45 p.m. with the meeting record remaining open until midnight, August 23, 2006.

Questions and Comments

1. The North Fork Kaskaskia River segments are listed for manganese and iron. The North Fork report states that these impairments are most likely due to the mineral content in the soils. The East Fork watershed is right next to the North Fork, and share the same soil types. Why wasn't East Fork Kaskaskia River segments listed for manganese and iron as well?

   Response: The North Fork Kaskaskia impaired segments OKA-01 and OKA-02 have a public water supply designated use, whereas the East Fork Kaskaskia impaired segments are not designated as a public water supply. Therefore, the North Fork Kaskaskia segments were listed as impaired for violating the manganese and iron public water supply standards. These standards do not apply to the East Fork Kaskaskia. However, aquatic life use standards apply to the East Fork Kaskaskia for manganese and iron. East Fork Kaskaskia segments OK-01 and OK-02 are currently not listed as causes of impairment for manganese or iron for aquatic life use. Please note that the public water supply designated use will no longer apply to North Fork Kaskaskia River segments OKA-01 and OKA-02 in the near future because the Village of Patoka will no longer use these as sources for their public water supply.

TMDL Implementation Plan

North Fork Kaskaskia River Watershed

Prepared for Illinois Environmental Protection Agency

March 2007

North Fork Kaskaskia River (IL_OKA-01): Manganese, dissolved oxygen, pH, iron, fecal coliform

North Fork Kaskaskia River (IL_OKA-02): Manganese, dissolved oxygen, pH, iron

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SUMMARY

Total Maximum Daily Loads (TMDLs) were developed and approved by the U.S. EPA in September 2006 for two segments of the North Fork Kaskaskia River in southern Illinois, to address a number of water quality impairments. Specifically, TMDLs were developed for dissolved oxygen, pH, manganese, and iron in segments IL-OKA-01 and IL-OKA-02, and additionally for fecal coliform in segment IL-OKA-01.

The next step in the TMDL process it to develop an 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, identifies priority areas for controls and provides monitoring recommendations. Best management practices for nonpoint sources will strictly be voluntary.

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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. The Illinois Environmental Protection Agency's (IEPA) 2006 303(d) list 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 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).

Two segments of the North Fork Kaskaskia River (Segments IL_OKA-01 and IL_OKA-02) 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 were targeted as high priority waterbodies for TMDL development. TMDLs were developed for pH, manganese, iron, and fecal coliform bacteria in segment IL_OKA-01, and for pH, manganese, and iron in segment IL_OKA-02 (LTI, 2006). These TMDLs were approved by the U.S. EPA. TMDLs were also completed for dissolved oxygen in segments IL_OKA-01 and IL_OKA-02. Although the dissolved oxygen TMDLs are considered completed by IEPA, they will not be approved by U.S. EPA Region V because the low dissolved oxygen levels were determined to be due to low flow, and not pollutants; TMDLs cannot be written to control flow.

The next step in the TMDL process is to develop an 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 North Fork Kaskaskia River watershed TMDLs. It is divided into sections describing the watershed, summarizing the allowable loads and needed reductions identified in the Stage 3 TMDL report, describing the implementation strategy, describing existing controls, discussing alternatives to reduce the existing loadings of the pollutants of concern, identifying priority areas for controls, describing reasonable assurances that the measures will be implemented, and outlining future monitoring and adaptive management.

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WATERSHED DESCRIPTION

The two impaired stream segments addressed in this report are in the North Fork Kaskaskia River watershed, located in southern Illinois, approximately 75 miles southeast of Springfield, Illinois, and 60 miles east of St. Louis, Missouri. The headwaters of the North Fork Kaskaskia River originate in Fayette County, Illinois, and this is the origin of segment IL_OKA-02. Segment IL_OKA-02 flows westward through Marion County, ending about 0.5 miles upstream of the US Route 51 overpass, where this segment flows into segment IL_OKA-01. Segment IL_OKA-01 flows westward from just east of the US Route 51 overpass, through Clinton County, to its terminus at Carlyle Lake. The project study area is predominantly agricultural (74%) and includes portions of three counties (Fayette, Marion and Clinton). Figure 1 shows a map of the North Fork Kaskaskia River watershed, and includes key features such as waterways, impaired waterbodies, and public water intakes. The map also shows the locations of point source discharges that have a permit to discharge under the National Pollutant Discharge Elimination System (NPDES). A detailed characterization of the watershed was provided in an earlier report (LTI, 2004).

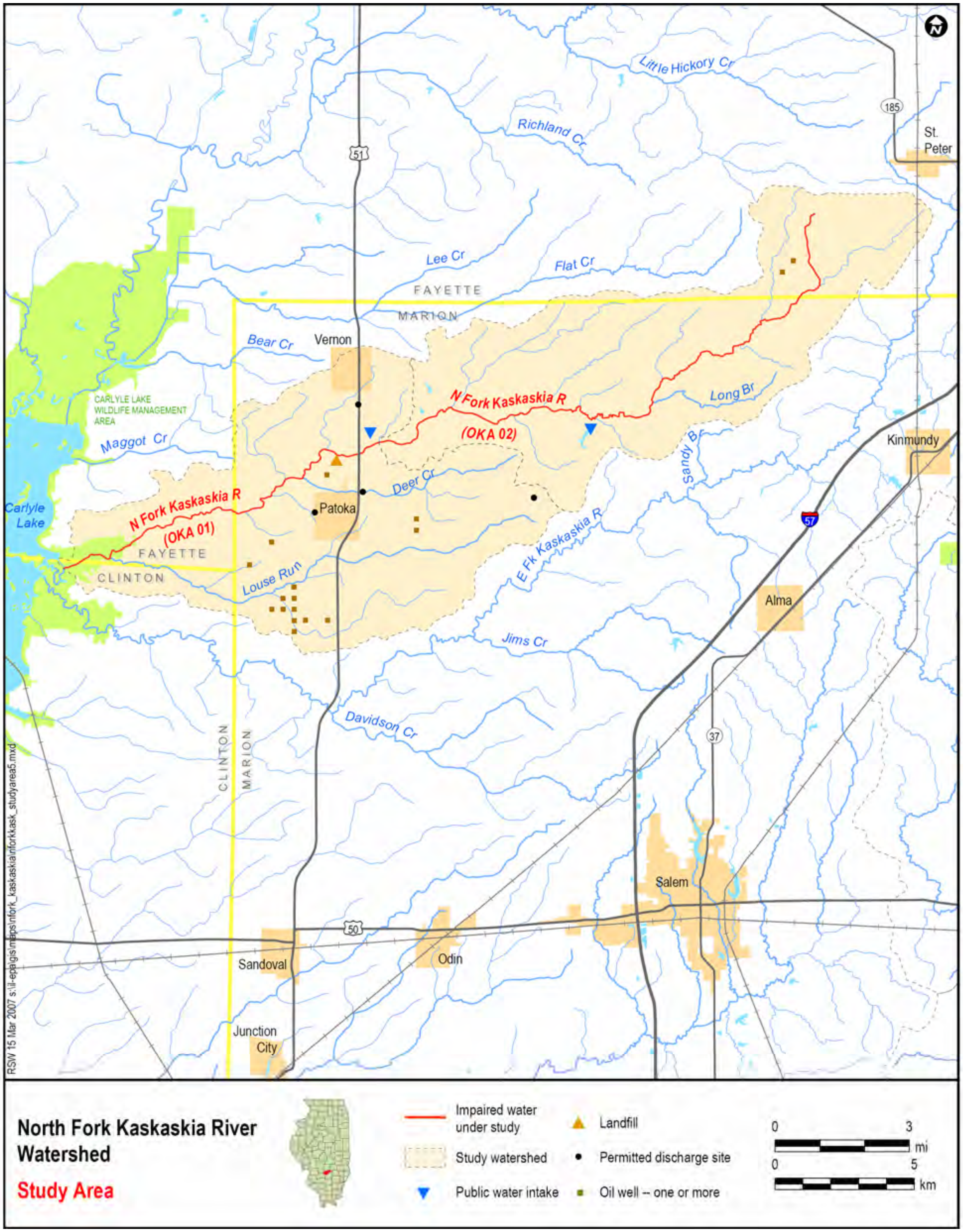

Figure 1. North Fork Kaskaskia River Watershed

TMDL SUMMARY

The North Fork Kaskaskia segments are listed on the Illinois 303(d) list for the following impairments:

- North Fork Kaskaskia River (IL_OKA-01): Dissolved Oxygen, pH, Manganese, Iron, and Fecal Coliform.
- North Fork Kaskaskia River (IL_OKA-02): Dissolved Oxygen, pH, Manganese, and Iron.

Additional information on these impairment listings is summarized in Table 1.

Table 1. Summary of Impairment Listing for North Fork Kaskaskia River

North Fork Kaskaskia River	
Assessment Unit ID	IL_OKA-01
Length (miles)	10.11
Listed For	**Dissolved oxygen, pH, manganese, iron, fecal coliform,** total phosphorus
Use Support[1]	Aquatic life (N), Fish consumption (F), Public and food processing water supplies (N), Primary contact (N)[2], Secondary contact (X)

[1]F = Fully supporting, N=not supporting, X= not assessed

North Fork Kaskaskia River	
Assessment Unit ID	IL_OKA-02
Length (miles)	15.31
Listed For	**Dissolved oxygen, pH, manganese, iron,** total phosphorus
Use Support[1]	Aquatic life (N), Fish consumption (X), Public and food processing water supplies (N)[2], Primary contact (X), Secondary contact (X)

[1]F=fully supporting, N=not supporting, X=not assessed

[2]Three public water supply intakes were previously located near the Route 51 crossing of the North Fork Kaskaskia River and in the Patoka Old and Patoka New Reservoirs. These were discontinued on July 31, 2006; the new source is Lake Carlyle. The public water supply use is no longer applicable for the North Fork Kaskaskia River.

Potential sources contributing to the impairment listing of waterbodies in the North Fork Kaskaskia River watershed are summarized in Table 2.

Table 2. Sources of Impairment for North Fork Kaskaskia River

Waterbody	Cause of impairments	Potential Sources
North Fork Kaskaskia River (IL-OKA-01)		
	Dissolved Oxygen	Sediment oxygen demand Conditions exacerbated during low flow Runoff of nutrients from lawns and agricultural lands (cropland and livestock), sewage from failing septic systems or straight pipes, two NPDES permitted dischargers[1]
	pH	Four NPDES permitted dischargers[2]; Naturally acidic soils
	Manganese	Naturally elevated concentrations in groundwater; streambank erosion of soils naturally enriched with manganese; release from bottom sediments during anoxic conditions; brine from oil wells
	Iron (dissolved)	Naturally elevated concentrations in groundwater; streambank erosion of soils naturally enriched with iron; release from bottom sediments during anoxic conditions; NPDES permitted discharger[3]
	Fecal Coliform	Wildlife, livestock, failing septic systems, NPDES permitted dischargers
North Fork Kaskaskia River (IL-OKA-02)		
	Dissolved Oxygen	Sediment oxygen demand Conditions exacerbated during low flow Runoff of nutrients from lawns and agricultural lands (cropland and livestock), sewage from failing septic systems or straight pipes[1]
	pH	Naturally acidic soils
	Manganese	Naturally elevated concentrations in groundwater; streambank erosion of soils naturally enriched with manganese; release from bottom sediments during anoxic conditions; brine from oil wells
	Iron (dissolved)	Naturally elevated concentrations in groundwater; streambank erosion of soils naturally enriched with iron; release from bottom sediments during anoxic conditions

[1] Modeling showed that these are not a cause of low dissolved oxygen in the North Fork Kaskaskia River
[2] These facilities are potential sources of pH, based on their current permit limits for pH (6.0 - 9.0 SU). Recent monitoring data showed these facilities are in compliance with their permit limits.
[3] One facility is a potential source of dissolved iron, however, recent monitoring data showed the facility is in compliance with its permit limit and does not contribute to impairment.

TMDLs require targets, numeric endpoints specified to represent the level of acceptable water quality 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 or are not practical for TMDL implementation, surrogate parameters must be selected to represent the designated use. TMDL targets were developed to represent each pollutant addressed in these TMDLs. The target parameters for the TMDLs discussed in this implementation plan are discussed further below and are summarized in Table 3.

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 the North Fork Kaskaskia River (IL_OKA-01 and IL_OKA-02), the TMDL target was based upon the water quality criterion for dissolved oxygen of 5 mg/l. For pH, the target was set to the water quality criterion of 6.5≤pH≤9.0. The manganese target was set to the water quality criterion for total manganese of 1,000 ug/l, while the iron target was set to the water quality criterion for dissolved iron of 1,000 ug/l. For fecal coliform, the TMDL target was set to the water quality criterion of 200 cfu/100ml.

Table 3. TMDL Summary

Pollutant	Target	Reductions needed	Wet or dry weather sources?
Fecal coliform	200 cfu/100ml	56 - 83% reductions needed over full range of flows	Wet and dry weather sources contribute
pH	6.5 – 9.0 SU	N/A[1]	
Manganese	1,000 ug/l	59%-84% reductions needed over full range of flows	Wet and dry weather sources contribute
Dissolved iron	1,000 ug/l	6% reduction in nonpoint source loads needed at lower flows	Primarily dry weather sources
Dissolved oxygen	5.0 mg/l minimum	N/A[2]	

[1] 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.

[2] Modeling showed low dissolved oxygen is caused by low flow, not a pollutant. No reductions needed.

The TMDLs for dissolved oxygen determined that sediment oxygen demand is the dominant source of the oxygen deficit; however, the true cause of low dissolved oxygen is a lack of base flow (which greatly exacerbates the effect of sediment oxygen demand). TMDLs cannot be written to control flow. Some of the implementation options in this implementation plan will improve baseflow and/or reduce water temperatures, both of which will help improve dissolved oxygen during low flows.

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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 to define the load-response relationship and define the maximum allowable pollutant load that the river 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 an 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, 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.

The first three steps described above have been completed, as documented in the TMDL report for the North Fork Kaskaskia River watershed (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.

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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. Discussions with local NRCS and SWCD staff during the early stages of TMDL development identified a number of ongoing control efforts within the watershed, as summarized briefly below.

According to the Marion, Fayette and Clinton County NRCS District Conservationists, primary crops in the watershed are soybeans (40-45%), corn (40%) and wheat (10-15%). Between 45% and 60% of the soybeans are no-till, with the rest tilled using mulch tillage methods, which leave about 20-30% residue. Most of the corn is conventional till in Marion County, with about 10% of the residue left on the fields. In Clinton County, many farmers practice no till and strip till farming, with little conventional farming being done. Residues are over 30% at a minimum (personal communication, Clinton SWCD Resource Conservationist). The primary tillage practice for wheat is mulch till (20-30% residue) and no-till.

There is a fairly large amount of land in the North Fork Kaskaskia River watershed in the Conservation Reserve Program (CRP). In Marion County, there are approximately 35,000 acres (personal communication, Marion County NRCS), with over 1,000 acres of land in the CRP in Clinton County (personal communication, Clinton County NRCS). In both counties, much of the bottomland is in the CRP or has been converted to filter strips due to the marginal value of this land for farming. According to the Fayette County SWCD and NRCS Conservationists, there are over 30,000 acres in the CRP in Fayette County and also a lot of participation in other programs such as implementing filter strips (typical filter strip width is 70 feet), soil testing to prevent the over-application of fertilizers, grade stabilization structures and placement of ponds to capture runoff. In upland areas of Marion County, filter strips along waterways are common (personal communication, Marion County NRCS). The strips are between 66 and 120 feet wide (personal communication, Marion County SWCD). Nutrient management programs are also becoming more prevalent in Marion County (estimated 20% of farmers have plans in the watershed), due to the 303(d) listing of several waterbodies in the county (personal communication, Marion County SWCD).

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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 TMDL, 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 TMDL, 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 and iron TMDLs, the primary sources are natural sources, including soils and groundwater. Manganese reductions are needed over the full range of flows, however iron reductions are only needed during low flow conditions. Soils naturally enriched in manganese and iron can settle in the river and contribute to manganese and iron exceedances during low flow, anoxic conditions, as the metals are released into the water column. The extent to which this mechanism contributes to the low flow exceedances of manganese and iron is not known; however, controls targeted at reducing wet weather loads of these metals may also reduce sedimentation and subsequent release of the metals during low flow periods. Because it is difficult to control groundwater sources, implementation alternatives were focused on measures to reduce erosion, including:

- Conservation Buffers
- Streambank Enhancement and Protection
- Sediment Control Basins
- Grassed Waterways
- Conservation Tillage
- Wetland Restoration

For fecal coliform in segment IL_OKA-01, 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)[1]. 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).

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, bacteria, 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).

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 lowering stream temperature.

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

[1] http://www.economics.nrcs.usda.gov/cost/priceindexes/index.html

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.

STREAMBANK ENHANCEMENT AND PROTECTION

Erosion of the banks and beds of the North Fork Kaskaskia River and its tributary streams is recognized as a significant problem. Streambank erosion likely contributes to the manganese and iron impairments, and possibly the pH impairment, given the acidic nature of the local soils. In addition, the channel degradation contributes to the low dissolved oxygen (IDOA, 2005). Streambank stabilization (including grade stabilization to reduce erosive velocities and shear stresses) is a key measure in reducing erosion and the associated impairments.

A recent aerial assessment report concluded that the North Fork Kaskaskia River is impacted by degradation (IDOA, 2005). This study recommends rock riffle grade control to stabilize the streambed, increase turbulence to improve dissolved oxygen concentrations, and reduce erosion. The report estimates that the cost for installing rock riffles along 20.4 miles of the North Fork Kaskaskia River would be $2,413,500. In addition to the rock riffles, the IDOA study recommends lateral bank treatment, which could cost up to an additional $2,417,500. However, rock riffle installation is recommended as the higher priority and will likely diminish the need for lateral bank treatment (IDOA, 2005).

Because of the high potential cost of stabilizing streambanks throughout the watershed, additional study is recommended to prioritize sites for streambank stabilization. Such study should include direct observation of bank conditions, as well as an assessment of stream hydraulics and geomorphology to support identification and design of effective stabilization measures.

SEDIMENT CONTROL BASINS

Sediment control basins trap sediments (and constituents bound to that sediment) before they reach surface waters (EPA, 2003). Because the pH, manganese, and iron impairments have been attributed to natural contributions from local soils, sediment control basins could help reduce loadings of these sources. 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.

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).

CONSERVATION TILLAGE

The objective of conservation tillage is to provide profitable crop production while minimizing soil erosion (UIUC, 2005). 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, 2006) suggests that 84% of land under soybean production in Marion County is farmed using reduced till, mulch till, or no-till, while 59% of the land in small grain production and 71% of corn fields are farmed with conventional methods. In Fayette County, 79% of land under soybean production and all of the land in small grain production is farmed using reduced till, mulch till, or no-till, while 80% of corn fields are farmed with conventional methods. In Clinton County, 71% of soybean fields and 85% of small grain fields are farmed using reduced- mulch- or no-till methods, while 67% of corn fields are farmed conventionally. Additional conservation tillage measures should be considered as part of this implementation plan, particularly for cornfields.

Conservation tillage practices have been reported to reduce sediment loads by 75%. 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).

WETLAND RESTORATION

Wetland restoration is defined as rehabilitation of a drained or degraded wetland to its natural condition, to the extent practicable (NRCS, 1998). Wetlands can be an effective BMP for reducing loading of sediments, bacteria, and oxygen-demanding substances (Commonwealth of Virginia, 2003). Currently there are approximately 14,000 acres of hydric soils in the North Fork Kaskaskia watershed that are not developed, forested or wetland. (Note that this number only considers lands in Marion and Clinton Counties; data for Fayette County are not available.) These are potential areas where wetlands could be restored. This is discussed in more detail later in this Implementation Plan. If hydric soils are present, the work required to implement a restoration project may involve simply disabling or removing drain tiles and blocking drain ditches to restore the natural hydrology. In other cases, it may require more engineering effort and replanting wetland vegetation (TWI, undated). 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 size of the wetland, the work needed for restoration, and land costs. However, a general unit cost of $500 to $1200 per acre has been suggested (FWS, 2006) for restoration projects in Illinois.

PRIVATE SEPTIC SYSTEM INSPECTION AND MAINTENANCE PROGRAM

Most of the North Fork Kaskaskia River watershed is served by septic systems, with the exception of the village of Patoka. Calls to local health department personnel indicated that many septic systems may be failing (the Fayette County Health Department estimated as many as 25% could be failing), and there may also be some straight pipe connections within the watershed (LTI, 2004). These could be significant sources of fecal coliform to the North Fork Kaskaskia River. The local health departments indicated that inspection programs are reactive, occurring primarily in response to complaints. 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; however, the local health departments currently do not have sufficient staff nor funding to take on new inspection duties. 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 to administer the program and conduct inspections; cost depends on the level of staffing needed. Illinois EPA has proposed a draft general permit for Surface Discharging Private Sewage Disposal Systems (http://www.epa.state.il.us/public-notices/2006/general-private-sewage/draft-permit.pdf). The intent of this permit is to ensure that effluent discharge from private sewage disposal systems to waters of the state comply with water quality standards. This will reduce the risk to public health and the environment, which is associated with failing systems. IEPA held public hearings on January 8, 10 and 11, 2007 to receive oral and written comments on the draft general permit.

Costs for annual maintenance agreements have been estimated at $200/year per household (IEPA, 2006a).

RESTRICT LIVESTOCK ACCESS TO LAKE AND TRIBUTARIES

Livestock are a potential source of fecal coliform. In addition, livestock can cause or exacerbate streambank erosion and trample riparian buffers. There are a number of livestock operations in Marion, Fayette, and Clinton Counties, though it is not known how many are in the North Fork Kaskaskia River watershed (LTI, 2004). In Clinton County, livestock operations are located away from the bottomlands (due to the propensity of high water levels to flood these areas) and it is believed that the majority of the cattle are fenced away from streams (LTI, 2004). A winter feed station program has been implemented in the portion of the watershed in Clinton County, which involves setting up a feed station away from streams to allow farmers to collect waste more easily and reduce the impact of the cattle on the streams. However, in Marion County, only about 25% to 33% of cattle are fenced off from local waterbodies (LTI, 2004).

A suggested best management practice could be to restrict livestock access to the North Fork Kaskaskia River and its tributaries. 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 improving 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).

POINT SOURCE CONTROLS

There are four NPDES permitted point source dischargers in the North Fork Kaskaskia River watershed; of these, two are sewage treatment plants (STPs) expected to discharge fecal coliform bacteria: Patoka STP and Patoka Community Unit School (LTI, 2004). Both of these facilities have year-round disinfection exemptions, and are not required to remove fecal coliform from their discharges. As presented in the TMDL, the wasteload allocation for these two facilities is consistent with the instream fecal coliform concentration meeting 200 counts/100 ml at the end of the facilities' disinfection exemption reach. The four point sources and the disinfection exemption reaches for the two STPs are shown in Figure 2. The disinfection exemption reach for the Patoka STP extends 1,845 feet below the discharge and the disinfection exemption reach for the Patoka Community Unit School extends 9,130 feet below the discharge. IEPA is in discussions with USEPA to evaluate the disinfection exemption program.

All four NPDES permitted dischargers in the watershed have permit limits for pH and one, Mobile Pipeline-Patoka Station, also has permit limits for dissolved iron. None of the facilities have permit limits for manganese. 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 4 presents a summary of the four point sources in the North Fork Kaskaskia River watershed and relevant permit information.

Table 4. Point Source Summary

Facility Name (NPDES ID)	Permit limits				Permit Expiration Date
	Fecal coliform	pH	Dissolved iron	Manganese	
Patoka STP (ILG580022)	Year-round disinfection exemption	6.0 – 9.0 SU	N/A	N/A	12/31/2007
Patoka Community Unit School (IL0024376)	Year-round disinfection exemption	6.0 – 9.0 SU	N/A	N/A	6/30/2011
Mobile Pipeline Patoka Station (IL0071218)	N/A	6.0 – 9.0 SU	1,000 ug/l	N/A	1/31/2011
Ameren Energy - Kinmundy Power Plant (IL0075001)	N/A	6.0 – 9.0 SU	N/A	N/A	4/30/2011

N/A – no applicable permit limits

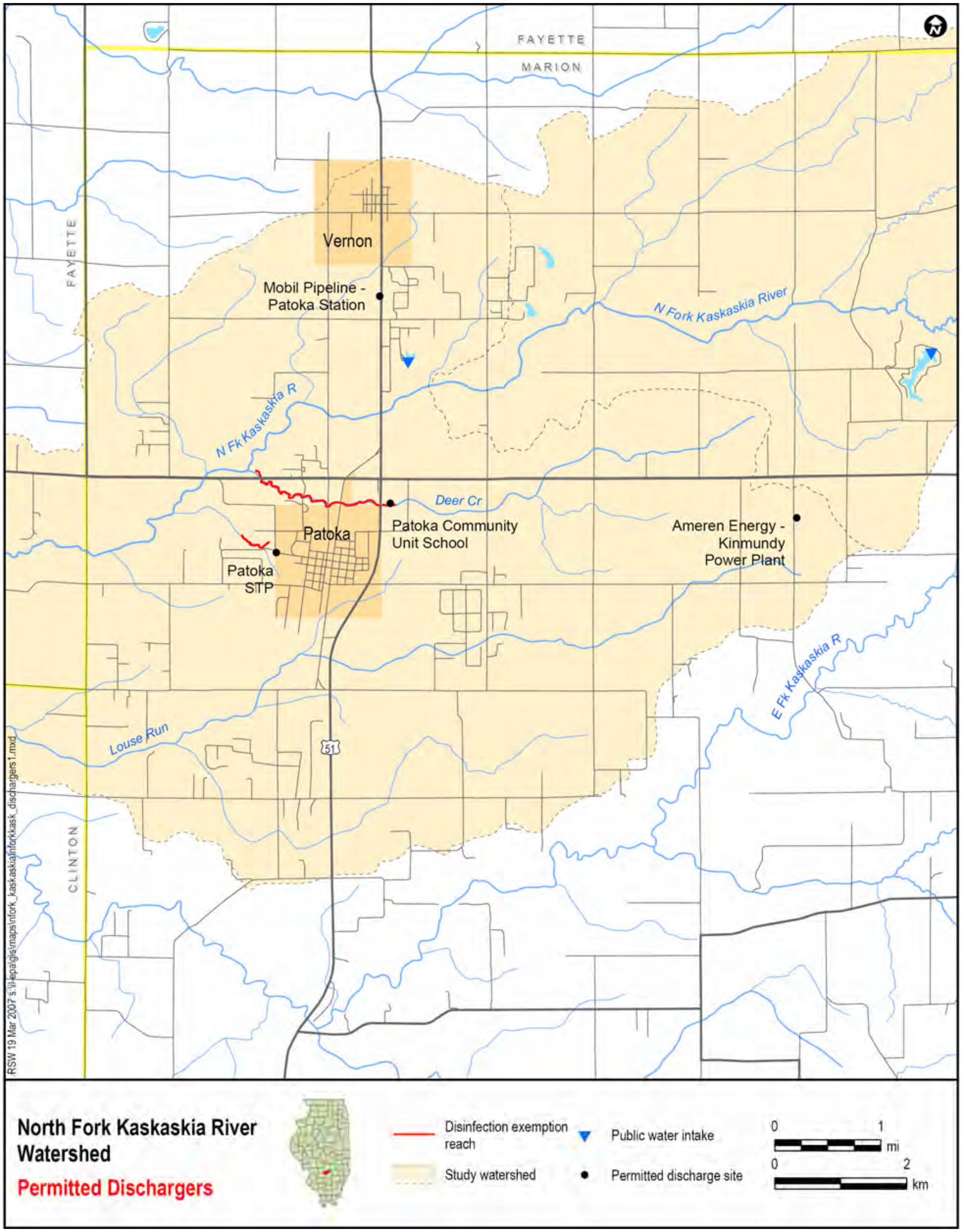

Figure 2. Point Sources and Disinfection Exemption Reaches

SUMMARY OF ALTERNATIVES

Table 5 summarizes the implementation alternatives identified for the North Fork Kaskaskia River watershed. These alternatives should be evaluated by the local stakeholders to identify those most likely to provide the necessary load reductions, based on site-specific conditions in the watershed.

Table 5. Summary of Implementation Alternatives

Alternative	Estimated Cost	Notes
Conservation Buffers	$200 - $360/acre	
Streambank and Shoreline Stabilization	$2,413,500 or higher Other streambank stabilization projects at priority sites, cost varies depending on nature and size of site	Recommended by IL Dept. of Agriculture Additional study required to identify priority sites
Sediment Control Basins	$1,200 to more than $200,000 per basin, depending on size	
Grassed Waterways	$1,800/acre	
Conservation Tillage	$12 to $83/acre	
Wetland Restoration	$500 to $1200/acre estimated	Costs may be higher, depending on size, work required, and land costs
Private Sewage Disposal System Inspection and Maintenance Program	Variable	Cost would be low if existing staff could accomplish
Restriction of Livestock Access	Fencing: $3,500 to $4,000 per mile Pipeline watering: $0.32 - $2.60 per foot Watering tanks and troughs: $291 - $1,625 each	
Point Source Controls	Cost will vary, depending on facility characteristics	

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IDENTIFYING PRIORITY AREAS FOR CONTROLS

Preliminary identification of priority areas for siting of implementation alternatives was accomplished through a review of available information. It should be noted that additional, more detailed evaluation may be necessary to refine the site selection. Furthermore, additional analysis will be required to prioritize implementation activities.

Information reviewed for this preliminary evaluation included: tributary water quality data; an aerial assessment report; and GIS-based data. Based on this review, it is recommended that streambank stabilization be initiated to reduce bank erosion, and that this work occur concurrently with watershed controls in priority areas. Additional evaluation of potential wetland restoration sites is also recommended. Tributary monitoring to better assess current conditions and monitor improvement as controls are implemented is recommended as well.

TRIBUTARY MONITORING

Available water quality data obtained as part of the Stage 1 Watershed Characterization work were reviewed and no recent tributary monitoring data were identified. Since completion of the Stage 1 work, some additional sampling of the North Fork Kaskaskia River and one tributary, Louse Run, has been completed. Through this sampling it was observed that iron and manganese concentrations exceed water quality standards in both segments IL_OKA-01 and IL_OKA-02, with the lowest concentrations observed downstream. One violation of the manganese standard was also observed in Louse Run. pH measurements along the length of the river and in Louse Run were all within the 6.5 – 9.0 SU range. Additional tributary monitoring data would help target particular areas for implementation efforts. Specific data collection recommendations are provided in the Monitoring and Adaptive Management Section later in this Implementation Plan.

AERIAL ASSESSMENT REPORT

A 2005 report (IDOA, 2005) examined streambank conditions along the North Fork Kaskaskia River. The assessment involved collection of aerial-based digital video of stream channel conditions, for purposes of identifying sites for stream bank or channel stabilization, as a means of reduction erosion and sedimentation problems in the watershed. The report recommended installation of rock riffle grade controls to improve both dissolved oxygen levels and bed stability. Additional, more detailed analysis is required to refine costs and to prioritize stabilization efforts. This analysis should include a hydrologic and hydraulic analysis of the creek, field observation to document erosion problems in more detail, a geomorphic assessment of the creek, and additional review of land use and land ownership.

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% (Figure 3), highly erodible soils, classified within the SSURGO GIS soils as HEL (highly erodible land) (Figure 4), and finally, priority areas for BMPs (Figure 5). (Note that these maps cover only the portions of the watershed in Clinton and Marion Counties; GIS data for

Fayette County were not available.) The priority areas are defined as cropland areas that have both steep slopes and highly erodible soils. Priority areas are logical locations for targeting 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. BMPs that would be applicable for the locations shown in Figure 5 include: conservation buffers, streambank enhancement and protection, sediment control basins, grassed waterways and conservation tillage.

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 (approximately 29%) of the North Fork Kaskaskia River watershed was identified as being potentially suitable for wetland restoration or creation. These areas are shown in Figure 6. (Note that only the portions of the watershed within Clinton and Marion Counties are included; GIS data for Fayette County were not available.)

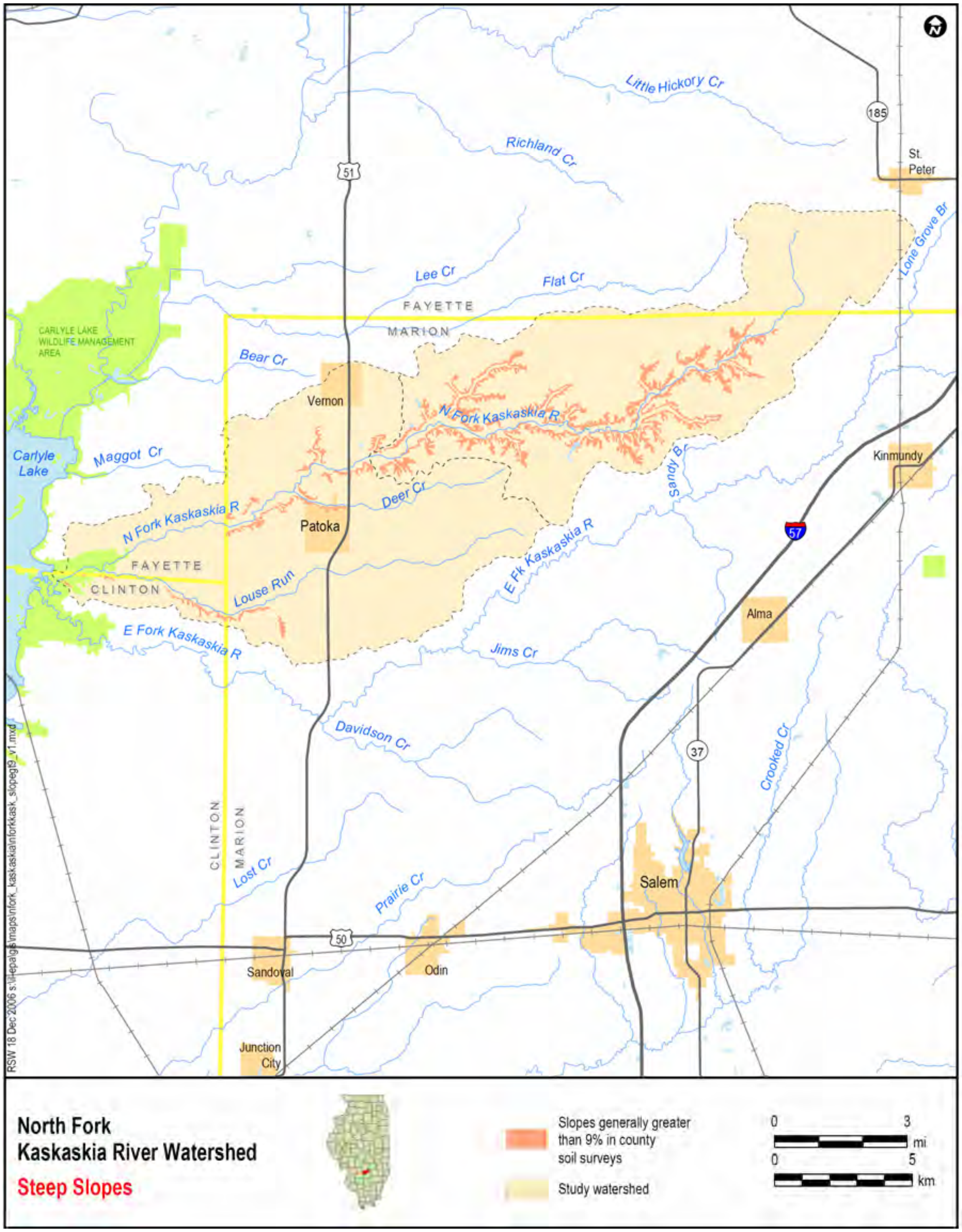

Figure 3. Areas with Steep Slopes

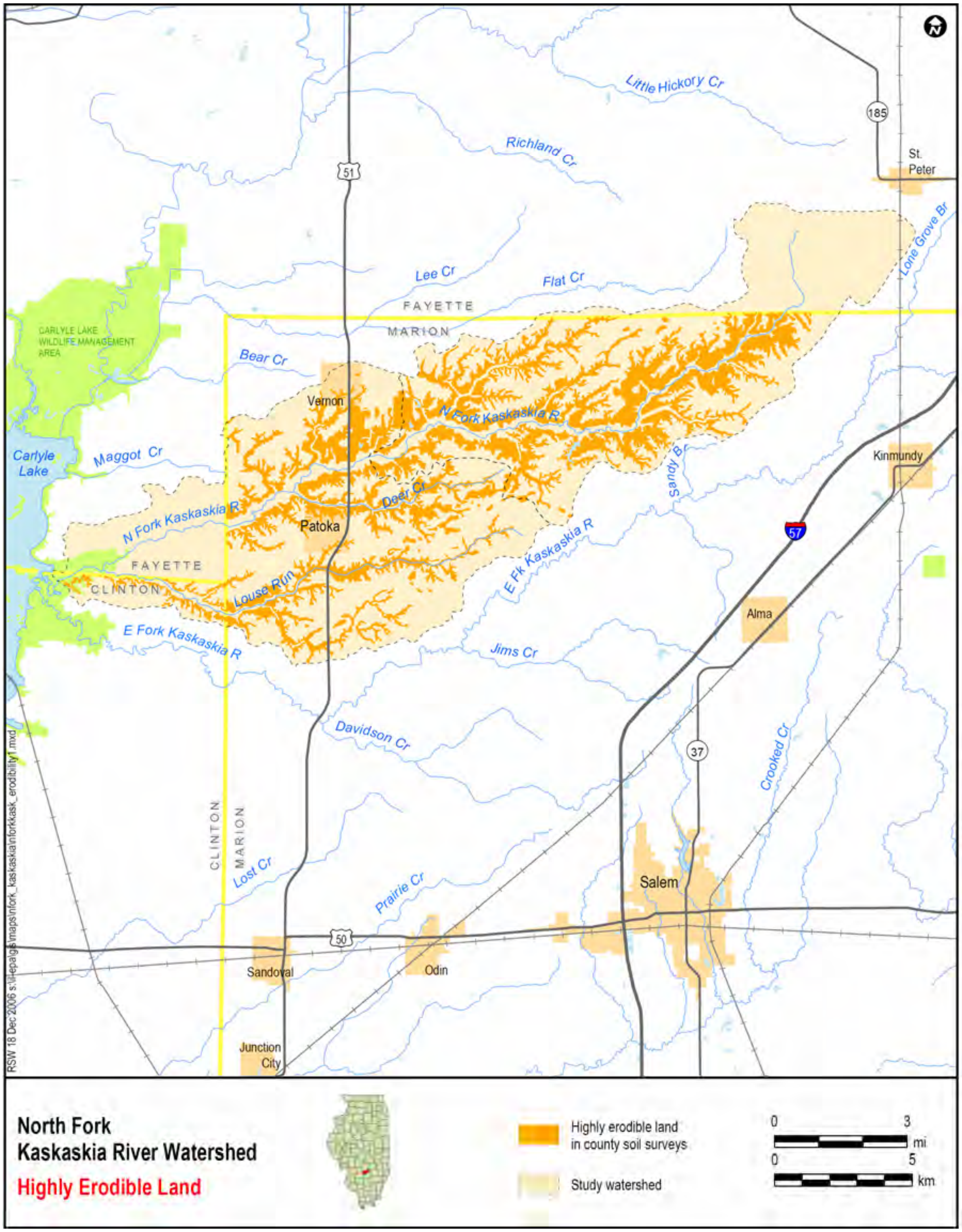

Figure 4. Areas with Highly Erodible Soils

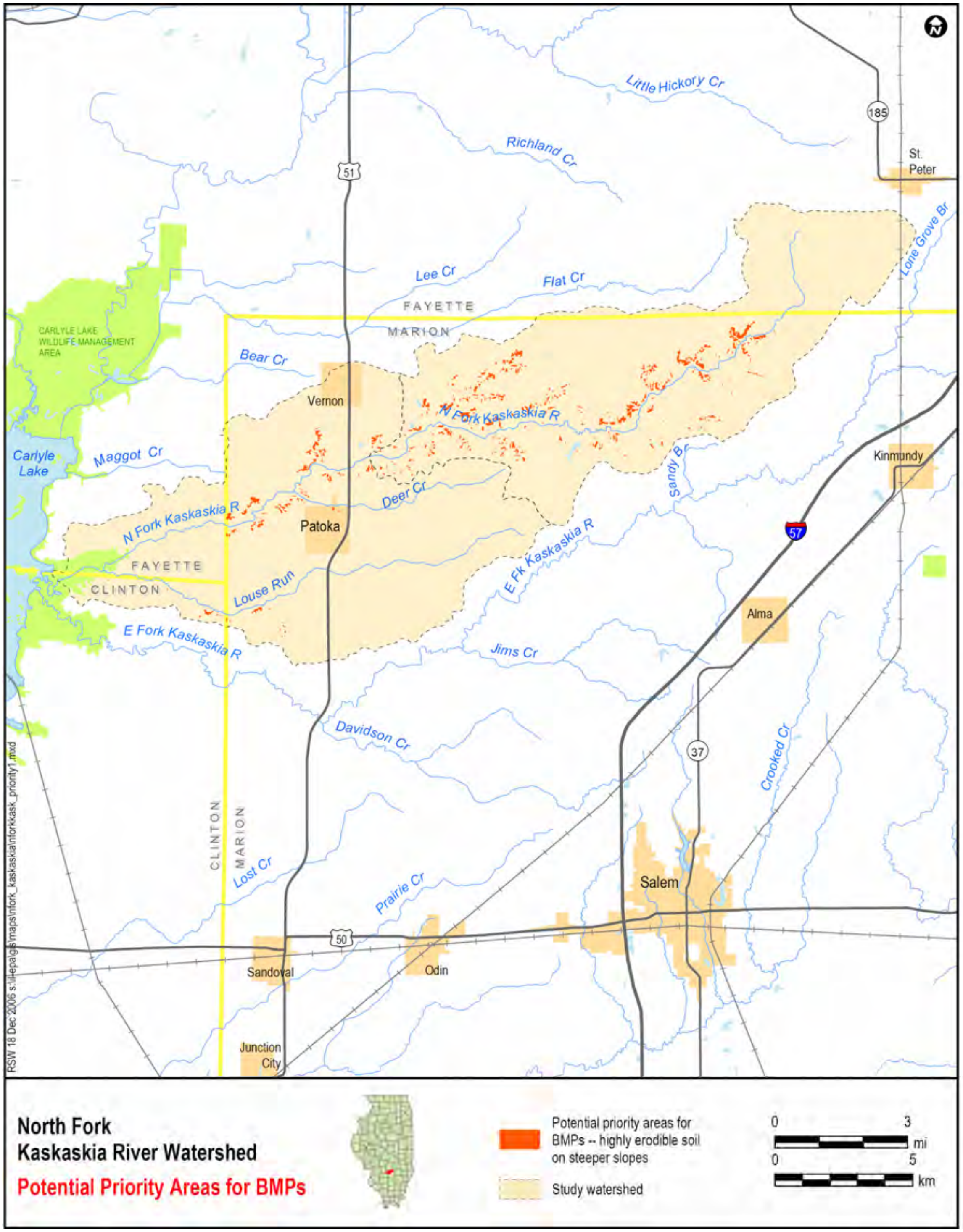

Figure 5. Potential Priority Areas for Best Management Practices

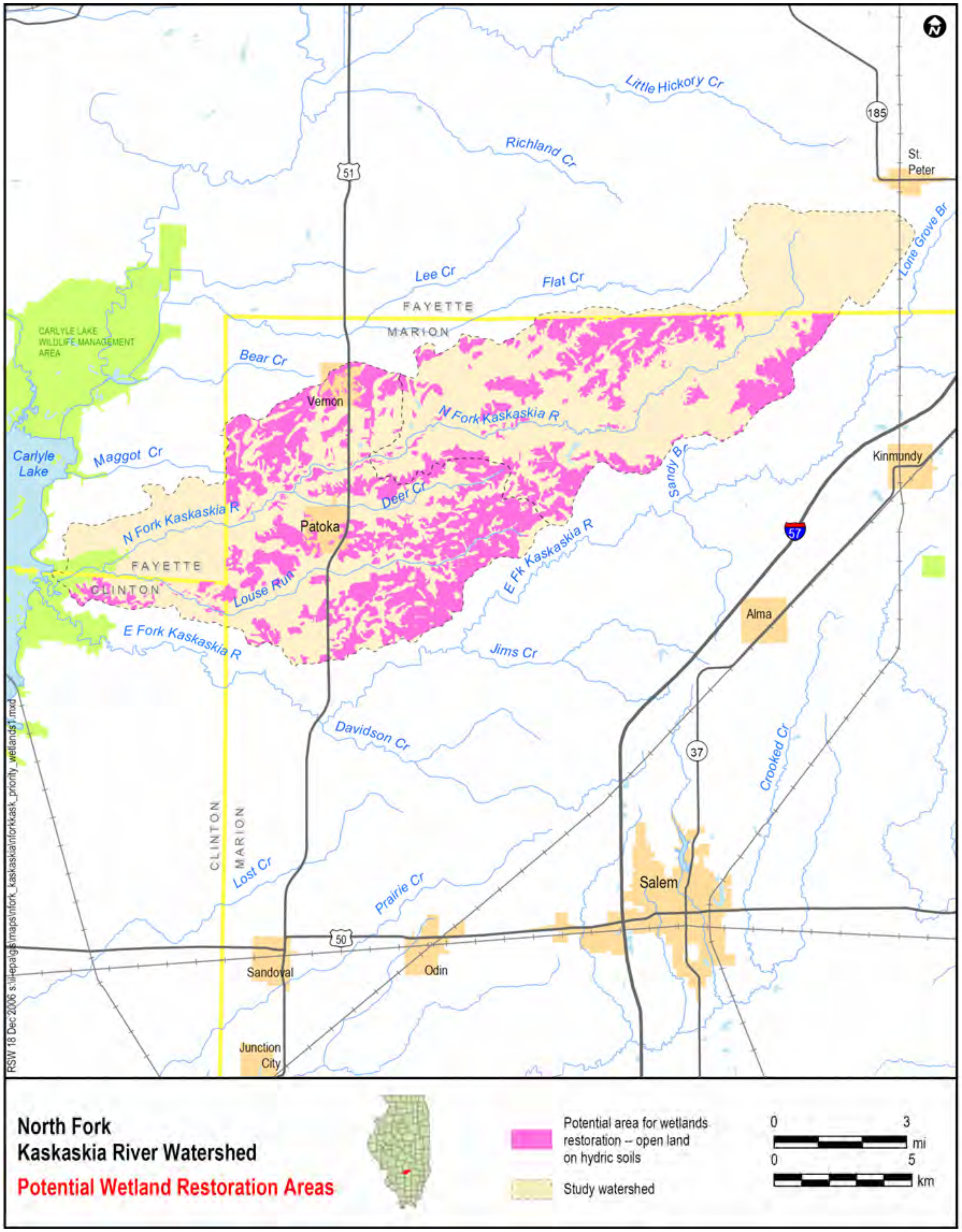

Figure 6. Potential Wetland Restoration Areas

REASONABLE ASSURANCE

The U.S. EPA requires states to provide reasonable assurance that the load reductions identified in the TMDL will be met. In terms of reasonable assurance for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting, and CAFO permitting. Reasonable assurance for point sources means that NPDES permits will be consistent with any applicable wasteload allocation contained in the TMDL. The permit for point source dischargers in the watershed will be revised to ensure it is consistent with the applicable wasteload allocation.

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 non-point 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 Federal 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.

- *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 participants may enroll in 10 and 15-year contracts. 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 (e.g., fencing off livestock from stream access, grassed waterways, nutrient management, riparian buffers, and wetland restoration). 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.

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
- Using the results of future monitoring to conduct adaptive management

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MONITORING AND ADAPTIVE MANAGEMENT

Future monitoring is needed to assess the effectiveness of the various restoration alternatives and conduct adaptive management. The Illinois EPA conducts a variety of lake and stream monitoring programs (IEPA, 2002). Ongoing stream monitoring programs include: a statewide 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. One site on the North Fork Kaskaskia River, Station OKA 01 (Old Patoka Road Bridge) is an AWQMN site. 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 lakes.

These ongoing efforts will provide the basis for assessing 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.

In particular, monitoring for fecal coliform is recommended at several sites, to better understand where loads are being generated in the watershed. Manganese, dissolved iron and pH monitoring at several mainstem locations would help assess water quality improvement as BMPs are implemented. This monitoring should be conducted during both wet and dry weather and is described in more detail below.

Preliminary recommended monitoring activities in the North Fork Kaskaskia River watershed include:

- Fecal coliform monitoring in the North Fork Kaskaskia River and major tributaries. This monitoring should be conducted primarily during wet weather. 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 Deer Creek and Louse Run, as well as several locations along the mainstem of the North Fork Kaskaskia River
- Dry weather fecal coliform monitoring is also recommended upstream and downstream of the Patoka STP and Patoka Community Unit School outfalls. The downstream monitoring should be conducted at the downstream end of the disinfection exemption reach (see Figure 2 for disinfection exemption reaches). This monitoring will help assess the contributions of these sources to the fecal coliform impairment.
- Wet and dry weather monitoring of manganese, pH and dissolved iron at several locations along the mainstem of the North Fork Kaskaskia River to assess water quality improvement as BMPs are implemented. Suggested locations include: North Fork Kaskaskia River at Griffin Road, North Fork Kaskaskia River at Co. Rd. 100 N. The North Fork Kaskaskia River at US 51 (station OKA 01) should be monitored by IEPA as part of their ongoing AWQM program.

- Periodic low flow dissolved oxygen and water temperature monitoring of both segments of the North Fork Kaskaskia River is also recommended, to provide feedback on the effect that improvement projects have on instream dissolved oxygen.

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