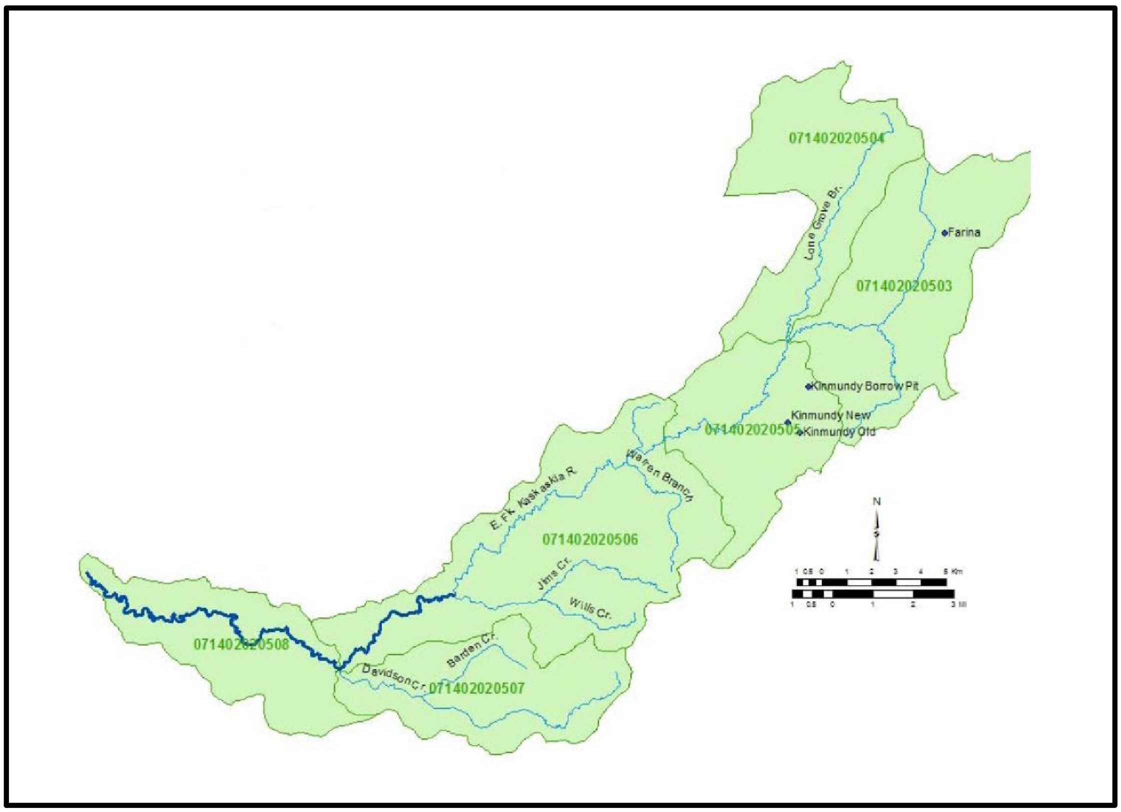
Illinois
Environmental
Protection Agency

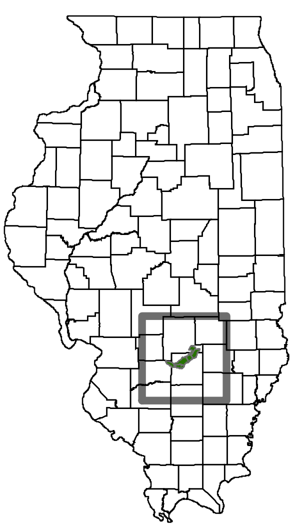
Bureau of Water
P.O. Box 19276
Springfield, IL 62794-9276

August 2007

IEPA/BOW/07-011

EAST FORK KASKASKIA WATERSHED TMDL REPORT





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EAST FORK KASKASKIA RIVER TMDLS
(IL_OK-01 and IL_OK-02)

Prepared Under Contract to

Illinois Environmental Protection Agency

and

Approved by US EPA

Prepared By

Baetis Environmental Services, Inc.

Chicago, Illinois

In Support Of

Limno-Tech, Inc.

Ann Arbor, Michigan

August 2007

Contents

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

REPLY TO THE ATTENTION OF:
WW-16J

SEP 28 2005

Marcia T. Willhite, Chief
Bureau of Water
Illinois Environmental Protection Agency
1021 North Grand Ave. East
P.O. Box 19276
Springfield, IL 62794-9276

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Load (TMDL) for the impaired segments in the East Fork Kaskaskia River watershed (SOB, ROZY, SOG, and SOF) including supporting documentation and follow up information. IEPA's submitted TMDLs address the presence of elevated levels of manganese that impairs the Public Water Supply Use in Farina Lake, Kinmundy Lake, Kinmundy Borrow Pit, and Kinmundy Lake New (segments SOB, ROZY, SOG, and SOF) in the East Fork Kaskaskia River watershed. Based on this review, U.S. EPA has determined that Illinois's TMDLs for manganese meet the requirements of Section 303(d) of the Clean Water Act and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves Illinois's 4 TMDLs for the impaired segments in the East Fork Kaskaskia River watershed (SOB, ROZY, SOG, and SOF). The statutory and regulatory requirements, and U.S. EPA's review of Illinois's compliance with each requirement, are described in the enclosed decision document.

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

Sincerely yours,

Jo Lynn Traub
Director, Water Division

RECEIVED
OCT 18 2005
BUREAU OF WATER
BUREAU CHIEF'S OFF

Enclosure

cc: Bruce Yurdin, IEPA

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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SEP 14 2006

REPLY TO THE ATTENTION OF

WW-16J

Marcia T. Willhite, Chief
Bureau of Water
Illinois Environmental Protection Agency
1021 North Grand Ave. East
P.O. Box 19276
Springfield, IL 62794-9276

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Load (TMDL) for the East Fork Kaskaskia River watershed including supporting documentation and follow up information. IEPA's submitted TMDL report addresses the presence of elevated levels of fecal coliform impairing the primary contact use in the East Fork Kaskaskia River (Segment IL_OK-01). Based on this review, U.S. EPA has determined that Illinois's TMDL for fecal coliform meets the requirements of Section 303(d) of the Clean Water Act and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves Illinois's one TMDL for the East Fork Kaskaskia River watershed (Segment IL_OK-01). The statutory and regulatory requirements, and U.S. EPA's review of Illinois's compliance with each requirement, are described in the enclosed decision document.

In addition, as discussed in the first element of the enclosed decision document, IEPA determined that the dissolved oxygen (DO) impairments in the East Fork Kaskaskia River watershed are a result of flow-related conditions rather than a specific pollutant cause. Therefore, since TMDLs are required only for pollutants, and flow is not a pollutant, no TMDL for DO is required for the East Fork Kaskaskia River watershed (Segments IL_OK-01 and IL_OK-02) under the Clean Water Act or EPA regulations.

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

Sincerely yours,

for Jo Lynn Traub,
Director, Water Division

Enclosure

cc: Bruce Yurdin, IEPA
Trevor Sample, IEPA

Illinois
Environmental
Protection Agency

Stage One Report
TMDLs and Implementation Plans for Target Watersheds

Project Watershed HUC 0714020205 (East Fork Kaskaskia River)

Prepared by

Baetis
ENVIRONMENTAL SERVICES, INC.
Chicago, Illinois

On behalf of Limno-Tech, Inc., Ann Arbor, Michigan
April 2005

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Acronyms

ALMP	Ambient Lake Monitoring Program
AWQMN	Ambient Water Quality Monitoring Network
CFR	Code of Federal Regulations
CLA	Carlyle Lake Association
Cu	Copper
DO	Dissolved oxygen
EPA	Environmental Protection Agency
IAC	Illinois Administrative Code
IEPA	Illinois Environmental Protection Agency
KWA	Kaskaskia Watershed Association
Mn	Manganese
OK01	Impaired segment of the East Fork Kaskaskia River
P	Phosphorus
ROZY	Kinmundy Lake Old
SOB	Farina Lake
SOG	Kinmundy Borrow Pit
SOF	Kinmundy Lake New
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

EXECUTIVE SUMMARY

This progress report documents initial work towards the development of a Total Maximum Daily Load (TMDL) for the East Fork Kaskaskia watershed (HUC 0714020205). The objective of this report is to update Stage 1 work supporting TMDL development in the project watershed. The effort completed to date includes:

- Data and information compilation to complete a detailed watershed characterization
- Creation of a water quality database
- Analysis of the available data 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
- Review of and recommendation for approaches to developing the TMDL
- A plan for collection of additional field data
- Public participation in the process, including a public meeting reviewing Stage 1 findings

Data collection, or Stage 2, if authorized by the Illinois EPA, will precede TMDL development and implementation planning (Stage 3).

Confirmation of Impairments

TMDLs are warranted for the five impaired waterbodies in the East Fork Kaskaskia River watershed. One stream segment of the East Fork Kaskaskia River, OK 01, should have dissolved oxygen and fecal coliform bacteria TMDLs developed. Four impaired water supply lakes, Farina (SOB), Old Kinmundy (ROZY), New Kinmundy (SOF), and Kinmundy Borrow Pit (SOG) should have manganese TMDLs developed.

Recommendations for TMDL Development

Watershed and receiving water models were reviewed for suitability for TMDL development. To analyze the effects on the receiving stream, we recommend that a QUAL2K model be built and calibrated for the East Fork Kaskaskia River. This model will be used to assess the dissolved oxygen deficits in the waterbody and to develop the DO TMDL. Additional field data are required to develop the model.

The fecal coliform bacteria impairment of OK 01 presents an opportunity to apply a simple load/wasteload reduction as an alternative to, or perhaps in combination with, mathematical modeling and some additional field data collection. A reduction of bacteria loads, as a percent of current conditions, can be allocated from available data through a load duration analysis.

The manganese-caused use impairments of the four water supply lakes are similar to each other. The approach to these four TMDLs for Stage 3 will focus on use of field measurements to estimate Mn loads and load reductions. This approach recognizes the dependence of manganese concentrations on seasonal lake hypoxia and eutrophication.

Recommendations for Field Data Collection

Limited additional data is recommended for collection in order to develop a QUAL2K model of the East Fork Kaskaskia River:

- Stream channel geometry and hydraulic information

- BOD and SOD estimates
- Pollutant concentration data at selected locations in the target watershed

Along with DO, BOD and temperature data for the QUAL2K model, we have included plans for collection of additional fecal coliform bacteria data for the watershed. Bacteria data are not necessary for development of the TMDL, but, additional coliform data will provide for increased certainty regarding source loads and wasteloads.

Existing, available data will be used to develop manganese TMDLs for the four water supply lakes. Stage 3 for these TMDLs can proceed upon approval of Stage 1. Data on lake morphometry and water supply operations will also need to be obtained from the municipalities. A review of available data on manganese concentrations in shallow groundwater is also recommended.

INTRODUCTION

TMDL Process

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to develop Total Maximum Daily Loads (TMDLs) for 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. 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).

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, chemical, and/or physical monitoring data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for these waters.

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized by the Illinois EPA on a watershed basis. 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 2004 303(d) list (IEPA, 2004). These waterbodies are located within the same ten-digit hydrologic unit, or watershed, consistent with the draft 2004 303(s) list. HUC 0714020205, which includes the East and North Fork Kaskaskia River targeted watersheds, was divided for this work, with this report addressing only the East Fork Kaskaskia River watershed. The East Fork Kaskaskia River includes six subwatersheds: 071402020503, 071402020504, 071402020505, 071402020506, 071402020507, and 071402020508.

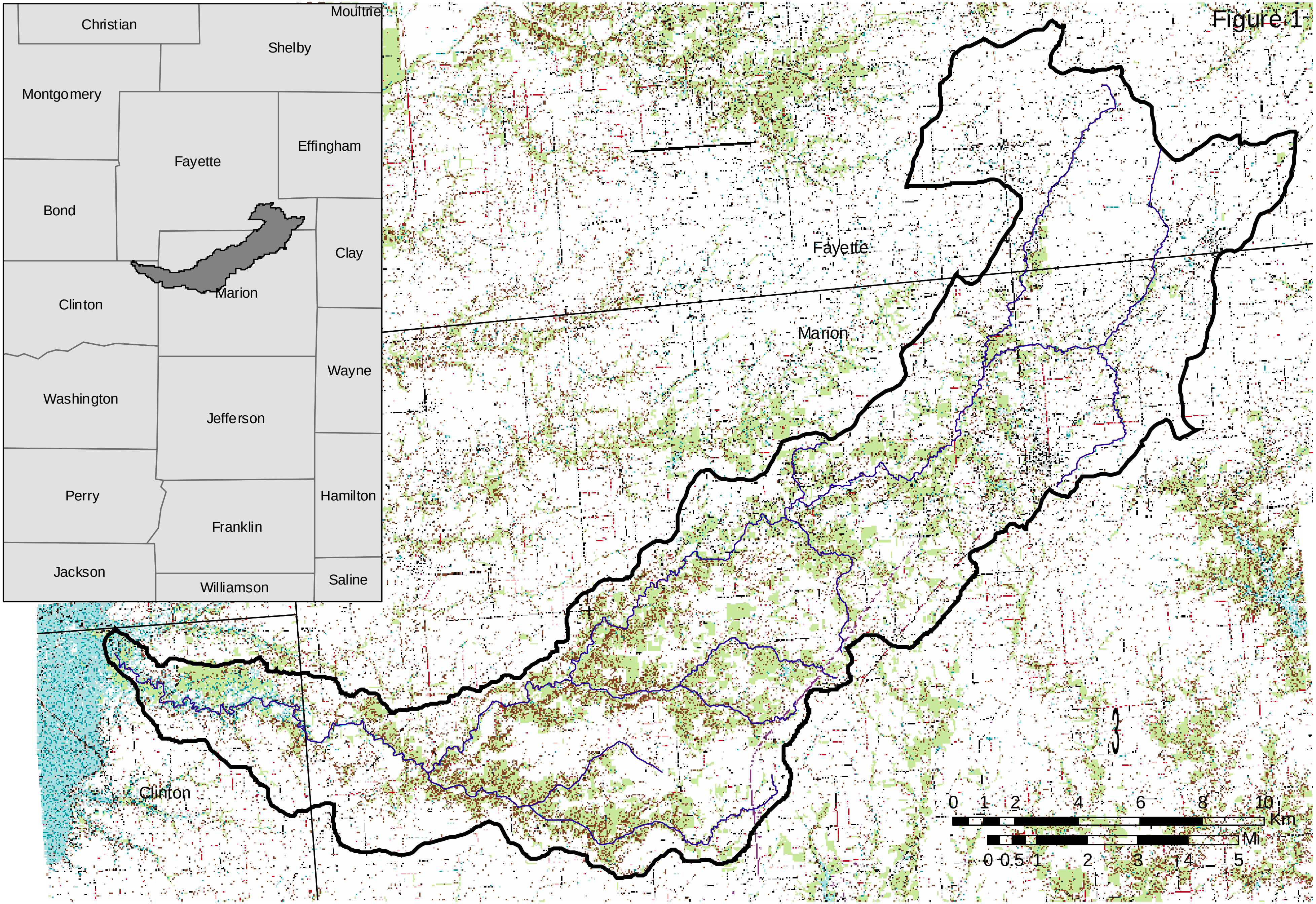
Figure 1 is a location map for the targeted watershed. Figure 2 shows the locations of the impaired waterbodies.

Table 1. Impaired waterbodies in the project watershed, 0714020205 (Source: IEPA, 2004)

Watershed	Waterbody Segment	Waterbody Name	Size	Year Listed	Listed for
0714020205	OK01	East Fork Kaskaskia River	17.13 mi	1998	Dissolved oxygen, total fecal coliform bacteria, total phosphorus (statistical guideline)
	SOB	Farina Lake	4 ac	2002	Manganese, copper, total phosphorus (numeric standard)
	SOG	Kinmundy Borrow Pit	5 ac	2004	Manganese
	SOF	Kinmundy Lake New	107 ac	2004	Manganese
	ROZY	Kinmundy Lake Old	20 ac	2004	Manganese

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).

Stream segment OK 01 has a TMDL approved for siltation (Harza, 2003).

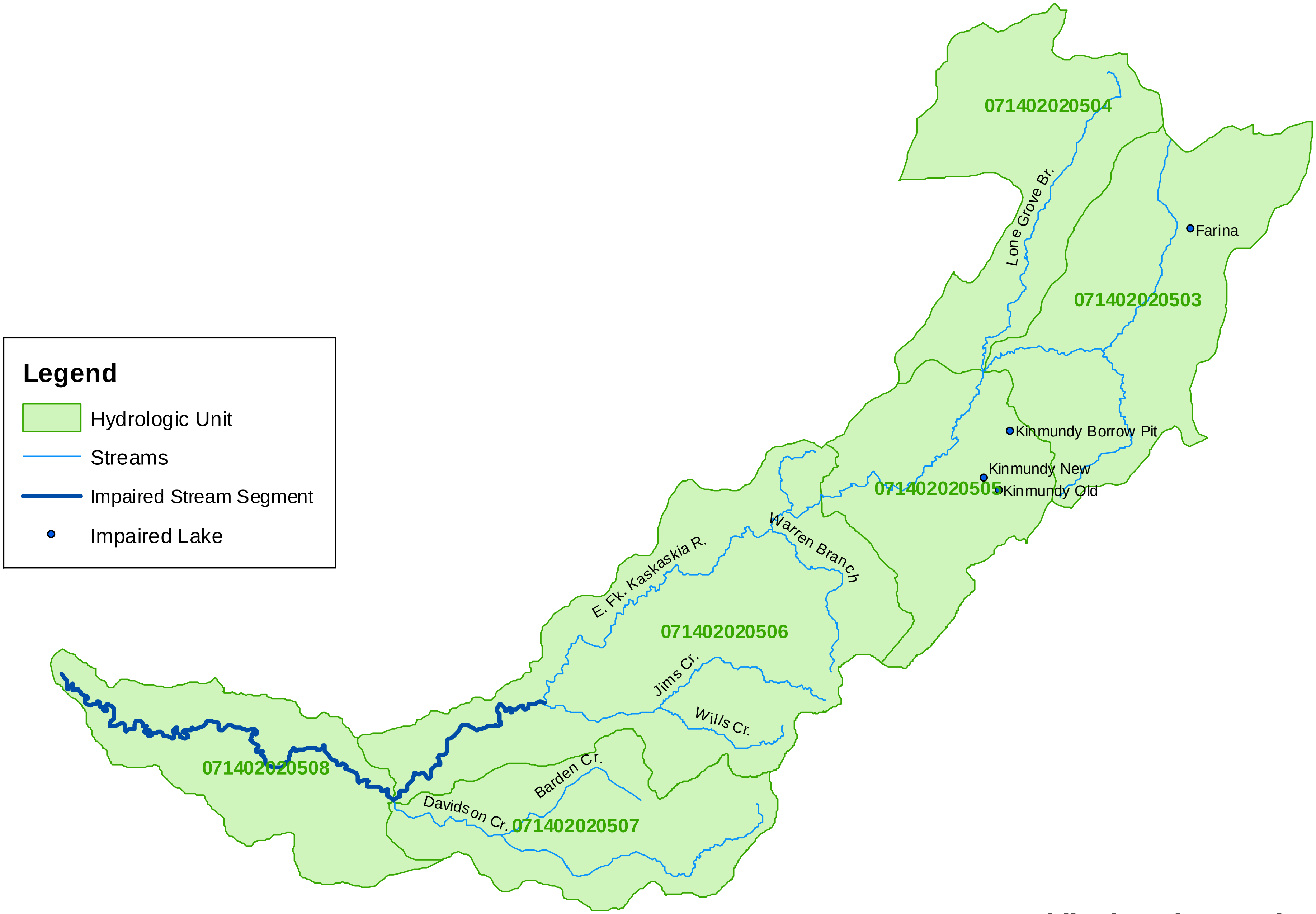


Location Map
East Fork Kaskaskia River Watershed

Data Sources:
1. ESRI Data and Maps, 2002
2. USGS topographic maps (http://www.isgs.uiuc.edu/nsdihome/isgsindex.html)
3. USDA 12-digit watershed boundary dataset (http://ftw.nrcs.usda.gov/huc_data.html)

Baetis

Figure 2



303(d)-Listed Waterbodies
East Fork Kaskaskia River Watershed

Baetis

Sources:
1. USDA 12-digit watershed boundary dataset (http://www.ftw.nrcs.usda.gov/huc_data.html)
2. Illinois EPA Bureau of Water GIS files

WATERSHED CHARACTERIZATION

Methods

The watershed was characterized 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, local agencies were contacted to obtain information on crops, pesticide and fertilizer application practices, tillage practices and best management practices employed. Additionally, site visits were conducted on June 17 and 18, 2004 and meetings were held with the Marion County SWCD, Natural Resource Conservation Service, City of Kinmundy, and Village of Farina. Site visits and additional meetings with local water supply operators were held March 17 and 18, 2005. Appendix A lists the information obtained and the consultations with local or state officials.

Once the watershed boundaries for the impaired waterbodies in the project watershed were delineated from topographic and stream network (hydrography) information, other relevant information was obtained, including land use and cover, cropland, State and Federal lands, soils, point source dischargers, state, county and municipal boundaries, landfills, coal mines, dams, data collection locations, and the location of 303(d) listed lakes and streams.

East Fork Kaskaskia River Watershed Characterization

Land Use and Cover

The watershed is largely used for corn and soybean production, with about 69% of the land overall used for agriculture (Tables 2 and 3).

Figure 3 is a map of current land cover / land use in the project watershed. Figure 3 also shows point source dischargs, impaired waterbody segments, monitoring sites, and other watershed characteristics.

Major roads through the watershed include Interstate 57 and Illinois Route 37, both of which trend northeast-southwest, along the length of the watershed. Through traffic generally utilizes these two routes.

Table 2. East Fork Kaskaskia watershed land use / land cover in year 2000 (Source: Illinois Natural History Survey, Illinois Gap Program)

Class	Hectares	Acres	Percentage
Corn	6338	15,662	19%
Soybeans	10,762	26,593	32%
Winter Wheat / Soybeans	1688	4171	5%
Winter Wheat	700	1729	2%
Other Small Grains and Hay	400	989	1.2%
Other Agriculture	566	1398	2%
Rural Grassland	2257	5576	7%
Barren Land	11	27	0.03%
Upland Dry-Mesic Forest	4342	10,730	13%
Upland Mesic Forest	1763	4357	5%
Upland Savanna / Partial Canopy	458	1131	1.4%
High-Density Urban	173	428	0.5%
Low/Medium Density Urban	456	1126	1.4%
Urban Open Space	149	369	0.4%
Shallow Marsh	347	858	1.0%
Deep Marsh	107	263	0.3%
Seasonally Flooded	176	435	0.5%
Wetland Forest	163	404	0.5%
Wetland Forest	29	72	0.09%
Wetland Forest	2099	5187	6%
Shallow Water	135	334	0.4%
Surface Water	168	416	0.5%
	33,288	82,254	100%

Table 3. Percentage of subwatershed land use / land cover (Source: Illinois Natural History Survey, Illinois Gap Program)

	Subwatershed HUC					
Land Use Class	071402020503	071402020504	071402020505	071402020506	071402020507	071402020508
Rowcrop	77%	80%	44%	39%	55%	50%
Small Grains / Hay	8%	10%	11%	11%	8%	13%
Other Agriculture	1%	1%	2%	2%	1%	2%
Upland Forest	6%	5%	26%	34%	25%	12%
Urban Land	4%	2%	5%	1%	1%	0.5%
Wetland	2%	3%	10%	12%	9%	21%
Other Land	0.4%	0.04%	1%	0.2%	0.2%	2%

Topography and Soils

The watershed is in the Southern Till Plains Natural Division of Illinois. The topography of this Division, including the targeted watershed, is typically gently rolling hills, originally vegetated with post oak flatwood forests and mesic tall-grass prairies.

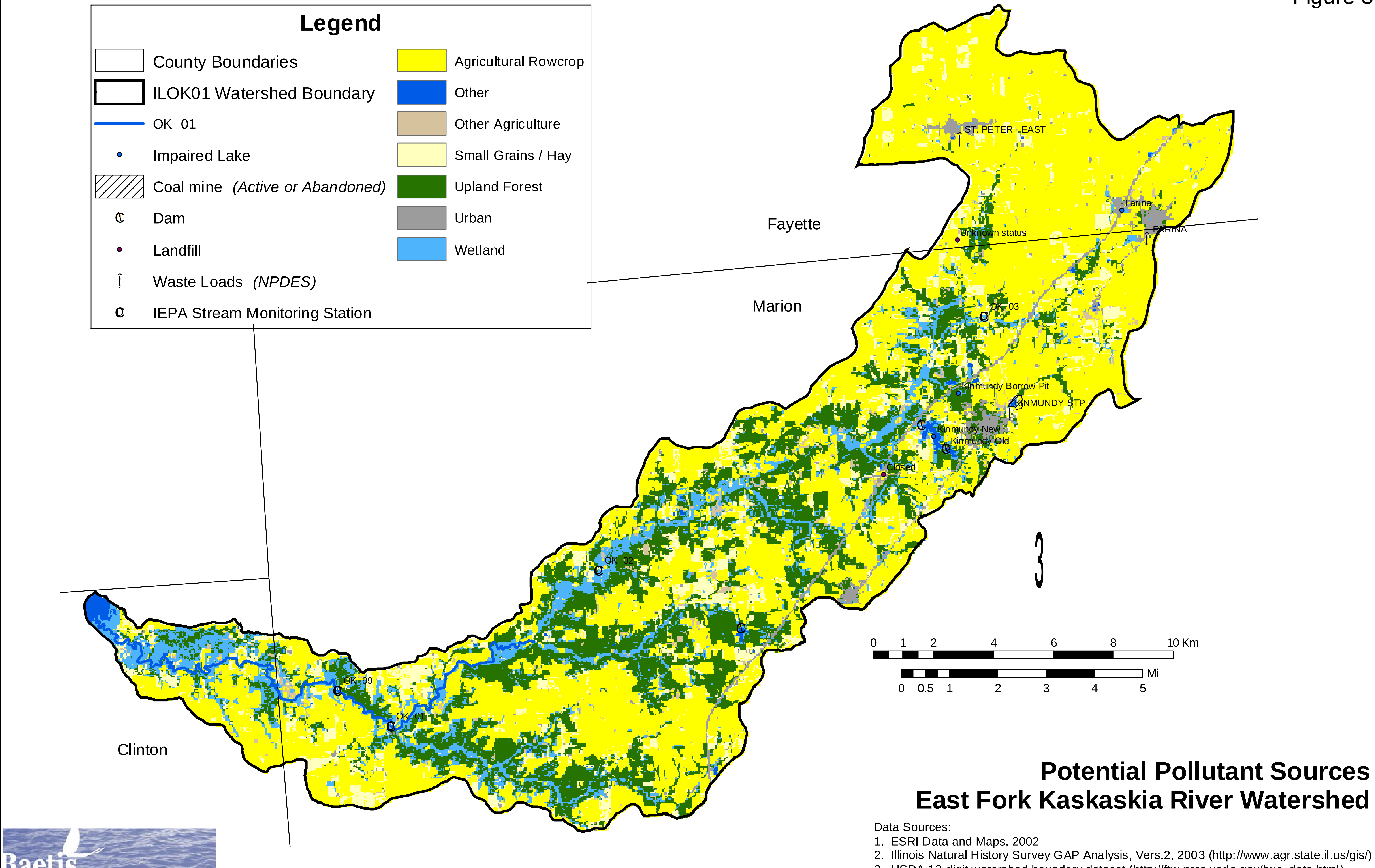
Upland soils tend to be derived from loess, whereas alluvium soils occupy the lowlands (Miles, 1996). The Southern Till Plain is entirely covered by fertile Illinoian glacial till. Figure 4 presents the major soil associations found in the watershed,obtained from the national STATSGO database. Soil associations in the watershed include the Bluford-Ava-Hickory Association (IL038) and the Cisne-Hoyleton-Darmstadt Association (IL006).

Table 4 presents a summary of soil association type and abundance. Each soil type of the association is discussed below.

Table 4. Watershed soils (Source: STATSGO)

Soil Association	Acres	Percentage
Bluford-Ava-Hickory (IL038)	51,850	63%
Cisne-Hoyleton-Darmstadt (IL006)	30,359	37%
Water	46	0.06%
Total	82,254	100%

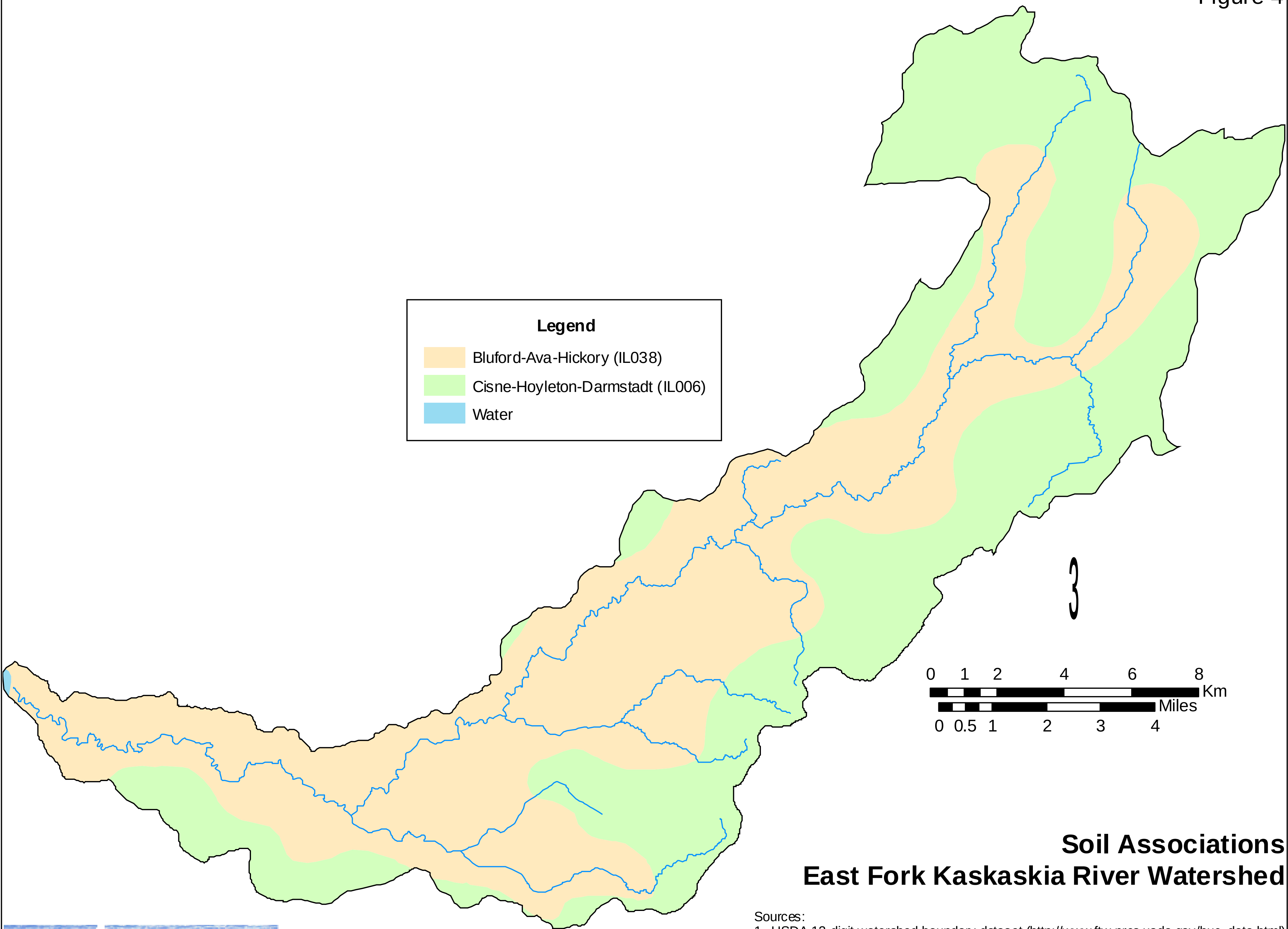
Figure 3



Potential Pollutant Sources
East Fork Kaskaskia River Watershed

Data Sources:
1. ESRI Data and Maps, 2002
2. Illinois Natural History Survey GAP Analysis, Vers.2, 2003 (http://www.agr.state.il.us/gis/)
3. USDA 12-digit watershed boundary dataset (http://ftw.nrcs.usda.gov/huc_data.html)

Figure 4



Soil Associations
East Fork Kaskaskia River Watershed

Sources:
1. USDA 12-digit watershed boundary dataset (http://www.ftw.nrcs.usda.gov/huc_data.html)
2. Illiniois EPA Bureau of Water GIS files
3. STATSGO data (http://www.ncgc.nrcs.usda.gov/branch/ssb/products/statsgo/data/il.html

Miles (1996) describes the Bluford-Ava-Hickory Association as being nearly level to very steep, somewhat poorly drained, very slowly to moderately permeable soils. This association is on side slopes along drainages and on broad ridge tops. It was originally deciduous forests. Slopes vary widely, ranging from one to 45 percent. The Cisne-Hoyleton-Darmstadt Association is not recognized as a distinct soil association by Miles (1996). This association is found in nearly level to gently sloping, poorly drained areas. These are the prairie soils; they are found on broad till plains, with slopes up to 7 percent.

Both of these soil associations are considered by Miles to be well suited or moderately well suited to cultivated crops.

Climate

The climate in the East Fork Kaskaskia River watershed is temperate continental. The Midwest Regional Climate Center (Champaign, Illinois) provided 30 years of historical precipitation data for Station 114756 in Kinmundy, IL. Kinmundy averages 41.23 inches of precipitation each year. The monthly average is 3.44 inches, and ranges from 2.09 inches in February to 4.19 inches in July.

Hydrology

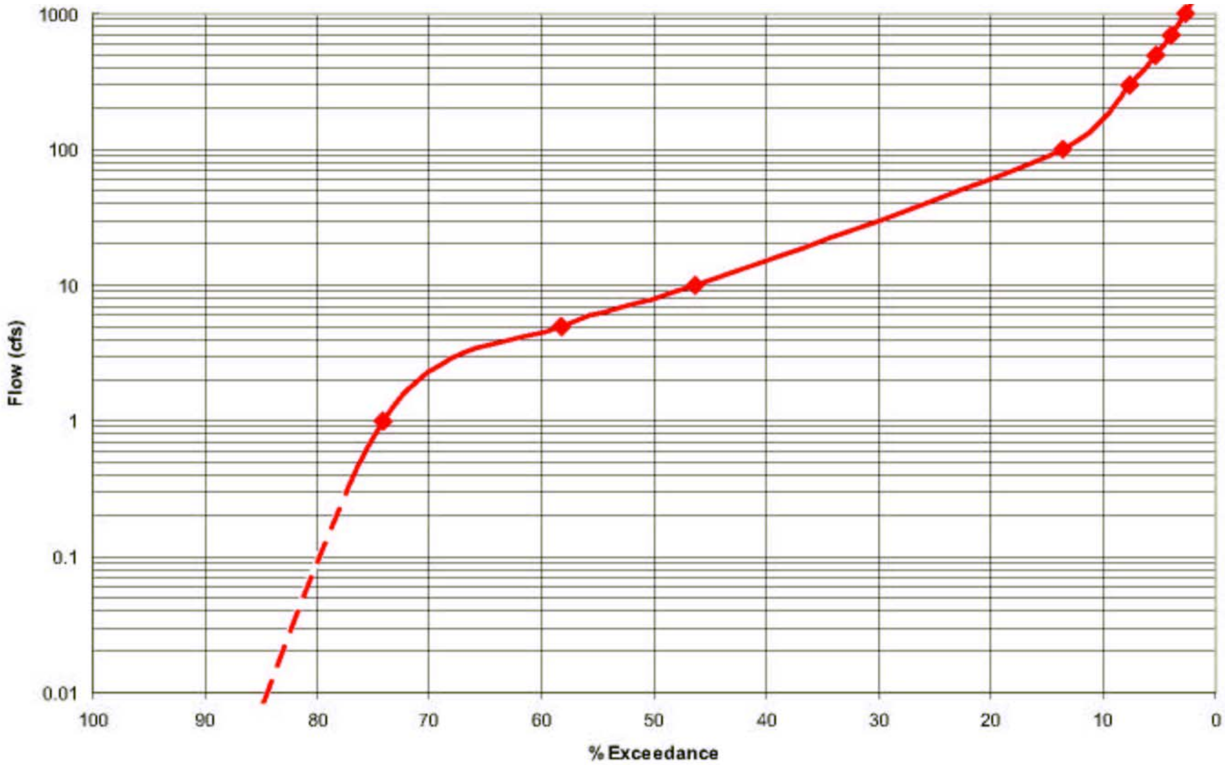
Streamflow data for watershed ILOK01 are available from a gage on the East Fork Kaskaskia River near Sandoval, IL (05592900). The gage is located on the left (south) bank at U.S. Highway 51, at river mile 9.9. The drainage area of this gage is reported by the USGS to be 113 square miles (72,320 acres). There are daily discharge records from October 1979 to date. From these records, Harza Engineering Company calculated return periods for given floods (Table 5).

Table 5. Estimated discharges for select return periods at East Fork Kaskaskia River near Sandoval, IL (Source: Harza, 2003)

Return Period (years)	Discharge (cfs)
1	750
2	2,900
3	3,800
5	4,900
10	6,400

Figure 5 is a flow duration curve, indicating median flows around 8 ft^3/s. According to Singh *et al*. (1988) the 7-day, 10-year low flow is zero for this stream.

Figure 5. Flow Duration Curve, East Fork Kaskaskia River near Sandoval, Illinois
(Source: Harza, 2003)



Urbanization and Growth

Urbanization of the watershed is centered in the towns of Kinmundy, Farina and Alma. The 1999-2000 Illinois Gap Analysis Program indicates that the watershed is about 2% urbanized.

Population statistics and projections are available on a county basis. Most of the targeted watershed is in Marion County. Marion County's population has declined in nearly every census since 1940, when it had 47,989 residents. In 1990, Marion County had a population of 41,561. In the 2000 census, 41,691 were counted by the US Census Bureau. The Illinois State Data Center projects the trend in declining population in Marion County to continue through 2020, when 38,275 residents are predicted (IDCCA, 1997).

Point Source Discharges

Three entities are permitted to discharge treated wastewater to the East Fork Kaskaskia River or its tributaries. These three municipal discharges to the river are publicly-owned sewage treatment lagoons belonging to St. Peter (NPDES permit ILG580007), Kinmundy (ILG580123), and Farina (ILG580047). Figure 3 shows the locations of these discharges.

Each of these three municipal treatment plants has been approved to discharge to the East Fork Kaskaskia year-round without disinfecting the effluent.

The Town of Alma, also in the targeted watershed, is on septic systems. Alma has been issued a NPDES permit for a treatment plant, but construction has yet to begin.

There are no permitted dischargers to the four Mn-impaired water supply lakes.

Watershed Institutions

Local institutions with an interest in watershed management will be important for successful implementation of this TMDL. From interviews with the SWCD and internet searches, we have identified the following institutions that are active in or near the project watershed: Carlyle Lake Ecosytem Partnership and Kaskaskia Watershed Association.

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 a 6-county watershed area, Illinois Department of Natural Resources, and other interested organizations to form the Carlyle Lake Ecosystem Partnership. As indicated on their website, http://dnr.state.il.us/orep/c2000/ecosystem/partnerships/carlyle/carlyle1.htm, their current projects 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. The Southwestern Illinois RC&D recently prepared a watershed action plan that recognizes the need to address water quality impairments (SWIRCD, 2002).

The principal stakeholders for the four Mn-impaired water supply lakes are the towns of Kinmundy and Farina.

DATABASE DEVELOPMENT AND DATA ANALYSIS

Data sources

Existing data describing water quality in the impaired waterbodies were obtained from the USEPA's STORET online database and Illinois EPA files. Tables 6 through 10 summarize these data. Sampling station locations are shown in Figure 3.

Table 6. Water quality database describing OK 01, East Fork Kaskaskia River

Parameter	Records	Mean†	Maximum	Minimum
Dissolved oxygen	2/1999-6/2003 n=38	7.41 mg/L	13.20 mg/L	0.90 mg/L
Fecal coliform bacteria	6/1998-10/2002 n=21	215 CFU/100mL	1880 CFU/100mL	46 CFU/100mL
Suspended solids	6/1998-10/2002 n=21	23.5 mg/L	78 mg/L	6 mg/L

† Arithmetic means are shown, except for fecal coliform bacteria, for which the geometric mean is shown.

Table 7. Water quality database describing SOB, Farina Lake

Parameter	Records	Mean†	Maximum	Minimum
Manganese	4/1999-10/1999 n=5	331 µg/L	620 µg/L	76 µg/L
Copper	4/1999-10/1999 n=5	224 µg/L	550 µg/L	16 µg/L
Total Phosphorus	4/1999-10/1999 n=5	0.517 mg/L	1.290 mg/L	0.07 mg/L

Table 8. Water quality database describing ROZY, Kinmundy Lake Old

Parameter	Records	Mean†	Maximum	Minimum
Manganese	5/2003-8/2003 n=4	772 µg/L	1900 µg/L	90 µg/L

Table 9. Water quality database describing SOG, Kinmundy Borrow Pit

Parameter	Records	Mean†	Maximum	Minimum
Manganese	4/2001-10/2001 n=4	210 µg/L	540 µg/L	58 µg/L

Table 10. Water quality database describing SOF, Kinmundy Lake New

Parameter	Records	Mean†	Maximum	Minimum
Manganese	4/2001-10/2001 n=5	498 µg/L	1000 µg/L	150 µg/L

Methods of Analysis

The water quality data were analyzed to confirm the cause of impairment for each waterbody and, in combination with the watershed characterization data, an assessment was made to confirm the sufficiency of the data to support the listing decision and the sources of impairment that are included on the draft 2004 303(d) list. Analysis methods included computing summary statistics, graphical analysis to discern relationships in the data, and independent replication of the Agency's use support procedure.

CONFIRMATION OF CAUSES AND SOURCES OF IMPAIRMENT

Table 11 lists the impaired waterbodies, the impaired use, causes of impairment, water quality endpoints (or standard), and the number of endpoint exceedances during the period of record.

Stream segment OK 01, the East Fork Kaskaskia River, has an Ambient Water Quality Monitoring Network station (AWQMN) located there, and sampling occurs nine times each year. Methods, detection limits, and a stratified random sampling design provide data of a relatively high quality at AWQMN sites. While not all analyses are completed every year (for example, no fecal coliform bacteria data were collected in 2003 at OK 01) this provides an adequate database to assess use support at an acceptable level of certainty.

Substantially less data is available for assessing use impairment at the four lakes. These lakes and dozens others around the State are sampled through the Ambient Lake Monitoring Program (ALMP) on a five-year cycle. While the methods, detection limits and experimental design are consistent with the AWQMN, very few observations are available for assessing use support. Four samples were collected from SOG during the most recent ALMP survey. And, as shown in Table 11, half of the samples collected and analyzed for Mn exceeded the standard. When such a high proportion of the observations exceed the endpoint, we can be relatively certain that the waterbody cannot be rated as "full support". Table 12 provides some additional summary statistics for the ALMP manganese data. The mean Mn concentrations for the lakes are all above the 150 µg/L water quality standard. Table 12 also illustrates that datasets with so few observations lead to large confidence intervals, and consequently, lowered certainty in the assessments.

A Clean Lakes Phase 1 study is underway for Kinmundy Old, ROZY, which will provide additional data suitable for assessing use support and TMDL development for that waterbody. Further, additional ALMP data were collected at SOB in 2004; these data were not available at the time of this writing, but will be available for use in Stage 3.

Table 11. Water quality impairments and endpoints

Cause of impairment	Impaired Use	Endpoint	Basis of Impairment
Stream segment OK01, East Fork Kaskaskia River			
Dissolved oxygen	Aquatic Life	5 mg/L minimum	9 out of 38 DO measurements < standard
Fecal coliform bacteria	Primary Contact	200 CFU/100mL	Geo mean > 200 and 17% exceed 400 when TSS ≤50th percentile
SOB, Farina Lake			
Manganese	Public Water Supply	150 µg/L	3 out of 5 measurements > standard
Copper	Aquatic Life	13 µg/L[††]	5 out of 5 measurements > standard[*]
Total Phosphorus	Aquatic Life & Secondary Contact	0.05 mg/L	11 out of 11 measurements > standard
ROZY, Kinmundy Lake Old			
Manganese	Public Water Supply	150 µg/L	3 out of 4 measurements > standard
SOG, Kinmundy Borrow Pit			
Manganese	Public Water Supply	150 µg/L	2 out of 4 measurements exceed standard
SOF, Kinmundy Lake New			
Manganese	Public Water Supply	150 µg/L	4 out of 5 measurements exceed standard

†† Chronic water quality standard computed from the average hardness values in SOB

* In addition to these water measurements, one sediment sample contained 610 ppm Cu, exceeding the 590 ppm “highly elevated” sediment quality benchmark

Table 12. Confidence intervals for lake manganese concentrations (µg/L)

Waterbody	95% Confidence Interval
SOB - Farina	331 ± 300
ROZY – Kinmundy Old	723 ± 1307
SOG – Kinmundy Borrow Pit	211 ± 358
SOF – Kinmundy New	498 ± 564

The Illinois EPA 303(d) Water Quality Report (IEPA, 2004) defines potential sources as known or suspected activities, facilities or conditions that may be contributing to impairment of a designated use (Table 13a). We supplemented the Agency's list of potential sources with data reflecting point source discharges in the watershed, non-point pollution sources, our field observations and interviews, and professional judgment (Table 13b).

Table 13a. Waterbody impairment causes and sources (from IEPA, 2004)

Waterbody ID	Cause	Potential Source(s)
OK01 – East Fork Kaskaskia	Dissolved oxygen Fecal coliform bacteria	Agriculture Crop-related Sources Nonirrigated Crop Production Unknown Source Municipal Point Sources
SOB – Farina	Manganese Copper Total Phosphorus	Herbicide/Algicide Application Unknown Source
ROZY – Kinmundy Old	Manganese	Unknown Source
SOG - Kinmundy Borrow Pit	Manganese	Unknown Source
SOF – Kinmundy New	Manganese	Unknown Source

Table 13b. Other identified impairment causes and sources

Waterbody ID	Cause	Potential Source(s)
OK01 - East Fork Kaskaskia	Dissolved oxygen	In-situ respiration/Sediment oxygen demand
	Fecal coliform bacteria	ILG580007, ILG580123, ILG580047
SOB – Farina	Manganese	Seasonal hypolimnetic anoxia
	Copper	No additional sources identified
	Total Phosphorus	Seasonal hypolimnetic anoxia Agriculture Crop-related Sources Nonirrigated Crop Production
ROZY – Kinmundy Old	Manganese	Seasonal hypolimnetic anoxia
SOG - Kinmundy Borrow Pit	Manganese	Seasonal hypolimnetic anoxia
SOF – Kinmundy New	Manganese	Seasonal hypolimnetic anoxia

Within the target subwatershed of the impaired segment of the East Fork Kaskaskia River, OK 01, there are no permitted point sources of BOD (biochemical oxygen demand) or fecal coliform bacteria. Upstream of the target subwatershed, there are three small aerated lagoon wastewater treatment plants (WWTP) that serve St. Peter, Kinmundy, and Farina (Figure 3). Each of these point sources are regulated by a National Pollutant Discharge Elimination System (NPDES) permit that limits daily maximum BOD discharges to 40 mg/L and average monthly concentrations to 25 mg/L. Daily maximum permitted BOD waste loads for these three permitted facilities are tabulated below, together with the number of BOD effluent violations that are recorded recently.

Table 14. Wastewater treatment facility information (Source: IEPA DMR files and USEPA Permit Compliance System)

Facility	Capacity (MGD)	Subwatershed	Average BOD Load (lbs/d)	Max BOD Load (lbs/d)	No. Permit BOD Violations - 7/02 to 12/03
St. Peter	0.042	071402020504	35	57	1 out of 18 measurements
Kinmundy	0.146	071402020503	92	147	0 out of 18 measurements
Farina	0.105	071402020503	129	207	13 out of 18 measurements

A siltation TMDL for this watershed recommended that the Farina WWTP, clearly exceeding its suspended solids limits on a regular basis, be examined for possible upgrading (Harza, 2003). The Farina WWTP also appears to be exceeding its permitted effluent BOD load.

Fecal coliform bacteria are not regulated under the NPDES permits and have not been routinely monitored by the owners. Recently, Farina began monitoring their effluent for fecal coliform bacteria and ammonia nitrogen. None of the three plants chlorinate their effluent to disinfect it prior to discharge.

Public water supply use support in the four lakes in Table 1 is impaired by manganese (Mn). Mn has multiple valence states in the environment and these valence states vary in solubility. Mn exists as the less soluble oxidized species (Mn III, IV) and, under reduced conditions, the more soluble species (Mn II) predominates. The oxidation-reduction chemistry of Mn (and the similar metal iron) is well studied in lakes. In the oxidized state, that is in lakes' aerobic epilimnia, Mn is in particulate form, possibly colloidal, and present as Mn III or Mn IV. During summer stratification, lakes develop anoxia in bottom waters and manganese undergoes chemical reduction to Mn II (before iron does) and becomes dissolved in the water column (Cole, 1994). Limnologists have found that increases in water column profiles of dissolved Mn may be associated with the reduction of Mn as particles settle into the anoxic zones of lakes, or from reduction and upward transport of dissolved manganese derived from lake bottom sediment (Davison, 1985). Hence, the measurements of Mn in the midwater samples collected by the ALMP exceed the water quality standard as a result of thermal stratification and the development of reducing conditions in the hypolimnion.

In addition to manganese, Farina Lake (SOB), is also impaired by copper and phosphorus. The source of copper is the owner's routine use of copper-based algicide to control plankton blooms in the lake. Farina has a permit for use of copper in SOB to control algae, issued under 35 IAC Section 602.102. Such a permit exempts SOB from meeting the general use water quality standard for copper (35 IAC 302.302) and, therefore, from a copper TMDL.

Algae are abundant because of the high nutrient concentrations, particularly phosphorus, in SOB. Phosphorus (P), like manganese, has fate and transport linked to the redox cycle associated with summer anoxia. The solubilization of iron and manganese in anoxic hypolimnetic water releases phosphorus that was adsorbed to the mineral particles. IEPA field scientists determined total and dissolved P in both epilimnetic and hypolimnetic waters. A Student's t test performed on the mean difference in paired P concentrations (epilimnion and hypolimnion) indicated that both dissolved and total P in hypolimnetic waters are higher than epilimnetic waters ($P<0.02$). The sources of P in SOB include local runoff from adjacent cropland, water diversions from the supplemental water intakes (Loy Pit and East Fork Kaskaskia River), internal release (from the sediment), and to lesser extents, atmospheric deposition and waterfowl feces. Under 35 IAC 302.205, lakes smaller than 20 acres are exempt from the 0.05 mg/L water quality standard. Farina, SOB, is four acres in area and therefore is not subject to 35 IAC 302.205 and a phosphorus TMDL is not required. However, the high P concentrations cause algae blooms, and lead to the use of copper-based algicides in SOB. We recommend that Farina prepare and implement a nutrient control plan to reduce P concentrations and the associated use of algicides in SOB, the East Fork Kaskaskia River, and Loy Pit. The Clean Lakes Program, Source Water Protection Program, or other water quality management programs may be sources of technical and financial assistance.

METHODOLOGIES, PROCEDURES, AND MODELS FOR TMDL DEVELOPMENT

This section discusses the planned linkages that are to be made between pollutant sources and surface water quality in the East Fork Kaskaskia River (OK 01), Kinmundy Lake Old (ROZY), Farina Lake (SOB), Kinmundy Lake New (SOF), and Kinmundy Borrow Pit (SOG) in order to develop TMDLs. The causes and primary suspected or known sources for these five 303(d)-listed waterbodies are shown in Tables 13a and 13b. Both the causes and sources were considered when identifying watershed and receiving water linkages to support TMDL development.

Linkages between sources and receiving water impairments are usually in the form of mathematical models that use computer technology. But, alternative approaches may be acceptable. Models may be used for simulating watershed nonpoint loads or wasteloads, or, for predicting the water quality response of receiving waterbodies. These types of models are reviewed below.

Watershed loads and wasteloads of fecal coliform bacteria and biochemical oxygen demand (BOD) need to be estimated for each identified source and linked to instream concentrations in the East Fork Kaskaskia River (OK 01). Manganese loads need to be estimated for each of the four lakes. These loads and linkages can be based on regression analyses, mechanistic models, or empirical evidence. Water quality models that predict the response of receiving waters to loads and wasteloads also need to be developed for fecal coliform bacteria (OK 01), dissolved oxygen (OK 01), and manganese (waterbodies SOB, SOG, SOF, and ROZY).

Restoring use support in the four manganese-impaired water supply lakes is not necessarily straight-forward, and neither is the approach to developing the TMDLs. The source of the manganese-caused impairments is the native soils of the lake bottom as they are exposed to seasonal hypolimnetic anoxia. Controlling external sources of manganese-bearing minerals will not remove impairments to the lakes. Impairments will continue because of the seasonal hypoxia and reduction of in-situ manganese minerals. We present a range of approaches for developing manganese TMDLs below. The simplest approach focuses on empirical evidence for the impairment and on the TMDL implementation plan. The most sophisticated approach links watershed nutrients to lake eutrophication, seasonal hypoxia, and manganese oxidation-reduction dynamics. Also presented is a mid-range approach that includes lake water quality modeling, suitable for evaluating lake management options in the implementation plan.

Models and Procedures

Application of a watershed and/or water quality model is typically performed as part of TMDL development in order to define allowable loads that will lead to attainment of water quality standards and designated uses. This section discusses the process of model selection and provides an overview of modeling objectives considered when identifying an appropriate model. For this TMDL effort, modeling objectives include:

1. Acceptability to Stakeholders
2. Site-specific Characteristics
3. Predictive Capability
4. Model Reliability

Acceptability to Stakeholders

Stakeholders for this TMDL include the Illinois EPA, US EPA, state and local agricultural resource agencies, the Science Advisory Committee and the public. Because of the Agency's interest in having a management tool developed in a relatively short time frame and with available or readily-collected data, it was recognized that a model with a high level of complexity may not be suitable. In addition, in an earlier TMDL for the East Fork Kaskaskia River a simple approach was met with mixed acceptance by stakeholders (Harza 2003).

Site-specific Characteristics

Site-specific features of relevance for selecting a watershed model include the constituents of interest, the nature of land use and nonpoint pollution sources, and the type of waterbodies (one river segment and four reservoirs). Additionally, model selection may consider a need for predicting loads during specific events, such as the 1-in-10-year storm.

The East Fork Kaskaskia River (OK 01) is listed for fecal coliform bacteria and low dissolved oxygen. Four man-made water supply lakes are also listed for manganese impairments. The model(s) selected will need to be capable of evaluating watershed loads and wasteloads of fecal coliform bacteria, oxygen-demanding substances and manganese. Furthermore, the method will need to be capable of evaluating loads from a variety of land uses (urban, agriculture, grassland and forest), and, in the case of manganese, release from lake bottom sediments.

Predictive Capability

The watershed/water quality model selected must be able to accurately predict the effects of different levels of wasteload treatment processes and land management practices on receiving water quality.

U.S. EPA's (1997) *Compendium of Tools for Watershed Assessment and TMDL Development* reviews watershed and water quality models. The *Compendium* divides watershed models into three categories:

1. Simple methods (e.g., EPA Simple Method)
2. Mid-range models (e.g., Generalized Watershed Loading Functions)
3. Detailed models (e.g., Hydrologic Simulation Program - HSPF)

The simple models typically predict annual loadings of pollutants to a waterbody, based upon empirical loading factors corresponding to watershed characteristics. Mid-range models are also typically based on empirical loading factors, but can provide greater temporal resolution (i.e., continuous simulation) and include site-specific runoff concentration data. Detailed models take a rigorous mechanistic approach to calculate loads, and predict pollutant accumulation and washoff rates, fate, and transport. Model selection should consider the above listed modeling objectives as well as the management objectives of the Illinois EPA and US EPA, and the available resources (time, data, and level of modeling effort) for developing the TMDLs.

Model Reliability

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.

Summary

Available simple and mid-range watershed models are compared in Table 15. The water quality models considered were also adapted from those described in EPA's 1997 *Compendium*. Candidate water quality models are listed in Tables 16 (steady-state models) and 17 (dynamic models). Complex dynamic models provide much finer temporal and spatial resolution. This resolution requires more complicated model set-up and more detailed model inputs.

Table 15. Comparison of selected capabilities of simple and mid-range watershed models (adapted from EPA 1997)

Criteria		EPA Screening	Simple Method	Regression Method	SLOSS-PHOSPH	Watershed	FHWA	WMM	SITEMAP	GWLF	P8-UCM	Auto-QI	AGNPS	SLAMM
Land Uses	Urban	3	2	2		2	3	1	1	1	1	1	-	1
	Rural	2	-	3	2	2	3	1	1	1	-	-	1	-
	Point Sources	-	-	-	-	3	-	3	2	2	1	-	1	1
Time Scale	Annual	3	1	1	1	1	1	1	-	-	-	-	1	-
	Single Event	3	3	3	-	-	3	-	3	-	1	-	1	-
	Continuous	-	-	-	-	-	-	-	1	1	1	1	1	1
Pollutant Loading	Sediment	2	2	2	2	2	-	-	-	1	1	1	1	1
	Nutrients	2	2	2	2	2	2	2	3	3	3	3	3	3
	BOD	-	2	-	-	-	-	-	-	-	-	2	2	2
	Bacteria	-	-	-	-	-	-	-	-	-	-	1	-	1

1 = High 2 = Medium 3 = Low - = Not incorporated

Table 16. Comparison of capabilities of steady state water quality models (Adapted from EPA 1997)

		EPA Screening	EUTROMOD	PHOSMOD	BATHTUB	QUAL2K	EXAMSII	TOXMOD	SMPTOX4	TPM	DECAL
Water Body Type	Rivers/Streams	1	-	-	-	1	1	-	1	-	-
	Lakes/Reservoirs	1	1	1	1	3	-	1	-	-	-
Physical Processes	Advection	1	-	-	1	1	1	-	1	1	1
	Dispersion	1	-	-	1	1	1	-	1	1	1
Particle Fate		3	3	3	3	-	3	3	1	1	1
Eutrophication		1	1	1	1	1	-	-	-	1	-
Chemical Fate		1	-	-	3	3	1	1	1	3	1
Sediment-Water Interactions		3	3	2	3	3	2	2	2	1	2

1 = High 2 = Medium 3 = Low - = Not incorporated

Table 17. Comparison of capabilities of dynamic water quality models (Adapted from EPA 1997)

		DYNTOX	WASP6	CE-QUAL-R1	CE-QUAL-W2	CE-QUAL-ICM	HSPF
Water Body Type	Rivers/Streams	1	1	1	1	1	1
	Lakes/Reservoirs	-	2	-	1	1	3
Physical Processes	Advection	3	1	1	1	1	1
	Dispersion		1	1	1	1	-
Particle Fate		-	2	2	2	1	1
Eutrophication		-	1	1	1	1	1
Chemical Fate		3	1	3	3	3	1
Sediment-Water Interactions		-	1	3	2	1	3

1 = High 2 = Medium 3 = Low - = Not incorporated

Recommendations for Modeling and Data Collection

This section presents recommendations for watershed and receiving water modeling. The best candidate models include:

East Fork Kaskaskia River

- A load duration analysis for bacteria, in combination with QUAL2E modeling for dissolved oxygen, and supplemental data collection
- AGNPS and QUAL2E for dissolved oxygen and fecal coliform bacteria
- A modified version of GWLF and QUAL2E for dissolved oxygen and fecal coliform bacteria

Four manganese impaired reservoirs

- A non-modeling approach based upon a Mn mass balance
- Unit area nutrient loading rates and empirical lake water quality models
- AGNPS and WASP

Watershed Modeling

Candidate watershed models for the East Fork Kaskaskia River and the four water supply lakes are presented in Table 15. None of the simple and mid-range watershed models listed in this table are ideally suited to the East Fork Kaskaskia River watershed, either because they do not address the land uses in the watershed, or, because they do not include the pollutants of interest. Most can be adapted, however, to meet project needs. For example, many of the models are based on the Universal Soil Loss Equation (USLE), with which pollutant sorption coefficients can be used to estimate loads of pollutants that are associated with soil loss.

The AGNPS model has been updated since the EPA's 1997 *Compendium* was published and annual and continuous versions are now available and supported by the USDA Agricultural Research Service. AGNPS uses the curve number method for simulating runoff volumes, a modification of the USLE for estimating sediment yield, and loading functions for pollutant loadings. It can be adapted to meet the constituent needs of these TMDLs. GWLF could also be used, but would require more modifications to estimate BOD and bacteria loads than AGNPS.

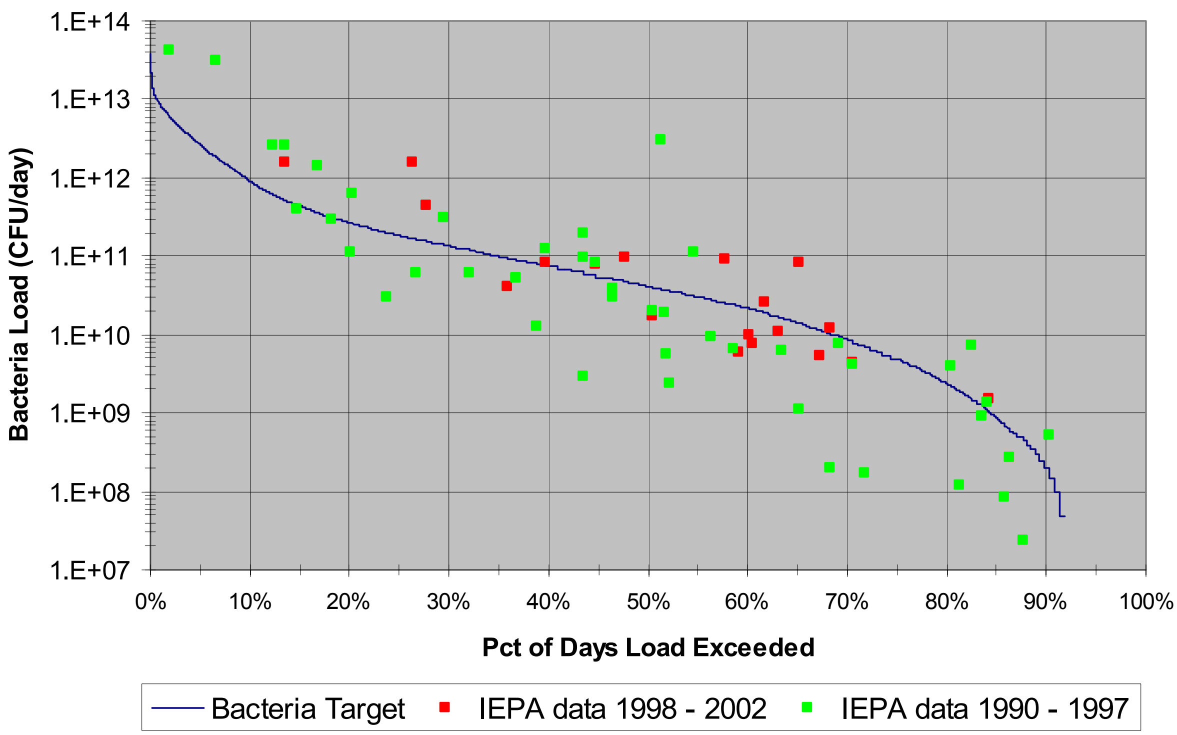
Other models that were considered are listed below.

Model	Reason for Rejection
Screening Procedures	Mixed reception by stakeholders in previous TMDL
Simple Method	Urban areas only
Regression	Mainly for urban areas
SLOSS-PHOSPH	Annual loads only, not event-based; no urban capabilities
Watershed	Annual loads only, not event-based
FHWA	Designed for highways and not appropriate for agricultural settings
WMM	Annual loads only, no erosion/sediment capability
SITEMAP	Designed for retention basins/wetlands; no sediment capability
P8-UCM	Urban only
Auto-QI	Continuous simulation only; no rural capabilities
SLAMM	Continuous simulation only; no rural capabilities

A non-modeling approach to TMDL development in this watershed involves the load duration method, first utilized by the Kansas Department of Health & Environment (Stiles 2001) and included as an example in the USEPA's Pathogen TMDL Protocol (USEPA 2001). This approach has been discussed with the Science Advisory Committee and the Agency deems it acceptable. Load duration analysis is convenient, simple, and reflects the continuum of water quality across a range of flow conditions. Load duration curves provide a visible, easily understood display of a waterbody's allowable load and the necessary reductions to meet a TMDL. The curves can also show seasonal loads and water quality effects, and may provide insight into the influence of specific pollutant sources.

Fecal coliform bacteria in treated effluents from the three wastewater plants in the targeted watershed are not regulated under the NPDES permits. And, with the recent exception of the Farina WWTP, bacteria concentrations routinely monitored by the owners. None of the three plants disinfect their effluent prior to discharge. Analysis of variance (ANOVA) failed to show significant correlation (α=.05) of fecal coliform or dissolved oxygen concentrations with discharge at OK 01. Nevertheless, load duration curves (Figures 6 and 7) for OK 01 provide insight to pollutant loadings over a wide range of stream discharges.

Figure 6. Fecal Coliform Bacteria Load Duration Curve, East Fork Kaskaskia River near Sandoval, Illinois



In Figure 6 illustrates the utility of the load duration method. The solid blue curve in Figure 6 is the product of a portion of the fecal coliform bacteria standard[1] (200 cfu/100mL) and the flow duration curve (Figure 5). Data collected by the Agency at OK 01 are shown as red or green points. Whenever the loads calculated from measured concentrations (red or green points) are above the load shown by the blue line, this indicates that the measured data exceed the primary recreation water quality criteria at a given flow. This figure illustrates that the primary contact (swimming) water quality standard is exceeded across the entire range of flows. This suggests that both dry weather bacteria sources (such as wastewater treatment plants, or WWTPs) and wet weather bacteria sources such as storm runoff are contributing to the use impairment. Further, the relative distance of the IEPA data points from the bacteria standard (blue line) reflects the necessary reduction in loads and wasteloads required to restore use support.

In a similar plot of dissolved oxygen (DO) concentrations recorded at OK 01, we illustrate that DO deficits are not large, and occur principally during low flow events (Figure 7). The DO data collected by the Agency, shown as colored points in Figure 2, fall below the solid blue line principally at lower streamflows. In recent years (1998 to 2003), with the exception of one data

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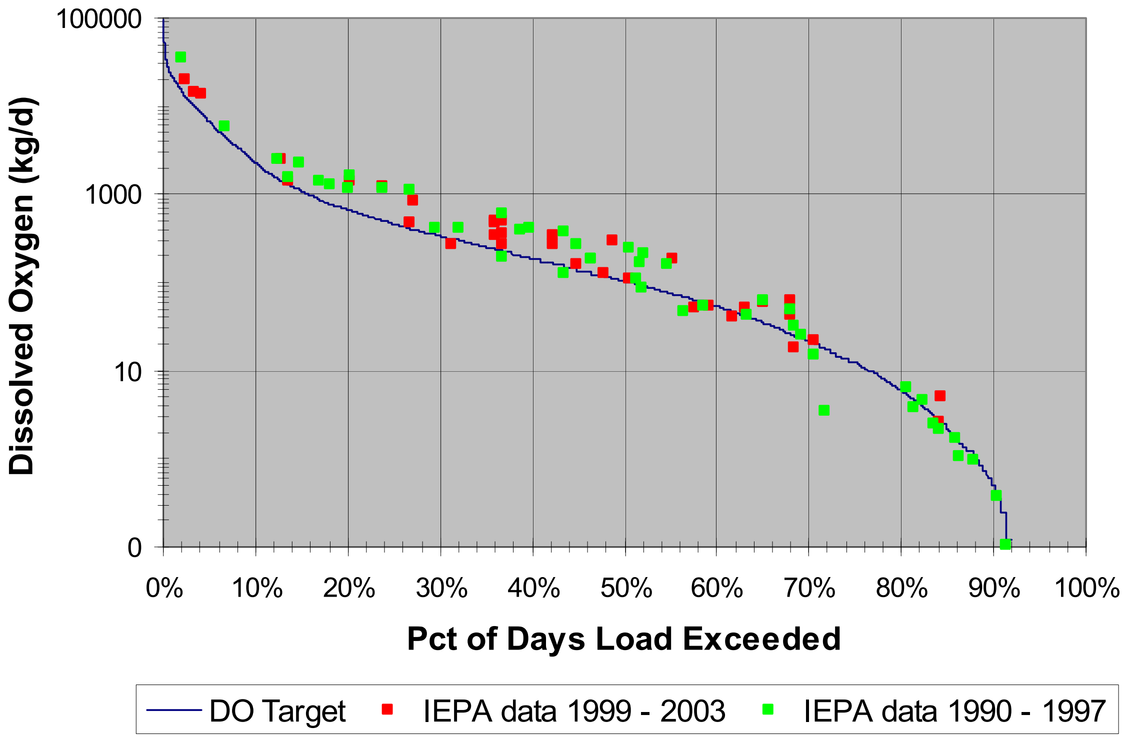
[1] The fecal coliform water quality standard for General Use Waters involves two measures of compliance. During the months may through October, based on a minimum of five samples taken over not more than a 30-day period, fecal coliform shall not exceed a geometric mean of 200 per 100 mL, nor shall more than 10% of the samples during any 30-day period exceed 400 per 100 mL.

point, DO concentrations less than 5 mg/L occur at streamflows less than 6 cfs, at flow frequencies exceeded more than 55% of the time. This is not unusual, given that stream reaeration rates increase at higher flow velocities.

Figure 7. Dissolved Oxygen Duration Curve, East Fork Kaskaskia River near Sandoval, Illinois



The utility of load duration curves in TMDL development has been reviewed by Stiles (2001). While not appropriate for DO impairment in OK 01, the load duration analysis may be appropriate for developing a TMDL for fecal coliform bacteria. The types of flow conditions where violations of the water quality standard occur, as well as load reductions required for each flow condition, can be estimated from the load duration curve (Figure 6) and an implementation plan prepared accordingly. The feasibility of percent reductions in bacteria loads and wasteloads can be assessed using a fairly simple transport equation incorporating first-order die-off. We recommend this approach to the fecal coliform bacteria TMDL.

Receiving Water Modeling

Evaluating the East Fork Kaskaskia River pollutant loads and wasteloads at a variety of flows can be performed relatively efficiently with QUAL2E, or its updated equivalent, QUAL2K. We recommend QUAL2K for modeling water quality in the East Fork Kaskaskia River. QUAL2K is a steady-state one-dimensional model readily adapted to dissolved oxygen and bacteria, and the basic model has been in use since the 1970s. Dynamic models would necessitate more time, data, and other resources than a suitable steady-state model. As elaborated upon by Freedman (2002), a model need only be sufficiently accurate to support a decision, in our case, to estimate the TMDL. Ideally, complex models provide more accuracy and reliability, but inadequate resources necessitate shortcuts, compromises, poor attention to detail, and limited analyses, often leading to an increase in uncertainty in model predictions.

Some additional data collection is recommended for development of a credible stream water quality model:

- Stream channel geometry
- Hydraulic information on the stream, such as time-of-travel, velocity, and/or reaeration rates
- BOD and SOD estimates
- Additional water quality data to characterize watershed pollutant loads and wasteloads, and, to build, calibrate and verify the model

While we present a recommendation to developing the Mn TMDLs, we discuss a range of possible approaches that may be used for four water supply lakes (Table 18).

The simplest approach focuses on empirical evidence regarding the manganese impairments, and, on the TMDL implementation plan. The TMDL would be developed using a mass balance approach and available data, and presented as a seasonally-based percent reduction in hypolimnetic manganese concentrations. Data on lake morphometry and water supply operations will need to be solicited from the municipalities or collected in the field. No quantitative linkage would be developed between P loads, lake trophic state, and manganese concentrations. The implementation plan would include a feasibility study of lake management alternatives to eliminate the manganese impairment.

Table 18 also presents more complex approaches to lake manganese TMDL development. These other approaches extend lake manganese-impairments to watershed nutrient loadings and lake eutrophication, at two levels of detail. The first approach uses unit area loading rates for watershed nutrient loads and empirical lake eutrophication models (such as BATHTUB) to develop linkages between lake manganese impairments and phosphorus loads. The load estimates will need to be modified to incorporate pumping between lakes for water storage purposes at Farina and Kinmundy. A similar but more sophisticated approach would perform this using AGNPS for watershed modeling, plus WASP lake quality modeling. Both approaches link watershed nutrients to lake eutrophication, seasonal hypoxia, and manganese oxidation-reduction dynamics. The implementation plan would include additional focus on watershed nutrient management, and at Farina, would allow the owners to also address copper and phosphorus impairments as well. Data on lake morphometry and water supply operations will also need to be solicited from the municipalities or collected in the field. WASP modeling will require significant supplemental data collection to build and verify the analysis.

Lastly, regardless of the approach selected for manganese TMDL development, we recommend collection and review of available existing data on manganese concentrations in Loy Pit and the East Fork Kaskaskia River, as well as in shallow groundwater. This information is needed to eliminate (or include) these sources of manganese in the lakes.

Table 18. Potential technical approaches to TMDL development in Mn-impaired water supply lakes

	Simple	**Mid-Range**	**Complex**
Watershed Modeling	None	Annual loads estimated for P using unit area loading method, adapted to incorporate water supply operations in Farina and Kinmundy	AGNPS
Lake Modeling	None, field data only	Empirical, EUTROMOD or BATHTUB	WASP6
Implementation Planning	Feasibility study of Mn control methods	Focus on P control and elimination of hypolimnetic anoxia	Focus on P control and elimination of hypolimnetic anoxia
Data Collection Requirements	Minimal. Morphometry and influence of water supply operations on lake water budget need to be defined. Groundwater Mn content.	Minimal. Morphometry and influence of water supply operations on lake water budget need to be defined. Groundwater Mn content.	Extensive. Morphometric, meteorological, hydraulic and hydrologic data. Additional water quality data also required. Groundwater Mn content.
Margin of Safety	Implicit	Implicit	Explicit and/or implicit

FIELD DATA COLLECTION PLAN

Figure 8 and Table 19 provide the details for recommended Stage 2 water quality sampling for the East Fork Kaskaskia River TMDL. There are five types of sampling sites:

1. Legacy (IEPA) monitoring sites, such as OK 99, OK 01, OK 02 and OK 03
2. Effluents of wastewater treatment plants
3. Urban runoff sites, intended for characterizing urban runoff loads
4. Stream quality sites intended to characterize other loads or pollutant assimilation
5. Discretionary sites that might be utilized in conjunction with, or, in lieu of one or more stream quality sites

Both physical and chemical measurements at these sites are recommended, as described below.

Water Quality Data Collection

Data on biochemical oxygen demand (BOD), sediment oxygen demand (SOD), water temperature, dissolved oxygen, nitrogen, and fecal coliform bacteria are recommended to be collected during Stage 2.

BOD Data

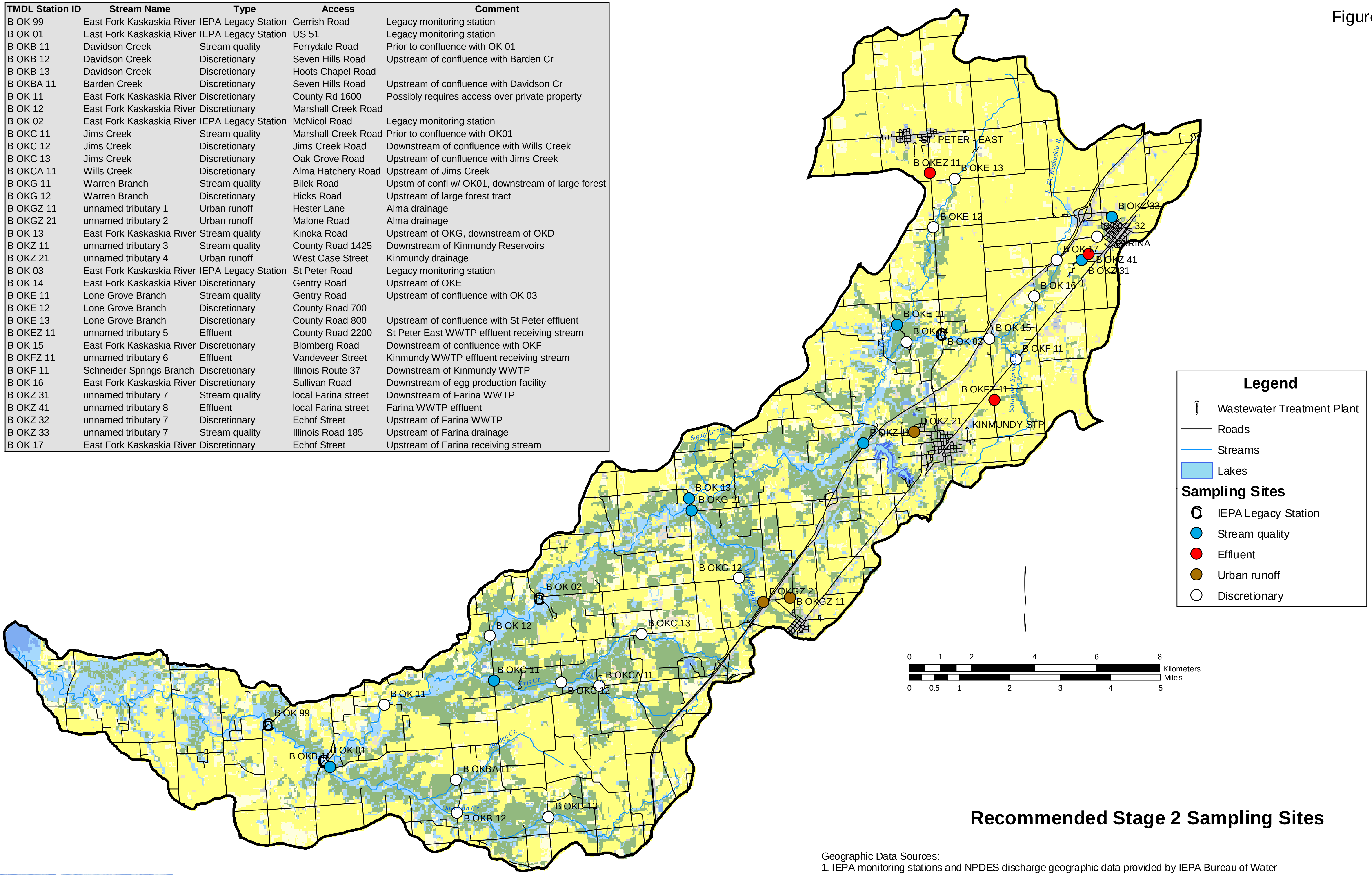
Dissolved oxygen models require, among other parameters, estimates of biochemical oxygen demand (BOD). BOD is an indicator of the concentrations of organic waste and microorganisms in a sample of water. Because microorganisms require oxygen for respiration, their numbers, and thus the concentration of dead organic matter metabolized by the bacteria, can be gaged by measuring the consumption of oxygen. A standardized measure of BOD, performed in a controlled environment, is used in many water quality models to estimate removal of DO in the system.

The IEPA does not collect BOD data during the normal course of their stream assessment efforts. And hence, there are no estimates of BOD in streams in our dataset. BOD data are available for the wastewater treatment plant effluent loads and the Discharge Monitoring Reports containing those data are available.

Fifteen (15) locations have been identified for stream BOD measurements (Figure 8). These data should be collected during low flow periods, when the DO deficits typically occur.

Figure 8

TMDL Station ID	Stream Name	Type	Access	Comment
B OK 99	East Fork Kaskaskia River	IEPA Legacy Station	Gerrish Road	Legacy monitoring station
B OK 01	East Fork Kaskaskia River	IEPA Legacy Station	US 51	Legacy monitoring station
B OKB 11	Davidson Creek	Stream quality	Ferrydale Road	Prior to confluence with OK 01
B OKB 12	Davidson Creek	Discretionary	Seven Hills Road	Upstream of confluence with Barden Cr
B OKB 13	Davidson Creek	Discretionary	Hoots Chapel Road	
B OKBA 11	Barden Creek	Discretionary	Seven Hills Road	Upstream of confluence with Davidson Cr
B OK 11	East Fork Kaskaskia River	Discretionary	County Rd 1600	Possibly requires access over private property
B OK 12	East Fork Kaskaskia River	Discretionary	Marshall Creek Road	
B OK 02	East Fork Kaskaskia River	IEPA Legacy Station	McNicol Road	Legacy monitoring station
B OKC 11	Jims Creek	Stream quality	Marshall Creek Road	Prior to confluence with OK01
B OKC 12	Jims Creek	Discretionary	Jims Creek Road	Downstream of confluence with Wills Creek
B OKC 13	Jims Creek	Discretionary	Oak Grove Road	Upstream of confluence with Jims Creek
B OKCA 11	Wills Creek	Discretionary	Alma Hatchery Road	Upstream of Jims Creek
B OKG 11	Warren Branch	Stream quality	Bilek Road	Upstm of confl w/ OK01, downstream of large forest
B OKG 12	Warren Branch	Discretionary	Hicks Road	Upstream of large forest tract
B OKGZ 11	unnamed tributary 1	Urban runoff	Hester Lane	Alma drainage
B OKGZ 21	unnamed tributary 2	Urban runoff	Malone Road	Alma drainage
B OK 13	East Fork Kaskaskia River	Stream quality	Kinoka Road	Upstream of OKG, downstream of OKD
B OKZ 11	unnamed tributary 3	Stream quality	County Road 1425	Downstream of Kinmundy Reservoirs
B OKZ 21	unnamed tributary 4	Urban runoff	West Case Street	Kinmundy drainage
B OK 03	East Fork Kaskaskia River	IEPA Legacy Station	St Peter Road	Legacy monitoring station
B OK 14	East Fork Kaskaskia River	Discretionary	Gentry Road	Upstream of OKE
B OKE 11	Lone Grove Branch	Stream quality	Gentry Road	Upstream of confluence with OK 03
B OKE 12	Lone Grove Branch	Discretionary	County Road 700	
B OKE 13	Lone Grove Branch	Discretionary	County Road 800	Upstream of confluence with St Peter effluent
B OKEZ 11	unnamed tributary 5	Effluent	County Road 2200	St Peter East WWTP effluent receiving stream
B OK 15	East Fork Kaskaskia River	Discretionary	Blomberg Road	Downstream of confluence with OKF
B OKFZ 11	unnamed tributary 6	Effluent	Vandeveer Street	Kinmundy WWTP effluent receiving stream
B OKF 11	Schneider Springs Branch	Discretionary	Illinois Route 37	Downstream of Kinmundy WWTP
B OK 16	East Fork Kaskaskia River	Discretionary	Sullivan Road	Downstream of egg production facility
B OKZ 31	unnamed tributary 7	Stream quality	local Farina street	Downstream of Farina WWTP
B OKZ 41	unnamed tributary 8	Effluent	local Farina street	Farina WWTP effluent
B OKZ 32	unnamed tributary 7	Discretionary	Echof Street	Upstream of Farina WWTP
B OKZ 33	unnamed tributary 7	Stream quality	Illinois Road 185	Upstream of Farina drainage
B OK 17	East Fork Kaskaskia River	Discretionary	Echof Street	Upstream of Farina receiving stream



Recommended Stage 2 Sampling Sites

Geographic Data Sources:
1. IEPA monitoring stations and NPDES discharge geographic data provided by IEPA Bureau of Water
2. Streams and roads are taken from http://www.isgs.uiuc.edu/nsdihome/webdocs/county.html
3. Watershed boundaries, modified, were downloaded from national hydrologic cataloging dataset: http://gateway.nrcs.usda.gov/

Baetis

Table 19. Field Data Collection Plan

Station ID	Stream Name	Type	Comment	DO	FC	BOD	Nitrogen	Channel Morph	Q
B OK 99	EF Kaskaskia River	IEPA Legacy Station	Legacy monitoring station	X					
B OK 01	EF Kaskaskia River	IEPA Legacy Station	Legacy monitoring station	X	X	X	X	X	X
B OKB 11	Davidson Creek	Stream quality	Prior to confluence with OK 01	X	X	X	X		X
B OKB 12	Davidson Creek	Discretionary	Upstream of confl with Barden Cr	X					
B OKB 13	Davidson Creek	Discretionary		X					
B OKBA 11	Barden Creek	Discretionary	Upstream of confl w/ Davidson Cr	X					
B OK 11	EF Kaskaskia River	Discretionary	Possible access over private property	X				X	
B OK 12	EF Kaskaskia River	Discretionary		X				X	
B OK 02	EF Kaskaskia River	IEPA Legacy Station	Legacy monitoring station	X	X	X	X	X	
B OKC 11	Jims Creek	Stream quality	Prior to confluence with OK01	X	X	X	X		X
B OKC 12	Jims Creek	Discretionary	Downstream of confl with Wills Cr	X					
B OKC 13	Jims Creek	Discretionary	Upstream of confluence with Jims Cr	X					
B OKCA 11	Wills Creek	Discretionary	Upstream of Jims Creek	X					
B OKG 11	Warren Branch	Stream quality	Upstm of confl w/ OK01	X	X	X	X		X
B OKG 12	Warren Branch	Discretionary	Upstream of large forest tract	X					
B OKGZ 11	unnamed tributary 1	Urban runoff	Alma drainage	X	X	X	X		
B OKGZ 21	unnamed tributary 2	Urban runoff	Alma drainage	X	X	X	X		
B OK 13	EF Kaskaskia River	Stream quality	Upstream of OKG, dnstrm of OKD	X	X	X	X	X	
B OKZ 11	unnamed tributary 3	Stream quality	Downstream of Kinmundy Reservoirs	X	X	X	X		
B OKZ 21	unnamed tributary 4	Urban runoff	Kinmundy drainage	X	X	X	X		
B OK 03	EF Kaskaskia River	IEPA Legacy Station	Legacy monitoring station	X	X	X	X	X	X
B OK 14	EF Kaskaskia River	Discretionary	Upstream of OKE	X				X	
B OKE 11	Lone Grove Branch	Stream quality	Upstream of confluence with OK 03	X	X	X	X	X	X
B OKE 12	Lone Grove Branch	Discretionary		X				X	
B OKE 13	Lone Grove Branch	Discretionary	Upstrm of confl with St Peter effluent	X					X

Table 19. Field Data Collection Plan

Station ID	Stream Name	Type	Comment	DO	FC	BOD	Nitrogen	Channel Morph	Q
B OKEZ 11	unnamed tributary 5	Effluent	St Peter WWTP effl receiving stream	X	X		X	X	X
B OK 15	EF Kaskaskia River	Discretionary	Downstream of confluence with OKF	X				X	
B OKFZ 11	unnamed tributary 6	Effluent	Knmdy WWTP effl receiving stream	X	X		X	X	X
B OKF 11	Schneider Springs	Discretionary	Downstream of Kinmundy WWTP		X				X
B OK 16	EF Kaskaskia River	Discretionary	Downstream of egg production facility	X		X	X	X	
B OKZ 31	unnamed tributary 7	Stream quality	Downstream of Farina WWTP	X	X	X	X	X	
B OKZ 41	unnamed tributary 8	Effluent	Farina WWTP effluent	X	X		X	X	X
B OKZ 32	unnamed tributary 7	Discretionary	Upstream of Farina WWTP	X					
B OKZ 33	unnamed tributary 7	Stream quality	Upstream of Farina drainage	X	X	X	X	X	X
B OK 17	EF Kaskaskia River	Discretionary	Upstream of Farina receiving stream	X					X
			Count	35	17	15	18	17	12

Notes:

DO: Dissolved Oxygen

FC: Fecal Coliform Bacteria

BOD: 5-day Biochemical Oxygen Demand

Q: Discharge

SOD Data

SOD, or sediment oxygen demand, is the sum of biological and chemical processes in sediment that utilize oxygen, or that distinct portion of oxygen removal that occurs benthically, by sediment respiration.

Field measurement of SOD involves confining sediment and overlying water and measuring the depletion of dissolved oxygen over time. A single measurement of SOD is recommended, and together with literature values of SOD and the QUAL2K SOD subroutine, we can develop reasonable estimates of SOD rates in the East Fork Kaskaskia River system. The location of that measurement will be determined in Stage 2.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and water temperature are also required for development and verification of the QUAL2K model. These measures can be collected fairly rapidly at numerous locations using field meters. As shown in Figure 8, 35 locations have been identified in the watershed for DO and temperature measurements. Again, we recommend these measurements be made during summer, when low flow and high temperatures can lead to high DO deficits in the stream.

Depending on the specific flow and temperature conditions present during the actual field data collection, a diurnal DO survey can also be performed, preferably at station OK 01 (US 51). A diurnal, around the clock, DO survey would provide data on nighttime DO minima (worse-case conditions) and daytime maxima and insight into aquatic respiration and nutrient assimilation in the stream.

Nitrogen

Ammonia oxidation can be a significant sink for DO in streams receiving treated wastewater effluent. Therefore, we have included measurements of ammonia nitrogen and nitrate+nitrite nitrogen in the field data collection plan at 18 selected locations (Table 19). This information will improve the calibration of the QUAL2K model. However, collection of nitrate+nitrite nitrogen data is optional, and left to the discretion of the Agency.

Fecal Coliform Bacteria Data

Use of the load duration analysis for development of a fecal coliform TMDL does not necessitate additional fecal coliform bacteria analysis. Supplemental data on fecal coliform bacteria will refine assumptions regarding source assessments and improve the confidence for the TMDL and the implementation plan.

The East Fork Kaskaskia River OK 01 segment use impairment was determined from the regulations in Part 302 of Title 35 of the Illinois Administrative Code, containing the state's water quality standards. The standard currently involves fecal coliform bacteria (STORET 31616, membrane filtration test for fecal coliform bacteria); our data collection plan is based on the fecal coliform standard and the load duration curve approach to TMDL development.

Figure 8 shows seventeen (17) sites for sampling and bacteria analysis. We recommend two rounds of sampling, once during a wet period, and again during the low flow sampling recommended for the DO data collection plan. The recommended sites include the IEPA legacy monitoring stations, the point sources (they do not routinely monitor coliform bacteria concentrations, although limited historical data are available), and, selected stream locations.

Due to the short holding times available to samplers, we recommend spreading the sampling over two to three days, providing sufficient travel time to the laboratory before the six-hour holding time expires.

Hydraulic Data Collection

Additional hydraulic and geomorphologic data collection is necessary to build and calibrate the QUAL2K model. Field data that need to be assembled include the following characteristics (at selected locations):

- Channel roughness
- Channel bottom width and side slopes
- Average depth
- Slope, velocity and/or time of travel
- Discharge

Table 19 lists twelve locations for discharge measurements and seventeen for channel cross section measurements. Additionally, this effort involves obtaining the rating curves for the gaging station at US 51 from the USGS.

Additional Data Requirements

Some limited data are required for developing the Mn TMDLs for the four water supply lakes. We will request data on lake morphometry and water supply operations from Farina and Kinmundy. No additional water quality data are recommended if the simple approach to TMDL development in these lakes is acceptable to the Agency.

There is an ongoing Clean Lakes Phase 1 Study of ROZY, Kinmundy Lake Old. Those data were not available for review and inclusion in the Stage 1 Report. We will again solicit the data as part of Stage 3.

PUBLIC PARTICIPATION

Stage 1 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 1. As quarterly progress reports were produced, the Agency posted them to their website. The draft Stage 1 Report for this watershed was available to the public for review beginning in December 2004.

In February 2005, a public meeting was and 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 Thursday, March 17, 2005 in Patoka, Illinois at the Village Civic Center. In addition to the meeting's sponsors, 18 individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage 1 findings by Baetis Environmental Services, Inc. This was followed by a general question and answer session.

The Agency entertained questions and concerns from the public at least through April 18, 2005. While there were several general questions, the Village of Farina expressed concerns regarding the limited data to support the listing of Farina Lake (SOB) and its Mn-caused impairment. Subsequently, the Village was informed that additional water quality data were collected in 2004 by the Agency. These data would be available for use in formulating the Mn TMDL. Farina also reported that they recently began monitoring ammonia nitrogen and fecal coliform bacteria in the Village's WWTP effluent and would be willing to share these data with the Agency for TMDL development.

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APPENDIX A. DATA SOURCES AND LOCAL CONTACTS

Table A-1. Data sources

Data Description	Agency	Telephone Or Website
Land Cover and Cropland	Illinois Natural History Survey and Illinois Department Of Agriculture	http://www.agr.state.il.us/gis/
Soils (STATSGO)	Natural Resources Conservation Service	http://www.ncgc.nrcs.usda.gov/branch/ssb/products/statsgo/data/il.html
12-Digit HUC Boundaries	Natural Resources Conservation Service	http://ftw.nrcs.usda.gov/huc_data.html
Roads	Natural Resources Conservation Service	http://datagateway.nrcs.usda.gov/
Water Quality (file data - hardcopy)	IEPA BOW	217-782-3362
Water Quality (electronic)	IEPA BOW	http://www.epa.gov/storet/
Topographic Maps	US Geological Survey	http://www.isgs.uiuc.edu/nsdihome/
Streams	Natural Resources Conservation Service	http://datagateway.nrcs.usda.gov/
IEPA Stream Stations	IEPA	http://maps.epa.state.il.us
Lakes	IEPA BOW	217-782-3362
NPDES DMRs	IEPA BOW	217-782-3362
NPDES Permits	US EPA	http://www.epa.gov/enviro/html/pcs/
Climate	ISWS	http://mcc.sws.uiuc.edu/Precip/IL/
Low Flow Statistics	ISWS	http://il.water.usgs.gov/drought/lowflow.html
Landfills and Mines	ISGS	http://www.isgs.uiuc.edu/nsdihome
Dams	IDNR	http://crunch.tec.army.mil/nid/webpages/nid.cfm

Table A-2. Local contacts

Person	Agency	Contact Means	Contact Details	Date	Subject
Burke Davies	Marion Co. SWCD	Telephone	618-548-2230	2/20/2004	Farming and fertilization practices, BMPs
Tony Antonacci	NRCS - Salem, IL	Telephone	618-548-2230	2/20/2004	BMPs, farming practices and pesticides
Melissa Mallow	Marion Co Health Dept	Telephone	618.548.3878	2/25/2004	Septic systems and pathogens
Jenni	Marion Co Ag. Ext.	Telephone	618.548.1446	3/16/2004	Directed us NRCS
Annette Ambuehl	Clinton Co. SWCD	Telephone	618.5267919	2/3/2004	Nutrient/pathogen sources, pesticides, BMPs
Howard Zinner	Clinton Co. NRCS	Telephone	618.526.7919	2/12/2004	Pollutant loading, ag practices, pesticides, pathogen sources.
Mike McMillian	Clinton Co. Health Dept.	Telephone	618-594-2723	2/20/2004	Discussed septic systems and pathogens
Mike Eggerman	Clinton County FSA	Telephone	618-526-7919	2/23/2004	CRP GIS mapping
Rodney Schultz	Fayette Co Health Dept	Telephone	618-283-1044	2/20/2004	Discussed septic systems and pathogens
Tony Pals	Fayette Co SWCD	Telephone	618-283-1095	2/23/2004	Farming and fertilization practices, BMPs
?	Fayette Co Ag Ext	Telephone	618-283-2753	3/11/2004	Referred us to the SWCD
Mary Ann Hoeffliger	Fayette County NRCS	Telephone	618-283-1095	3/12/2004	Watershed characterization
Teri Holland	IEPA BOW	eMail & phone	217-782-3362	5/11/2004	Lake water quality data request made.
Jon Goodwin & Steve Gustison	ISGS	Fax & email		5/21/2004	Oil and gas field data request
David Muir	IEPA BOW	Telephone	618-993-7200	6/1/2004	IBS report, coliform data and field visit
Matt Short	IEPA BOW	Telephone	217-786-6892	6/1/2004	IBS livestock data and coliform data
Tony Antonacci	NRCS - Salem, IL	Personal visit	618-548-2230	6/19/2004	Various matters
Burke Davies	Marion Co. SWCD	Personal visit	618-548-2230	6/19/2004	Various matters
Jessica Dickerson	Marion Co. SWCD	Personal visit	618-548-2230	6/19/2004	Various matters
Jerry Craig	City of Kinmundy	Personal visit	618-547-7241	6/19/2004 3/17/2005	Various matters
John Roberts	Village of Farina	Personal visit		6/19/2004 3/18/2005	Various matters

Person	Agency	Contact Means	Contact Details	Date	Subject
Darrell Hargrave	USDA FSA - Salem	Personal visit	618-548-2230	6/19/2004	GIS data on BMPs for Marion Co
Scott Twait	IEPA BOW	Telephone	217-782-1654	6/22/2004	WWTP effluent disinfection
Joe Stitely	IEPA BOW	Telephone	618-993-7200	6/23/2004	Farina Farms & Browns Produce
Teri Holland	IEPABOW	Email	217-782-3362	7/7/2004	Copper sulfate applications in lakes
Gerard Zimmer	IEPA BOW PWS	Telephone	217-782-1724	7/7/2004	Algicide permits
Joe Konczyk	IEPA BOW PWS	Telephone	217-785-4787	9/28/2004	Mn in groundwater
Mark Sedlacek	Village of Farina	Personal visit and Email		3/17/2005	Farina WWTP effluent monitoring

Illinois
Environmental
Protection Agency

Interim Report
Stage Two Field Data Collection
Project Watershed HUC 0714020205 (East Fork Kaskaskia River)

Prepared by

Baetis
ENVIRONMENTAL SERVICES, INC.
Chicago, Illinois

On behalf of Limno-Tech, Inc., Ann Arbor, Michigan
June 2006

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Eask Fork Kaskaskia River Watershed TMDLs and Implementation Plans

Stage 2 Report

Table of Contents

Introduction

In Illinois, TMDLs are being developed in three stages. Stage 1 involves watershed characterization and model selection. Stage 2 is optional and involves collection of specific field data to supplement the understanding of watershed pollutant sources and environmental processes. Stage 3 is the development of TMDLs and implementation plans. A Stage 1 effort for the East Fork Kaskaskia River Watershed recommended collection of additional data for TMDL development and implementation planning (Baetis 2005). This report describes data collected for Stage 2 of this TMDL effort.

Methods

A QAPP was prepared for the Stage 2 endeavor (Limno-Tech 2005). Details on data quality assurance and field methods are provided in that document and are summarized below. Sampling stations are shown in Figure 1.

Samples were collected from August 22 – 24, 2005 during low-flow conditions in the watershed. All tributaries except those receiving treated wastewater effluents were without flow and could not be sampled. Additional samples that were planned for characterizing wet weather runoff were not collected because of the 2005 drought and seasonal requirements for fecal coliform sampling.

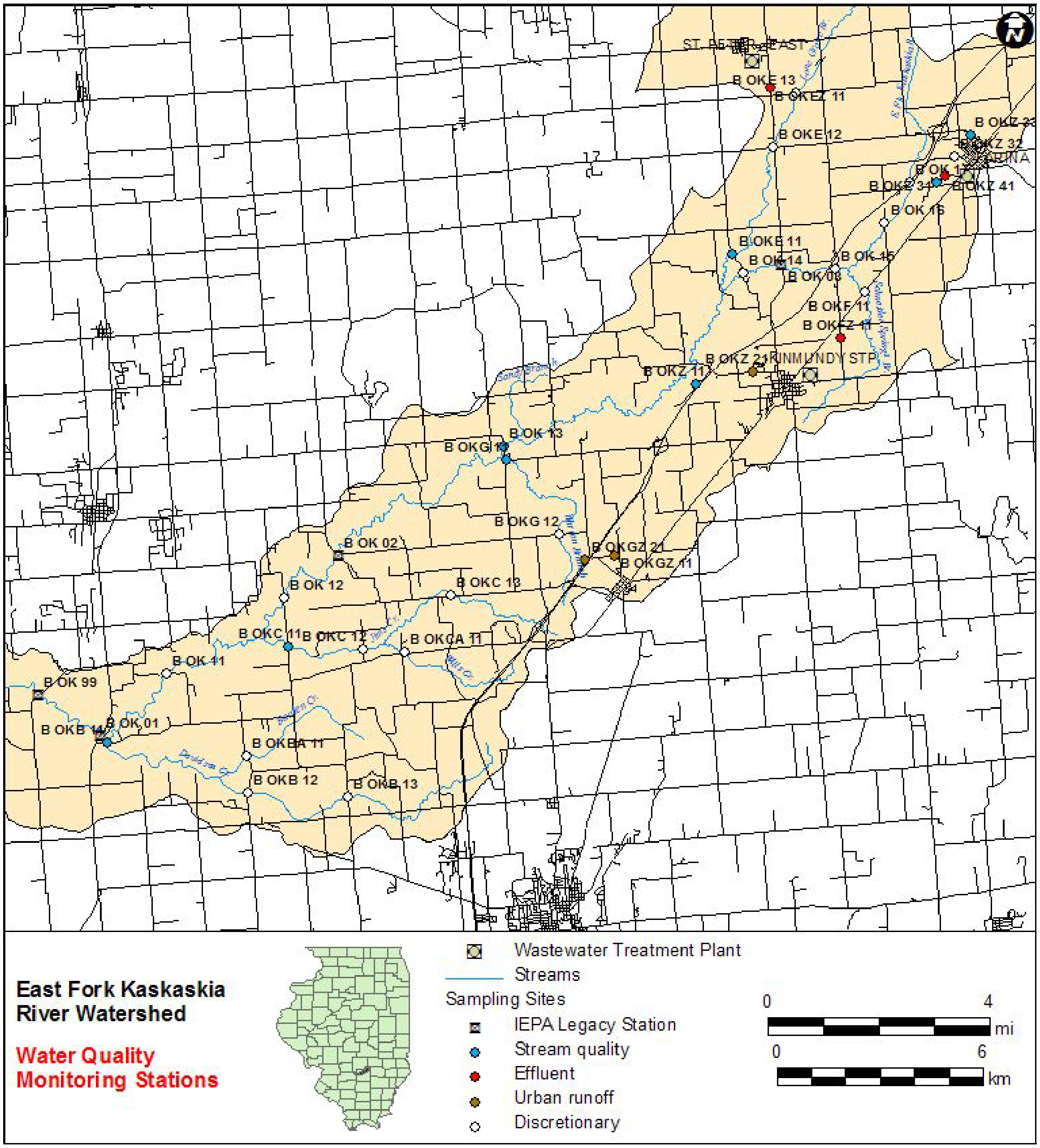
Field Measurements

Field water quality measurements of pH, conductivity, dissolved oxygen and water temperature were made using instruments (YSI Model 556 or YSI Model 58, Yellow Springs Instruments, Yellow Springs, Ohio). A data logger recorded water quality for a 24-hour period beginning on August 23 at 13:45 at the AWQMN station at US 51 (OK01).

Sediment oxygen demand (SOD) was measured in the pool adjacent to the bridge at US 51 on the afternoon of August 24. DO in the SOD chamber was measured at 5-minute intervals for 80 minutes. Per the SOP in the QAPP, a dark-bottle was used to correct for BOD in the overlying water.

Streamflow measurements were made using a pygmy type current meter and wading rod, equipped with the AquaCalc Pro Open Channel Flow Computer (Rickley Hydrological, Columbus, Ohio). In many instances, flow measurements were impossible, as velocities were less than those detectable by the pygmy current meter or depths were insufficient for proper measurements. At stations BOKZ41, BOKFZ11 and BOKEZ11, small weirs were constructed to allow for measurements.

Figure 1. Stage 2 Sampling Map



And lastly, photographs were taken at each site and general habitat conditions upstream and downstream were noted, including substrate, channel width, water width, and bank vegetation.

Surface Water Sampling and Analysis

Water quality samples were collected in bottles provided by the laboratories and contained any appropriate preservatives. The bottles were filled using a weighted bottle sampler or by hand. The labeled bottles were immediately placed in a cooler on ice and kept there until delivery to the laboratories.

ARDL, Inc. of Mount Vernon, Illinois performed analyses of ammonia, nitrate+nitrite, and biochemical oxygen demand (BOD). The Department of Agriculture Animal Disease Lab in Centralia, Illinois performed analyses of *E. coli*.

Data Verification and Validation

Non-conformance issues identified involved laboratory methods and field blank contamination. The QAPP was subsequently been revised to incorporate the new methods.

Field logs are complete and accurate. Meter calibration was performed daily and without incident. All samples were delivered to the laboratory within the holding times allowed for in the QAPP.

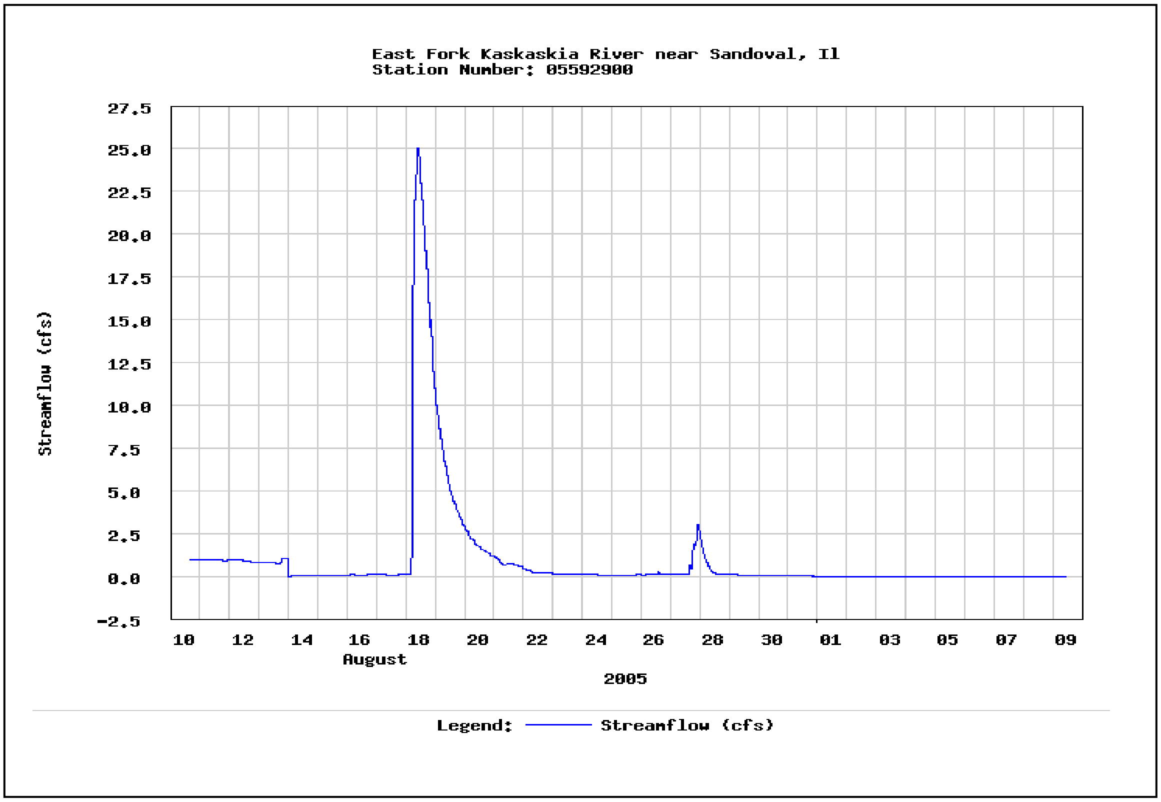
Table 1. Data Validation Summary	
Data Quality Objective	**Conformance Assessment**
Accuracy & Precision	One field duplicate resulted in the following relative percent difference (RPD): Ammonia nitrogen – 9.1%, Nitrate+nitrite nitrogen – 1.0%, BOD – 78%. The precision objective was 20% for these parameters, indicating a failure of the BOD to meet the data quality objectives (DQO). This failure is not expected to significantly affect DO modeling accuracy. The laboratory performed frequent calibration and recalibrating using reference standards, per their QA/QC manual. No calibration problems were reported.
Completeness	The study-wide goal for completeness is 90%. During the low-flow survey, completeness was 54%. This shortfall is attributed to the severe drought during the summer of 2005. All tributaries were dry, and the only flows in the watershed were discharges from wastewater treatment plants. Wet weather samples were not collected. Within the context of project goals for TMDL development, this non-compliance does not affect the ability to develop and calibrate a DO model. It does adversely affect the source assessment for coliform bacteria, as no low-flow tributary samples and no wet weather samples were collected.
Detection Limits	All detection limits were met.
Field Quality	Assessment of field duplicates reported above. Two field blanks analyzed for ammonia nitrogen were flagged for detection at concentrations equal to or greater than 20% of that found in the associated sample. Given the generally low levels of ammonia found in stream samples, we do not expect the apparent contamination of field blanks with ammonia to significantly affect DO modeling accuracy.

Survey Results

Streamflow

Flows were quite low during the Aug. 22-24 survey period. Figure 2 is an output from the USGS website for the real-time streamflow gage at US51 for the August field effort.

Figure 2. USGS Measured Discharge at OK01 (Source: http://il.water.usgs.gov/)



On August 24, at 17:30, we measured streamflow at OK01 to be 0.31 ft^3/s. For comparison, the USGS staff gage reported discharge at that time to be 0.08 ft^3/s. Given the extreme low flows, this difference is not surprising or considered unusual.

Table 2. Results of Discharge Measurements

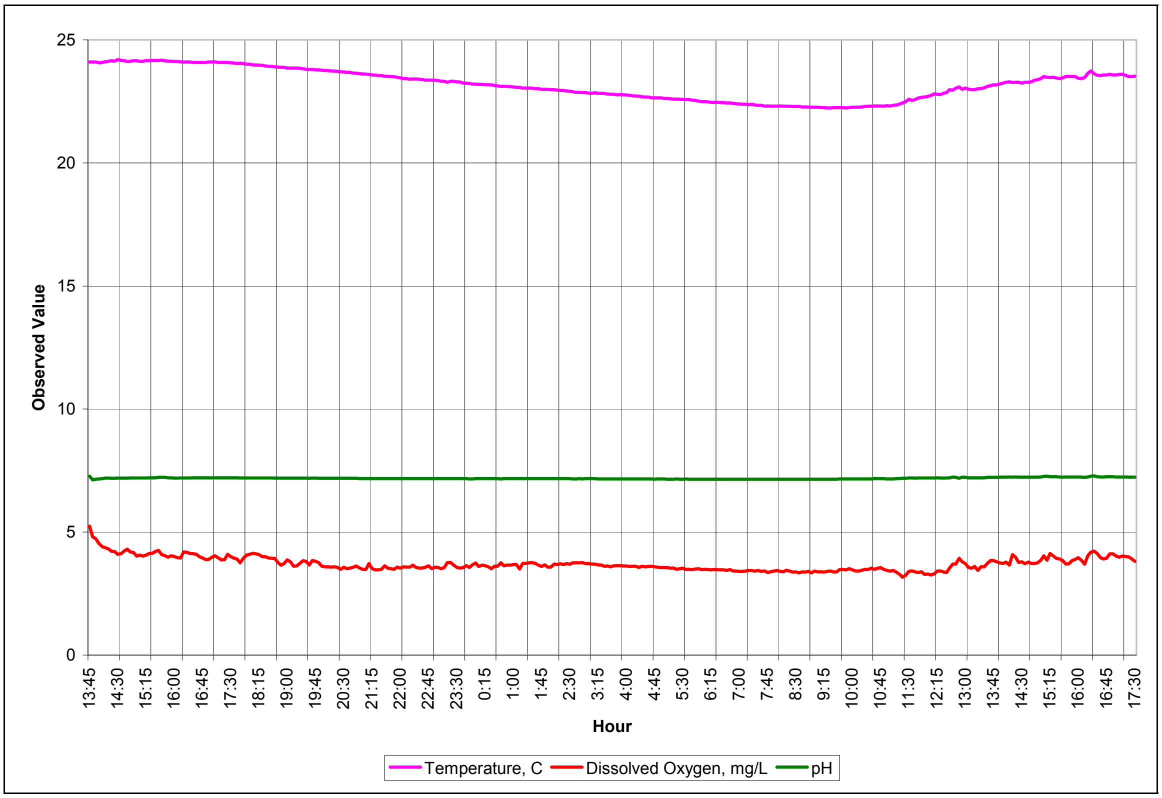
Location	Date Time	Discharge (cfs)
OK01 (East Fork Kaskaskia River at US51)	8/24/05 17:30	0.31
BOKEZ11 (St Peter East WWTP Discharge)	8/24/05 11:15	0.01
BOKFZ11 (Kinmundy WWTP Discharge)	8/23/05 13:00	0.04
BOK16 (East Fork Kaskaskia River at Sullivan Rd)	8/24/05 10:15	0.27
BOKZ41 (Farina WWTP Discharge)	8/23/05 10:30	0.4

Water Quality

The results of the water quality measurements are in Appendix A. Laboratory reports are reproduced as Appendix B.

Diurnal monitoring of dissolved oxygen (DO), water temperature and pH are plotted below. Maximum and minimum DO during the 28-hour period were 5.24 and 3.17 mg/L respectively. The range of pH during the 28-hour data logging period was not large, from a minimum of 7.12 to a maximum of 7.28.

Figure 3. Diurnal Monitoring at AWQMN Station OK01, August 23-24, 2005



Sediment Oxygen Demand

Sediment oxygen demand, or SOD, was measured once, largely to ascertain the streams' context within SOD values that would be expected from the literature. SOD was measured on August 24, 2005 in a pool adjacent to the USGS streamflow gage at US Highway 51, i.e. OK01. SOD corrected to 20ºC was measured to be 1.04 mg/L per day. Appendix C provides the calculation details.

Habitat

General physical habitat measures were made to support modeling (depth, channel width, stream width). Photographs were also taken at each location. Results will be part of the QUAL2E input and output files.

Recommendations for Stage 3

Based upon the low-flow field survey, we recommend the following measures for Stage 3 TMDL development and implementation planning:

1. Diurnal DO monitoring at OK01 does not suggest that photosynthesis or nocturnal respiration has a large affect on DO concentrations and QUAL2E modeling need not include algal or chlorophyll a modeling. It was hot and sunny during the monitoring period and, if significant daytime DO peaks and nocturnal deficits were significant, we would have observed a larger diurnal DO variation.

2. The East Fork Kaskaskia River was effluent-dominated system at the time of this survey, that is, all flows originated from wastewater treatment plant discharges. The character of the discharges set boundary conditions for modeling such critical stream conditions.

References

Baetis 2005. Stage One Report, TMDLs and Implementation Plans for Target Watersheds, Project Watershed HUC 0714020205 (East Fork Kaskaskia River). Prepared for the Illinois Environmental Protection Agency, Springfield, Illinois, by Baetis Environmental Services, Inc., Chicago, Illinois. April 2005.

Limno-Tech 2005. Quality Assurance Project Plan for TMDL Sampling Activities at the Following State of Illinois Watersheds: Macoupin Creek, Hodges Creek, Mauvaisse Terre Creek, East Fork Kaskaskia River, North Fork Kaskaskia River, Skillet Fork. Prepared for the Illinois Environmental Protection Agency, Springfield, Illinois, by Limno-Tech, Inc., Ann Arbor, Michigan. Revised September 2005.

Appendix A. Results of Water Quality Sampling, August 22-24, 2005

Results of Water Quality Sampling, August 22-24, 2005

TMDL Station	Collection Date / Time	Parameter	Sample ID	Lab ID	Result	Units	Qualifier
	8/22/2005 9:10:00 AM	Ammonia Nitrogen	29	127929-09	0.17	mg/L	B
	8/23/2005 1:30:00 PM	Ammonia Nitrogen	28	127929-08	0.25	mg/L	
	8/23/2005 1:30:00 PM	Biochemical Oxygen Demand, 5-Day	28	127929-08	1.2	mg/L	
	8/23/2005 1:30:00 PM	Eschericia coli	26	346904	0	cfu/100 mL	U
	8/23/2005 1:30:00 PM	Nitrate-Nitrite Nitrogen	28	127929-08	0.02	mg/L	U
	8/24/2005 9:20:00 AM	Ammonia Nitrogen	3	127932-03	0.8	mg/L	B
	8/24/2005 9:20:00 AM	Biochemical Oxygen Demand, 5-Day	3	127932-03	2	mg/L	U
	8/24/2005 9:20:00 AM	Eschericia coli	7	346982	0	cfu/100 mL	U
	8/24/2005 9:20:00 AM	Nitrate-Nitrite Nitrogen	3	127932-03	0.02	mg/L	U
B OK 01	8/22/2005 9:20:00 AM	Ammonia Nitrogen	8	127929-01	0.17	mg/L	
B OK 01	8/22/2005 9:20:00 AM	Biochemical Oxygen Demand, 5-Day	8	127929-01	17.2	mg/L	
B OK 01	8/22/2005 9:20:00 AM	Conductivity	32		353	mmhoms/cm	
B OK 01	8/22/2005 9:20:00 AM	Dissolved Oxygen	32		3.68	mg/L	
B OK 01	8/22/2005 9:20:00 AM	Dissolved Oxygen Saturation	32		44	%	
B OK 01	8/22/2005 9:20:00 AM	Eschericia coli	9	346860	114	cfu/100 mL	
B OK 01	8/22/2005 9:20:00 AM	Nitrate-Nitrite Nitrogen	8	127929-01	0.2	mg/L	
B OK 01	8/22/2005 9:20:00 AM	pH	32		6.96	SU	
B OK 01	8/22/2005 9:20:00 AM	Temperature, Air	32		27	degrees C	
B OK 01	8/22/2005 9:20:00 AM	Temperature, Water	32		24.9	degrees C	

TMDL Station	Collection Date / Time	Parameter	Sample ID	Lab ID	Result	Units	Qualifier
B OK 01	8/23/2005 1:40:00 PM	Eschericia coli	30	346904	55	cfu/100 mL	
B OK 01	8/23/2005 1:50:00 PM	Conductivity	43		343	mmhos/cm	
B OK 01	8/23/2005 1:50:00 PM	Dissolved Oxygen	43		4.81	mg/L	
B OK 01	8/23/2005 1:50:00 PM	pH	43		7.12	SU	
B OK 01	8/23/2005 1:50:00 PM	Temperature, Water	43		24.1	degrees C	
B OK 01	8/24/2005 1:20:00 PM	Eschericia coli	6	346982	25	cfu/100 mL	
B OK 01	8/24/2005 5:10:00 PM	Conductivity	42		342	mmhos/cm	
B OK 01	8/24/2005 5:10:00 PM	Discharge	42		0.31	cfs	
B OK 01	8/24/2005 5:10:00 PM	Dissolved Oxygen	42		4.02	mg/L	
B OK 01	8/24/2005 5:10:00 PM	pH	42		7.24	SU	
B OK 01	8/24/2005 5:10:00 PM	Temperature, Water	42		23.6	degrees C	
B OK 02	8/22/2005 11:45:00 AM	Ammonia Nitrogen	10	127929-02	0.18	mg/L	
B OK 02	8/22/2005 11:45:00 AM	Biochemical Oxygen Demand, 5-Day	10	127929-02	19.1	mg/L	
B OK 02	8/22/2005 11:45:00 AM	Conductivity	34		540	mmhoms/cm	
B OK 02	8/22/2005 11:45:00 AM	Dissolved Oxygen	34		2.97	mg/L	
B OK 02	8/22/2005 11:45:00 AM	Dissolved Oxygen Saturation	34		37	%	
B OK 02	8/22/2005 11:45:00 AM	Eschericia coli	12	346860	70	cfu/100 mL	
B OK 02	8/22/2005 11:45:00 AM	Nitrate-Nitrite Nitrogen	10	127929-02	0.41	mg/L	
B OK 02	8/22/2005 11:45:00 AM	pH	34		7.27	SU	
B OK 02	8/22/2005 11:45:00 AM	Temperature, Air	34		29	degrees C	
B OK 02	8/22/2005 11:45:00 AM	Temperature, Water	34		26.6	degrees C	
B OK 03	8/22/2005 1:15:00 PM	Ammonia Nitrogen	18	127929-04	0.77	mg/L	

TMDL Station	Collection Date / Time	Parameter	Sample ID	Lab ID	Result	Units	Qualifier
B OK 03	8/22/2005 1:15:00 PM	Biochemical Oxygen Demand, 5-Day	18	127929-04	15.7	mg/L	
B OK 03	8/22/2005 1:15:00 PM	Conductivity	36		265	mmhos/cm	
B OK 03	8/22/2005 1:15:00 PM	Dissolved Oxygen	36		8.64	mg/L	
B OK 03	8/22/2005 1:15:00 PM	Dissolved Oxygen Saturation	36		105	%	
B OK 03	8/22/2005 1:15:00 PM	Eschericia coli	17	346860	117	cfu/100 mL	
B OK 03	8/22/2005 1:15:00 PM	Nitrate-Nitrite Nitrogen	18	127929-04	0.077	mg/L	
B OK 03	8/22/2005 1:15:00 PM	pH	36		6.94	SU	
B OK 03	8/22/2005 1:15:00 PM	Temperature, Water	36		25.22	degrees C	
B OK 11	8/22/2005 10:35:00 AM	Conductivity	13		354	mmhos/cm	
B OK 11	8/22/2005 10:35:00 AM	Dissolved Oxygen	13		3.98	mg/L	
B OK 11	8/22/2005 10:35:00 AM	Dissolved Oxygen Saturation	13		48	%	
B OK 11	8/22/2005 10:35:00 AM	pH	13		6.94	SU	
B OK 11	8/22/2005 10:35:00 AM	Temperature, Water	13		24.73	degrees C	
B OK 12	8/22/2005 11:15:00 AM	Conductivity	14		477	mmhos/cm	
B OK 12	8/22/2005 11:15:00 AM	Dissolved Oxygen	14		3.81	mg/L	
B OK 12	8/22/2005 11:15:00 AM	Dissolved Oxygen Saturation	14		46.5	%	
B OK 12	8/22/2005 11:15:00 AM	pH	14		7.22	SU	
B OK 12	8/22/2005 11:15:00 AM	Temperature, Water	14		25.4	degrees C	
B OK 13	8/22/2005 12:30:00 PM	Ammonia Nitrogen	15	127929-03	0.33	mg/L	
B OK 13	8/22/2005 12:30:00 PM	Biochemical Oxygen Demand, 5-Day	15	127929-03	19.7	mg/L	
B OK 13	8/22/2005 12:30:00 PM	Conductivity	35		320	mmhos/cm	
B OK 13	8/22/2005 12:30:00 PM	Dissolved Oxygen	35		2.17	mg/L	

TMDL Station	Collection Date / Time	Parameter	Sample ID	Lab ID	Result	Units	Qualifier
B OK 13	8/22/2005 12:30:00 PM	Dissolved Oxygen Saturation	35		27	%	
B OK 13	8/22/2005 12:30:00 PM	Eschericia coli	16	346860	55	cfu/100 mL	
B OK 13	8/22/2005 12:30:00 PM	Nitrate-Nitrite Nitrogen	15	127929-03	0.29	mg/L	
B OK 13	8/22/2005 12:30:00 PM	pH	35		7.13	SU	
B OK 13	8/22/2005 12:30:00 PM	Temperature, Water	35		26.15	degrees C	
B OK 15	8/22/2005 1:45:00 PM	Conductivity	19		313	mmhos/cm	
B OK 15	8/22/2005 1:45:00 PM	Dissolved Oxygen	19		1.04	mg/L	
B OK 15	8/22/2005 1:45:00 PM	Dissolved Oxygen Saturation	19		12	%	
B OK 15	8/22/2005 1:45:00 PM	pH	19		7.1	SU	
B OK 15	8/22/2005 1:45:00 PM	Temperature, Water	19		25.5	degrees C	
B OK 16	8/24/2005 9:30:00 AM	Ammonia Nitrogen	1	127932-01	2.3	mg/L	
B OK 16	8/24/2005 9:30:00 AM	Ammonia Nitrogen	2	127932-02	2.1	mg/L	
B OK 16	8/24/2005 9:30:00 AM	Biochemical Oxygen Demand, 5-Day	1	127932-01	15.7	mg/L	D
B OK 16	8/24/2005 9:30:00 AM	Biochemical Oxygen Demand, 5-Day	2	127932-02	6.9	mg/L	D
B OK 16	8/24/2005 9:30:00 AM	Discharge	31		0.27	cfs	
B OK 16	8/24/2005 9:30:00 AM	Dissolved Oxygen	31		2.1	mg/L	
B OK 16	8/24/2005 9:30:00 AM	Eschericia coli	4	346982	131	cfu/100 mL	
B OK 16	8/24/2005 9:30:00 AM	Nitrate-Nitrite Nitrogen	2	127932-02	0.052	mg/L	
B OK 16	8/24/2005 9:30:00 AM	Nitrate-Nitrite Nitrogen	1	127932-01	0.051	mg/L	
B OK 16	8/24/2005 9:30:00 AM	Temperature, Water	31		23	degrees C	
B OK 99	8/22/2005 10:00:00 AM	Conductivity	33		449	mmhoms/cm	
B OK 99	8/22/2005 10:00:00 AM	Dissolved Oxygen	33		5	mg/L	

TMDL Station	Collection Date / Time	Parameter	Sample ID	Lab ID	Result	Units	Qualifier
B OK 99	8/22/2005 10:00:00 AM	Dissolved Oxygen Saturation	33		61	%	
B OK 99	8/22/2005 10:00:00 AM	pH	33		6.88	SU	
B OK 99	8/22/2005 10:00:00 AM	Temperature, Water	33		25.5	degrees C	
B OKEZ 1	8/24/2005 11:15:00 AM	Discharge	39		0.01	cfs	J
B OKEZ 1	8/24/2005 11:15:00 AM	Dissolved Oxygen	39		4.9	mg/L	
B OKEZ 1	8/24/2005 11:15:00 AM	Temperature, Water	39		24.5	degrees C	
B OKEZ 11	8/23/2005 8:00:00 AM	Ammonia Nitrogen	20	127929-05	0.41	mg/L	
B OKEZ 11	8/23/2005 8:00:00 AM	Biochemical Oxygen Demand, 5-Day	20	127929-05	8.4	mg/L	
B OKEZ 11	8/23/2005 8:00:00 AM	Conductivity	37		977	mmhos/cm	
B OKEZ 11	8/23/2005 8:00:00 AM	Dissolved Oxygen	37		1.88	mg/L	
B OKEZ 11	8/23/2005 8:00:00 AM	Dissolved Oxygen Saturation	37		22	%	
B OKEZ 11	8/23/2005 8:00:00 AM	Eschericia coli	21	346904	263	cfu/100 mL	
B OKEZ 11	8/23/2005 8:00:00 AM	Nitrate-Nitrite Nitrogen	20	127929-05	0.17	mg/L	
B OKEZ 11	8/23/2005 8:00:00 AM	pH	37		7.24	SU	
B OKEZ 11	8/23/2005 8:00:00 AM	Temperature, Water	37		22.49	degrees C	
B OKEZ 11	8/24/2005 11:15:00 AM	Eschericia coli	5	346982	82	cfu/100 mL	
B OKF 11	8/23/2005 12:00:00 PM	Conductivity	40		640	mmhos/cm	
B OKF 11	8/23/2005 12:00:00 PM	Dissolved Oxygen	40		2.02	mg/L	
B OKF 11	8/23/2005 12:00:00 PM	Dissolved Oxygen Saturation	40		24	%	
B OKF 11	8/23/2005 12:00:00 PM	Eschericia coli	24	346904	613	cfu/100 mL	
B OKF 11	8/23/2005 12:00:00 PM	pH	40		6.71	SU	
B OKF 11	8/23/2005 12:00:00 PM	Temperature, Water	40		22.76	degrees C	

TMDL Station	Collection Date / Time	Parameter	Sample ID	Lab ID	Result	Units	Qualifier
B OKFZ 11	8/23/2005 12:30:00 PM	Ammonia Nitrogen	27	127929-07	7.6	mg/L	
B OKFZ 11	8/23/2005 12:30:00 PM	Biochemical Oxygen Demand, 5-Day	27	127929-07	20.6	mg/L	
B OKFZ 11	8/23/2005 12:30:00 PM	Conductivity	41		766	mmhos/cm	
B OKFZ 11	8/23/2005 12:30:00 PM	Discharge	41		0.04	cfs	J
B OKFZ 11	8/23/2005 12:30:00 PM	Dissolved Oxygen	41		4.91	mg/L	
B OKFZ 11	8/23/2005 12:30:00 PM	Dissolved Oxygen Saturation	41		56	%	
B OKFZ 11	8/23/2005 12:30:00 PM	Eschericia coli	25	346904	649	cfu/100 mL	
B OKFZ 11	8/23/2005 12:30:00 PM	Nitrate-Nitrite Nitrogen	27	127929-07	0.28	mg/L	
B OKFZ 11	8/23/2005 12:30:00 PM	pH	41		7.26	SU	
B OKFZ 11	8/23/2005 12:30:00 PM	Temperature, Water	41		22.14	degrees C	
B OKZ 41	8/23/2005 10:00:00 AM	Ammonia Nitrogen	22	127929-06	6.2	mg/L	
B OKZ 41	8/23/2005 10:00:00 AM	Biochemical Oxygen Demand, 5-Day	22	127929-06	31.8	mg/L	
B OKZ 41	8/23/2005 10:00:00 AM	Conductivity	38		1645	mmhos/cm	
B OKZ 41	8/23/2005 10:00:00 AM	Discharge	38		0.4	cfs	J
B OKZ 41	8/23/2005 10:00:00 AM	Dissolved Oxygen	38		4.8	mg/L	
B OKZ 41	8/23/2005 10:00:00 AM	Dissolved Oxygen Saturation	38		58	%	
B OKZ 41	8/23/2005 10:00:00 AM	Eschericia coli	23	346904	108	cfu/100 mL	
B OKZ 41	8/23/2005 10:00:00 AM	Nitrate-Nitrite Nitrogen	22	127929-06	0.027	mg/L	
B OKZ 41	8/23/2005 10:00:00 AM	pH	38		8.67	SU	
B OKZ 41	8/23/2005 10:00:00 AM	Temperature, Water	38		24.95	degrees C	

Appendix B. Laboratory Reports

Sample ID: 8

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

RDL Number: 127929-01 Customer No.: BOK-01 Report Date:

ustomer: BAETIS ENVIRONMENTAL SERVICES
2650 W MONTROSE AVE; SUITE 307
CHICAGO, IL 60618
ttention: DAVID POTT
ollected By: CUSTOMER

Matrix
Date Logged In: 08/
Hour Logged In: 07:
Sampling Point: KASKASKI
Collection Date: 08/22/2005 Hour:

ANALYTE	RESULT
Biological Oxygen Demand	17.2 MG/L
Ammonia Nitrogen	0.17 MG/L
Nitrate-Nitrite Nitrogen	0.2 MG/L

Respectfully submitted:
D.J. Gillespie
Technical Servic

O. Box 1566 Rte 15E Mt. Vernon Airport Mt.Vernon, Illinois 62864 (6

"Test everything. Keep the good." 1 Thes. 5:21

Sample ID: 10

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

Number: 127929-02 Customer No.: BOK-02 Report Date: 09/12,

omer: BAETIS ENVIRONMENTAL SERVICES
2650 W MONTROSE AVE; SUITE 307
CHICAGO, IL 60618
ntion: DAVID POTT
ected By: CUSTOMER

Matrix: WAT
Date Logged In: 08/24/20
Hour Logged In: 07:48:32
Sampling Point: KASKASKIA RIV
Collection Date: 08/22/2005 Hour: 1145

ANALYTE	RESULT
Biological Oxygen Demand	19.1 MG/L
Ammonia Nitrogen	0.18 MG/L
Nitrate-Nitrite Nitrogen	0.41 MG/L

Respectfully submitted:
D.J. Gillespie
Technical Services Ma

Box 1566 Rte 15E Mt. Vernon Airport Mt.Vernon, Illinois 62864 (618)24

Sample ID: 15

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

ARDL Number: 127929-03   Customer No.: BOK-13   Report Date: 09/12/2005

Customer: BAETIS ENVIRONMENTAL SERVICES
2650 W MONTROSE AVE; SUITE 307
CHICAGO, IL 60618
Attention: DAVID POTT
Collected By: CUSTOMER

Matrix: WATER
Date Logged In: 08/24/2005
Hour Logged In: 07:48:32
Sampling Point: KASKASKIA RIVER
Collection Date: 08/22/2005   Hour: 1230

ANALYTE	RESULT
Biological Oxygen Demand	19.7 MG/L
Ammonia Nitrogen	0.33 MG/L
Nitrate-Nitrite Nitrogen	0.29 MG/L

Respectfully submitted:
D.J. Gillespie
Technical Services Manager

Sample ID: 18

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

ARDL Number: 127929-04   Customer No.: BOK-03   Report Date: 09/12/20

Customer: BAETIS ENVIRONMENTAL SERVICES
2650 W MONTROSE AVE; SUITE 307
CHICAGO, IL 60618
Attention: DAVID POTT
Collected By: CUSTOMER

Matrix: WATER
Date Logged In: 08/24/2005
Hour Logged In: 07:48:32
Sampling Point: KASKASKIA RIVER
Collection Date: 08/22/2005   Hour: 1315

ANALYTE	RESULT
Biological Oxygen Demand	15.7 MG/L
Ammonia Nitrogen	0.77 MG/L
Nitrate-Nitrite Nitrogen	0.077 MG/L

Respectfully submitted:
D.J. Gillespie
Technical Services Mana

Sample ID: 20

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

ARDL Number: 127929-05 Customer No.: BOKEZ-11 Report Date: 09/12/2005

Customer: BAETIS ENVIRONMENTAL SERVICES
2650 W MONTROSE AVE; SUITE 307
CHICAGO, IL 60618
Attention: DAVID POTT
Collected By: CUSTOMER

Matrix: WATER
Date Logged In: 08/24/2005
Hour Logged In: 07:48:32
Sampling Point: KASKASKIA RIVER
Collection Date: 08/23/2005 Hour: 0800

ANALYTE	RESULT
Biological Oxygen Demand	8.4 MG/L
Ammonia Nitrogen	0.41 MG/L
Nitrate-Nitrite Nitrogen	0.17 MG/L

Respectfully submitted:
D.J. Gillespie
Technical Services Manager

Sample ID: 22

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

ARDL Number: 127929-06 Customer No.: BOKZ-41 Report Date: 09/12/2005

Customer: BAETIS ENVIRONMENTAL SERVICES
2650 W MONTROSE AVE; SUITE 307
CHICAGO, IL 60618
Attention: DAVID POTT
Collected By: CUSTOMER

Matrix: WATER
Date Logged In: 08/24/2005
Hour Logged In: 07:48:32
Sampling Point: KASKASKIA RIVER
Collection Date: 08/23/2005 Hour: 1000

ANALYTE	RESULT
Biological Oxygen Demand	31.8 MG/L
Ammonia Nitrogen	6.2 MG/L
Nitrate-Nitrite Nitrogen	0.027 MG/L

Respectfully submitted:
D.J. Gillespie
Technical Services Manager

Sample ID: 27

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

ARDL Number: 127929-07   Customer No.: BOKFZ-11   Report Date: 09/12/2005

Customer: BAETIS ENVIRONMENTAL SERVICES
2650 W MONTROSE AVE; SUITE 307
CHICAGO, IL 60618

Matrix: WATER
Date Logged In: 08/24/2005
Hour Logged In: 07:48:32

Attention: DAVID POTT   Sampling Point: KASKASKIA RIVER
Collected By: CUSTOMER   Collection Date: 08/23/2005   Hour: 1230

ANALYTE	RESULT
Biological Oxygen Demand	20.6 MG/L
Ammonia Nitrogen	7.6 MG/L
Nitrate-Nitrite Nitrogen	0.28 MG/L

Respectfully submitted: D.J. Gillespie
Technical Services Manager

Sample ID: 28

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

RDL Number: 127929-08   Customer No.: BLANK   Report Date: 09,

ustomer: BAETIS ENVIRONMENTAL SERVICES
2650 W MONTROSE AVE; SUITE 307
CHICAGO, IL 60618

Matrix: W
Date Logged In: 08/24,
Hour Logged In: 07:48

ttention: DAVID POTT   Sampling Point: KASKASKIA R
ollected By: CUSTOMER   Collection Date: 08/23/2005   Hour: 13

ANALYTE	RESULT
Biological Oxygen Demand	1.2 MG/L
Ammonia Nitrogen	0.25 MG/L
Nitrate-Nitrite Nitrogen	<0.02 MG/L

Respectfully submitted: D.J. Gillespie
Technical Services

Sample ID: 29

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

RDL Number: 127929-09   Customer No.: BLANK(RINSE)   Report Date: 09/12/

ustomer: BAETIS ENVIRONMENTAL SERVICES   Matrix: WATE
2650 W MONTROSE AVE; SUITE 307   Date Logged In: 08/24/200
CHICAGO, IL 60618   Hour Logged In: 07:48:32
ttention: DAVID POTT   Sampling Point: KASKASKIA RIVE
ollected By: CUSTOMER   Collection Date: 08/22/2005   Hour: 0910

ANALYTE	RESULT
Ammonia Nitrogen	0.17 MG/L

Respectfully submitted:
D.J. Gillespie
Technical Services Mar

Sample ID: 3

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

ARDL Number: 127932-03   Customer No.: BLANK   Report Date: 09/12/2005

Customer: BAETIS ENVIRONMENTAL SERVICES   Matrix: WATER
2650 W MONTROSE AVE; SUITE 307   Date Logged In: 08/25/2005
CHICAGO, IL 60618   Hour Logged In: 07:31:55
Attention: DAVID POTT   Sampling Point:
Collected By: CUSTOMER   Collection Date: 08/24/2005   Hour: 0920

ANALYTE	RESULT
Biological Oxygen Demand	<2.0 MG/L
Ammonia Nitrogen	0.8 MG/L
Nitrate-Nitrite Nitrogen	<0.02 MG/L

Respectfully submitted:
D.J. Gillespie
Technical Services Manager

Sample ID: 1

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

ARDL Number: 127932-01 Customer No.: BOK-16A Report Date: 09/12/2005

Customer: BAETIS ENVIRONMENTAL SERVICES
2650 W MONTROSE AVE; SUITE 307
CHICAGO, IL 60618
Attention: DAVID POTT
Collected By: CUSTOMER

Matrix: WATER
Date Logged In: 08/25/2005
Hour Logged In: 07:31:55
Sampling Point: EF KASKASKIA RIVER
Collection Date: 08/24/2005 Hour: 0930

ANALYTE	RESULT
Biological Oxygen Demand	15.7 MG/L
Ammonia Nitrogen	2.3 MG/L
Nitrate-Nitrite Nitrogen	0.051 MG/L

Respectfully submitted:
D.J. Gillespie
Technical Services Manager

P.O. Box 1566 Rte 15E Mt. Vernon Airport Mt.Vernon, Illinois 62864 (618)244-3235

Sample ID: 2

LABORATORY REPORT

ARDL, Inc.
Applied Research and Development Laboratory

RDL Number: 127932-02 Customer No.: BOK-16B Report Date: 09/12,

ıstomer: BAETIS ENVIRONMENTAL SERVICES
2650 W MONTROSE AVE; SUITE 307
CHICAGO, IL 60618
ttention: DAVID POTT
ollected By: CUSTOMER

Matrix: WATE
Date Logged In: 08/25/200
Hour Logged In: 07:31:55
Sampling Point: (DUPL) D/S WWT
Collection Date: 08/24/2005 Hour: 0930

ANALYTE	RESULT
Biological Oxygen Demand	6.9 MG/L
Ammonia Nitrogen	2.1 MG/L
Nitrate-Nitrite Nitrogen	0.052 MG/L

Respectfully submitted:
D.J. Gillespie
Technical Services Mar

). Box 1566 Rte 15E Mt. Vernon Airport Mt.Vernon, Illinois 62864 (618)24

Illinois Department of Agriculture

Rod R. Blagojevich, Governor

Bureau of Animal Disease Laboratory ● 9732 Shattuc Rd. ● Centralia, IL 62801-5858 ● 618/532-6701 ● Fax 618/532-1195

Accession No: 346860

WATER

WATER PRIVATE

DAVID POTT
BAETIS
2650 W MONTROSE AVE SUITE 307
CHICAGO IL 60618

Date Submitted: 8/22/2005
Date Reported: 8/24/2005

PH: 773-4635858 FAX: 312 - 3620052

ample ID	Family:	Species:	Breed:	Sex:	Age:	Wt:
-BOK01						
-BOK02						
-BOK13						
-BOK03						

Notes:
KASKASKIA RIVER

LABORATORY FINDINGS
BACTERIOLOGY RESULTS:

1-BOK01 Water Culture, bacterial, aerobic, quantitative, E coli: 114 cfu/100ml

2-BOK02 Water Culture, bacterial, aerobic, quantitative, E coli: 70 cfu/100ml

3-BOK13 Water Culture, bacterial, aerobic, quantitative, E coli: 55 cfu/100ml

4-BOK03 Water Culture, bacterial, aerobic, quantitative, E coli: 117 cfu/100ml

Mark Hemker, Microbiologist
8/24/05

Gene Niles, DVM, MS, DABVP, DABVT
Laboratory Director
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Accession No: 346904

WATER

WATER PRIVATE

DAVID POTT
BAETIS
2650 W MONTROSE AVE SUITE 307
CHICAGO IL 60618

Date Submitted: 8/23/2005
Date Reported: 8/25/2005

PH: 773-4635858 FAX: 312 - 3620052

ample ID	Family:	Species:	Breed:	Sex:	Age:	Wt:
-BOKEZ-11						
-BOKZ-41						
-BOKF-11						
-BOKFZ-11						
-Blank						
-BOK-01						

Notes:

LABORATORY FINDINGS
BACTERIOLOGY RESULTS:

1-BOKEZ-11 Water Culture, bacterial, aerobic, quantitative, E coli: 263 CFU/100ML

2-BOKZ-41 Water Culture, bacterial, aerobic, quantitative, E coli: 108 CFU/100ML

3-BOKF-11 Water Culture, bacterial, aerobic, quantitative, E coli: 613 CFU/100ML

4-BOKFZ-11 Water Culture, bacterial, aerobic, quantitative, E coli: 649 CFU/100ML

5-Blank Water Culture, bacterial, aerobic, quantitative, E coli: 0 CFU/100ML

6-BOK-01 Water Culture, bacterial, aerobic, quantitative, E coli: 55 CFU/100ML
LG 8/25/2005

Mark Hemker, Microbiologist

Gene Niles, DVM, MS, DABVP, DABVT
Laboratory Director
8/25/05

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Accession No: 346982

WATER

WATER PRIVATE

Date Bled: 8/24/2005

Date Submitted: 8/24/2005

Date Reported: 8/26/2005

DAVID POTT
BAETIS
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CHICAGO IL 60618

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ample ID	Family:	Species:	Breed:	Sex:	Age:	Wt:
-BOK-16						
-BOKEZ-11						
-BOK-01						
-Blank						

Notes:

LABORATORY FINDINGS
BACTERIOLOGY RESULTS:

1-BOK-16 Water Culture, bacterial, aerobic, quantitative, E coli: 151cfu/100ml

2-BOKEZ-11 Water Culture, bacterial, aerobic, quantitative, E coli: 82cfu/100ml

3-BOK-01 Water Culture, bacterial, aerobic, quantitative, E coli: 25cfu/100ml

4-Blank Water Culture, bacterial, aerobic, quantitative, E coli: 0cfu/100ml
MH 8/25/2005

Michele Hester, Analyst
Gene Niles, DVM, MS, DABVP
Laboratory Director

Appendix C. SOD Computation

SOD Calculation Sheet

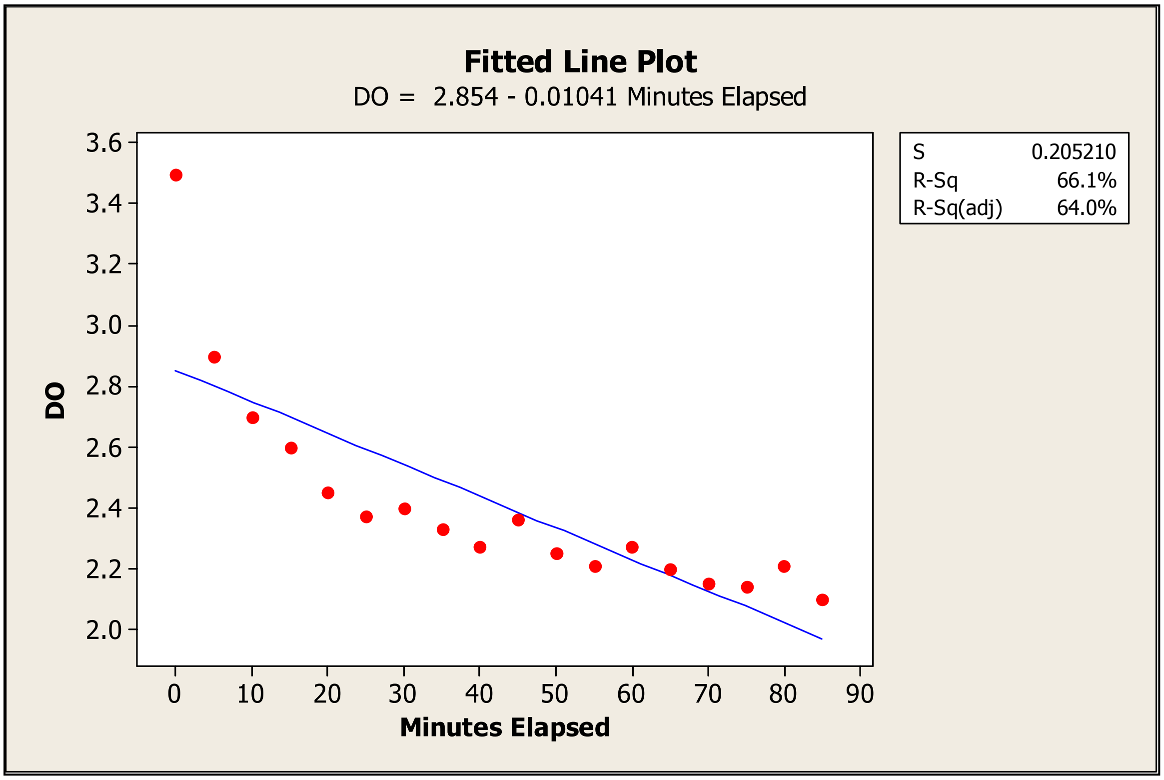
Project East Fork Kaskaskia TMDL
Site BOK02

Data Collected 23-Aug-05
Habitat Descr: Pool, silty sand substrat

Dark Bottle

	Time	DO (mg/L)	Temperature ©
	12:45	5.0	23.5
	14:20	4.75	24.0
Difference	1:35	0.25	0.5
"Background" Rate		0.0029412 mg/L/min	

SOD Chamber Results



SOD Calculation

Volume of Chamber	15.9	liters
Area of Chamber	0.1297	sq meters

SOD @ 23.75 C	1.318682	g/sq m/d
SOD @ 20 C	1.041308	g/sq m/d

DBP
13-Sep-05

Illinois
Environmental
Protection Agency

Stage Three Report
TMDLs for Target Watersheds

Project Watershed HUC 0714020205 (East Fork Kaskaskia River)
Farina Lake (SOB), Kinmundy Old (ROZY), Kinmundy New (SOF), Kinmundy Borrow Pit (SOG)

Prepared by

Baetis
ENVIRONMENTAL SERVICES, INC.
Chicago, Illinois

On behalf of Limno-Tech, Inc., Ann Arbor, Michigan
August 2005

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TMDLS FOR TARGETED WATERSHEDS, HUC 0714020205, EAST FORK KASKASKIA RIVER WATERSHED

FARINA LAKE (SOB), KINMUNDY OLD (ROZY), KINMUNDY NEW (SOF), AND KINMUNDY BORROW PIT (SOG)

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1. INTRODUCTION

1.1 Background

The State of Illinois assesses its water bodies for compliance with water quality standards established to protect their designated uses. This assessment is required by the federal Clean Water Act. Section 303(d) of the Clean Water Act requires states to identify waters which will not attain applicable water quality standards with technology-based controls alone. Water bodies so identified are placed on a 303(d) list and prioritized to have a Total Maximum Daily Load (TMDL) developed. The TMDL is specific to the water quality constituent(s) that is in violation of the water quality standard. 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 in-stream water quality conditions. This allows water quality based controls to be developed to reduce pollution and to restore and maintain water quality.

In the East Fork Kaskaskia Watershed, five water bodies have been identified as being water quality limited and are on Illinois' 2004 303(d) list. A segment of the East Fork Kaskaskia River is impaired by fecal coliform bacteria and dissolved oxygen deficits; a TMDL for these impairments will be the subject of a separate report. The water quality impairment in the four other listed waterbodies is caused by manganese (Mn). This report establishes manganese TMDLs for: Farina Lake (termed segment SOB), Old Kinmundy Lake (segment ROZY), New Kinmundy Lake (segment SOF) and Kinmundy Borrow Pit (SOG). All four lakes are public water supply lakes and have been assigned a high priority for TMDL development.

A TMDL for siltation in the East Fork Kaskaskia River (segment OK01) has previously been established (Harza 2003).

1.2 Watershed Description

The East Fork Kaskaskia Watershed (HUC 0714020205) is 82,254 acres (33,288 ha) in area. It is largely agricultural, with extensive soybean and corn production on its fertile glacial till soils. The watershed is described in detail in a Stage One TMDL Report.

The specific drainage to each of the four water supply lakes is relatively small, and in the cases of the two borrow pits, not much larger than the lakes themselves.

1.3 Water Quality Standard

The water use designation for Farina Lake, Old Kinmundy Lake, New Kinmundy Lake and Kinmundy Borrow Pit is public water supply. This designated use, as stated in Title 35 of the Illinois Administrative Code, is established to protect waters withdrawn for treatment and distribution as a potable supply or for food processing. The standard for total manganese in untreated public water supplies is 0.15 mg/L.

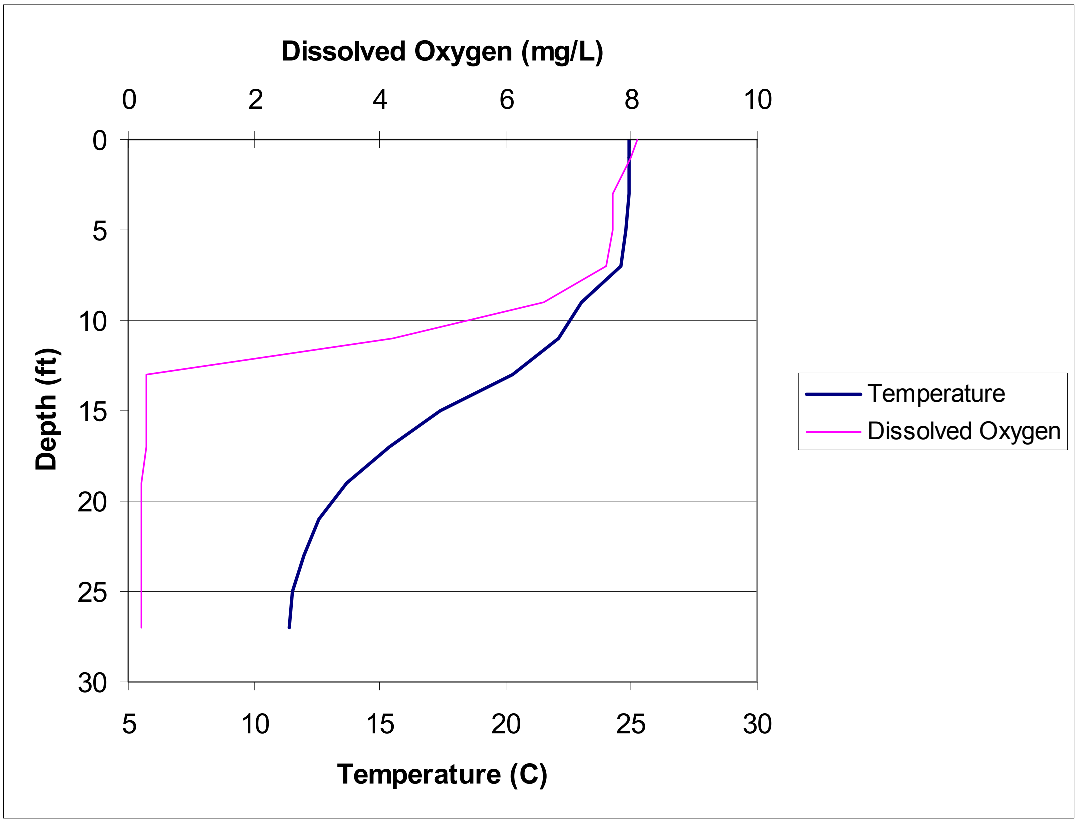
2. WATER QUALITY ASSESSMENT

These four lakes are sampled through the Agency's Ambient Lake Monitoring Program (ALMP) on a five-year cycle. Table 1 reprints available manganese data for these four lakes, some of it newly available since the Stage One TMDL Report was published. All lake water samples were collected at mid-depth at the sampling site(s). Note the significant instances of non-compliance with the public water supply standard 150 µg/L. Seasonality of Mn maxima is also apparent, with mid-summer periods showing the highest concentrations.

Table 2 provides summary statistics for the ALMP manganese data. The mean Mn concentrations for the lakes are all above the 150 µg/L water quality standard. Table 2 also illustrates that datasets with so few observations lead to large confidence intervals, and consequently, lowered certainty in the assessments.

During warmer months, lakes undergo thermal stratification wherein the surface waters of lakes warm more than bottom waters. As the weather warms, the thermal stratification becomes more severe. The warmer surface waters are less dense than cooler bottom waters. In this stratified condition, the surface layer of water (epilimnion) does not mix with bottom waters (hypolimnion). Thermal stratification in lakes is usually accompanied by chemoclines (changes in chemistry), where surface water quality differs from bottom waters. Dissolved oxygen is the classic example (Figure 1), but other parameters can vary with depth as well. This stratification begins in springtime, reaches a maximum during August or September, and usually ends in Illinois' lakes sometime in October as the weather cools and the lake "turns over", and the entire water column destratifies and mixes.

Figure 1. DO and Temperature Profile, Farina Lake (SOB), Aug. 25, 2004



In the aquatic environment, Mn has multiple valence states in the environment and these valence states vary in solubility. Under aerobic (or oxidized) conditions, Mn exists as the less soluble oxidized species (Mn III, IV) and, under reduced conditions, the more soluble species (Mn II) predominates. The oxidation-reduction chemistry of Mn (and the similar metal iron) is well studied in lakes. In the oxidized state, that is in a lakes' oxygen-rich epilimnion, Mn is largely in particulate form, possibly colloidal, and present as Mn III or Mn IV. During summer stratification, lakes develop anoxia in bottom waters and manganese undergoes chemical reduction to Mn II (before iron does) and becomes dissolved in the hypolimnetic water layer (Cole 1994). Limnologists have found that increases in water column profiles of dissolved Mn may be associated with the reduction of Mn as particles settle into the anoxic zones of lakes, or from reduction and upward transport of dissolved manganese derived from bottom sediment (Davison 1985). Hence, the measurements of Mn in the midwater samples collected by the ALMP exceed the water quality standard as a result of thermal stratification and the development of reducing conditions in the hypolimnion. Because the epilimnion and hypolimnion do not substantially mix during stratification, manganese-rich bottom waters may be overlaid by a Mn-poor epilimnion. ALMP samples that are analyzed for manganese (Table 1) are collected at mid-depth, and are typically representative of the hypolimnion or the metalimnion (transitional zone).

Table 1
Lake Water Quality Data
(Source: ALMP)

Lake	Segid	Site	Date	Depth (ft)	Mn (µg/L)
Farina	SOB		4/29/1999	16	76
	SOB		6/3/1999	15	150
	SOB		7/2/1999	16	620
	SOB		8/30/1999	15	550
	SOB		10/4/1999	15	260
	SOB		4/28/2004	16	32
	SOB		6/15/2004	16	82
	SOB		7/20/2004	16	210
	SOB		8/25/2004	16	550
	SOB		10/7/2004	16	170
Kinmundy Old	ROZY	1	6/27/2003	7	660
	ROZY	1	7/28/2003	7	1,900
	ROZY	1	8/26/2003	6	90
	ROZY	1	10/22/2003	7	370
	ROZY	2	5/15/2003	4	240
Kinmundy New	SOF	1	4/25/2001	13	160
	SOF	1	6/5/2001	14	190
	SOF	1	7/18/2001	12	1,000
	SOF	1	8/15/2001	12	150
	SOF	1	10/18/2001	13	990
	SOF	1	4/14/2005	7	160
Kinmundy Borrow Pit	SOG		4/12/2001	7	75
	SOG		6/12/2001	7	58
	SOG		8/13/2001	6	170
	SOG		10/2/2001	6	540
	SOG		4/14/2005	5	98

Table 2
Compliance with Water Quality Standard, Means, and 95% Confidence Intervals for Lake Manganese Concentrations

Waterbody	Non-Compliance	Mean Concentrations
SOB – Farina	6 out of 10 measurements	270 µg/L ± 158 µg/L
ROZY – Kinmundy Old	4 out of 5 measurements	652 µg/L ± 904 µg/L
SOG – Kinmundy Borrow Pit	2 out of 5 measurements	188 µg/L ± 250 µg/L
SOF – Kinmundy New	5 out of 6 measurements	442 µg/L ± 450 µg/L

3. SOURCE ASSESSMENT

3.1 Kinmundy Old, ROZY

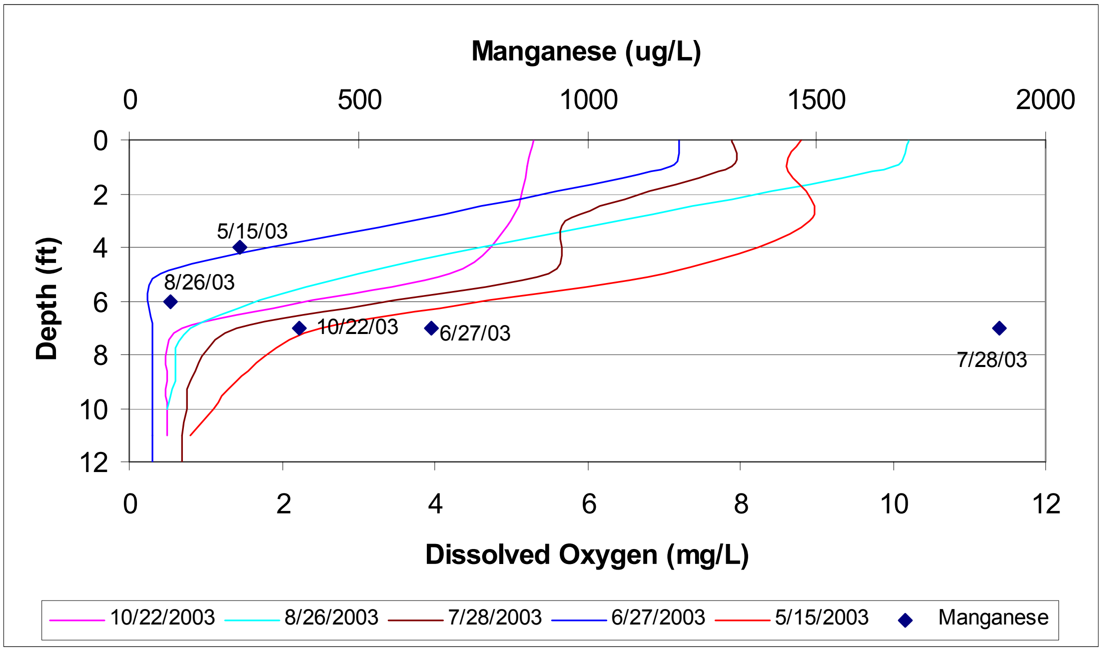
The source of manganese in ROZY is seasonal reduction of manganese in lake sediment during summer anoxia. While there are non-point sources of manganese from the watershed in the form of eroded soils, these are particulate forms and settle after being transported to the lake. Only after reduction to Mn II does the metal dissolve, enter the lake water column and cause it to exceed the water quality standard in hypolimnetic waters.

Figure 2 illustrates ALMP dissolved oxygen profiles and midwater Mn concentration data. Thermal stratification was present at various stages during all five sampling events. All midwater samples collected at site 1 in ROZY represent the hypolimnion or lower metalimnion. Three of the four samples from site 1 exceed the 0.150 mg/L standard.

While coal mining has occurred in the Kinmundy area, mining was underground and is now inactive and not discharging to surface water.

No point sources discharge to ROZY.

Figure 2. DO (mg/L) and Manganese (µg/L) Concentrations in ROZY-1



In ROZY, Old Kinmundy, sediment manganese was measured by the ALMP at two sites in 2003 to be 2,700 and 1,500 mg/kg.

3.2 Kinmundy New, SOF

The dominate source of manganese in SOF is seasonal reduction of manganese minerals in lake bottom sediment during summer anoxia. There are three other potential sources of manganese at SOF:

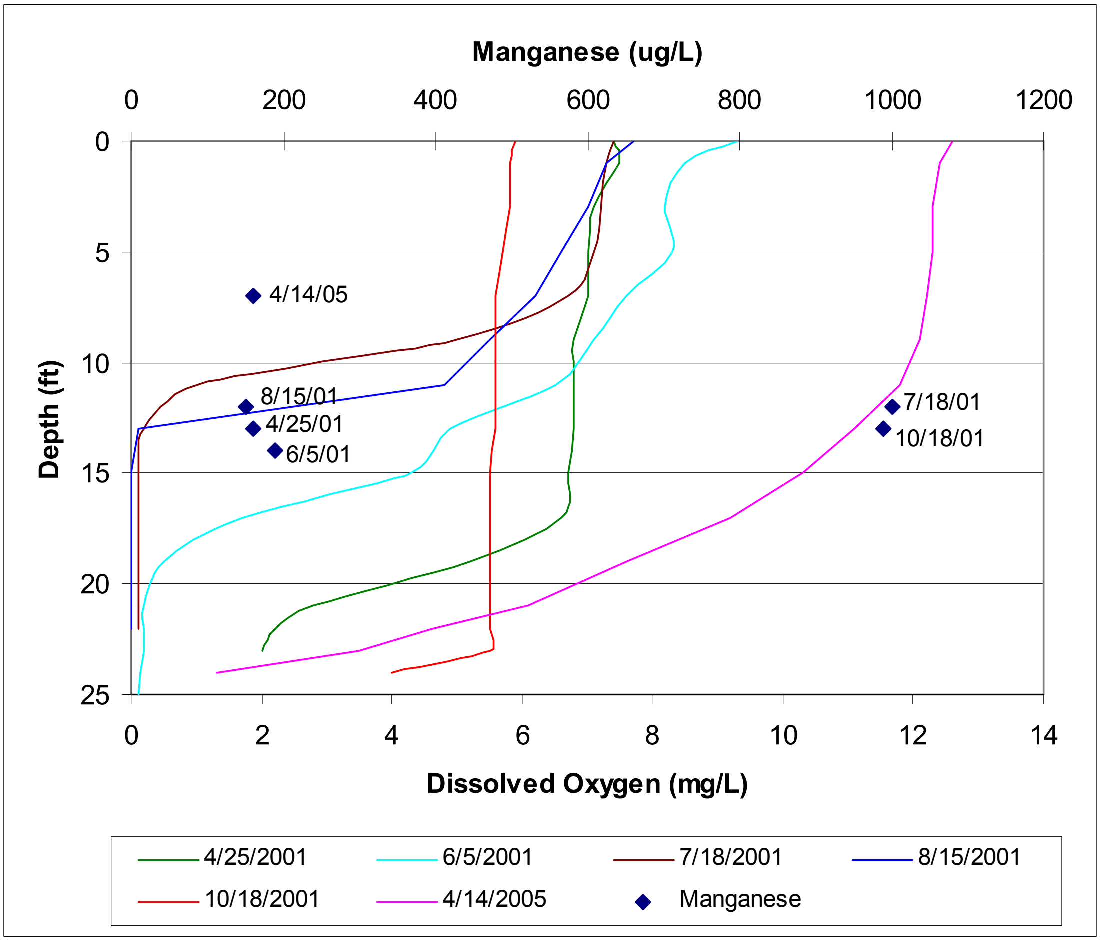
1. Manganese from eroded watershed soils
2. Manganese in spill from ROZY
3. Manganese in water pumped from the borrow pit, SOG

Particulate manganese from eroded soil that enters SOF will settle out. As described above, summer anoxia reduces the Mn in sediment to soluble forms that enter the lake water column and cause it to exceed the water quality standard in hypolimnetic waters. Spill from ROZY is from the surface of that lake and does not likely contain significant concentrations of soluble Mn. The City of Kinmundy pumps water to and from the borrow pit (SOG) to manage storage, but the pumps are not metered. Water is withdrawn from the floating intake platform in SOG at a depth of four feet; review of temperature-

DO profiles for SOG during the summer indicates that the depth of this intake is in the aerobic epilimnion and should not contain significant concentrations of dissolved Mn (Figure 3).

Neither coal mining nor point sources discharge to SOF.

Figure 3. DO (mg/L) and Manganese (μg/L) Concentrations in SOF



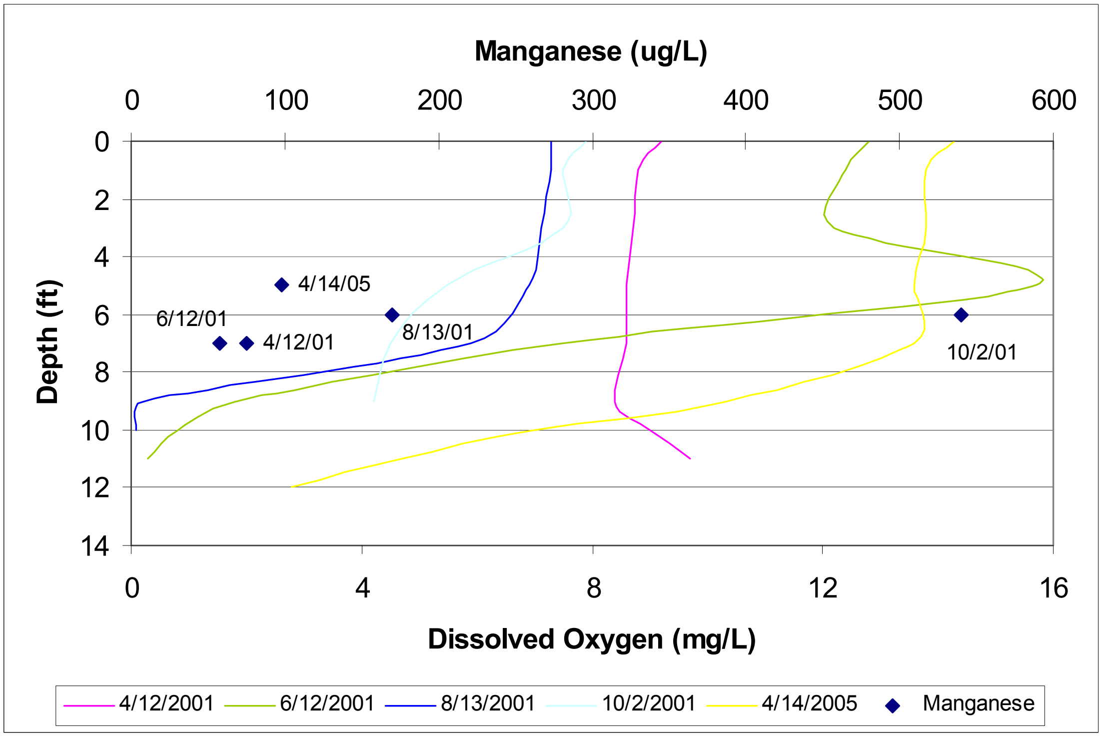
3.3 Kinmundy Borrow Pit, SOG

The dominate source of manganese in SOG is seasonal reduction of manganese in lake sediment during summer anoxia. The only other potential source would be manganese from eroded watershed soils. The drainage area to SOG is limited to the immediate shoreline area, which is well vegetated. Erosion from upstream drainage area will be minimal and will contain negligible amounts of manganese.

As indicated above, the City pumps water to and from the new lake (SOF) to manage storage, but the pumps are not metered. When water is pumped from SOF to SOG, it is withdrawn from SOF at a depth of 7 feet. Temperature-DO profiles for SOF during the summer indicate that the depth of this intake is in the aerobic epilimnion, and as such, should contain concentrations of dissolved Mn much lower than an intake located in deeper waters. There are five manganese samples from SOG and SOF taken on the same or nearly the same days. Correlation analysis on this limited number of samples indicates that they are strongly correlated (R^2=94%; α=.05; P=.006); this may simply reflect similar seasonal influences on Mn dynamics or may suggest the influence of pumping between the two water bodies. Figure 4 illustrates DO profiles and midwater Mn concentrations collected by the ALMP. Two samples exceed the 150 μg/L standard. On Aug. 13, 2001, Mn was measured to be 170 μg/L, but on Oct. 2, 2001, Mn was 540 μg/L. Manganese was also high in SOF in October 2001, and that lake may have turned over prior to the sampling of SOG on Oct. 2. Turn-over will mix Mn in the water column and could present a source of Mn to SOG other than internal loading.

Neither coal mining nor point sources discharge to SOG. Infiltration of shallow groundwater to SOB may be a source of Mn, but no data on groundwater infiltration rates or Mn concentrations in shallow groundwater are available.

Figure 4. DO (mg/L) and Manganese (μg/L) Concentrations in SOG



3.4 Farina Lake, SOB

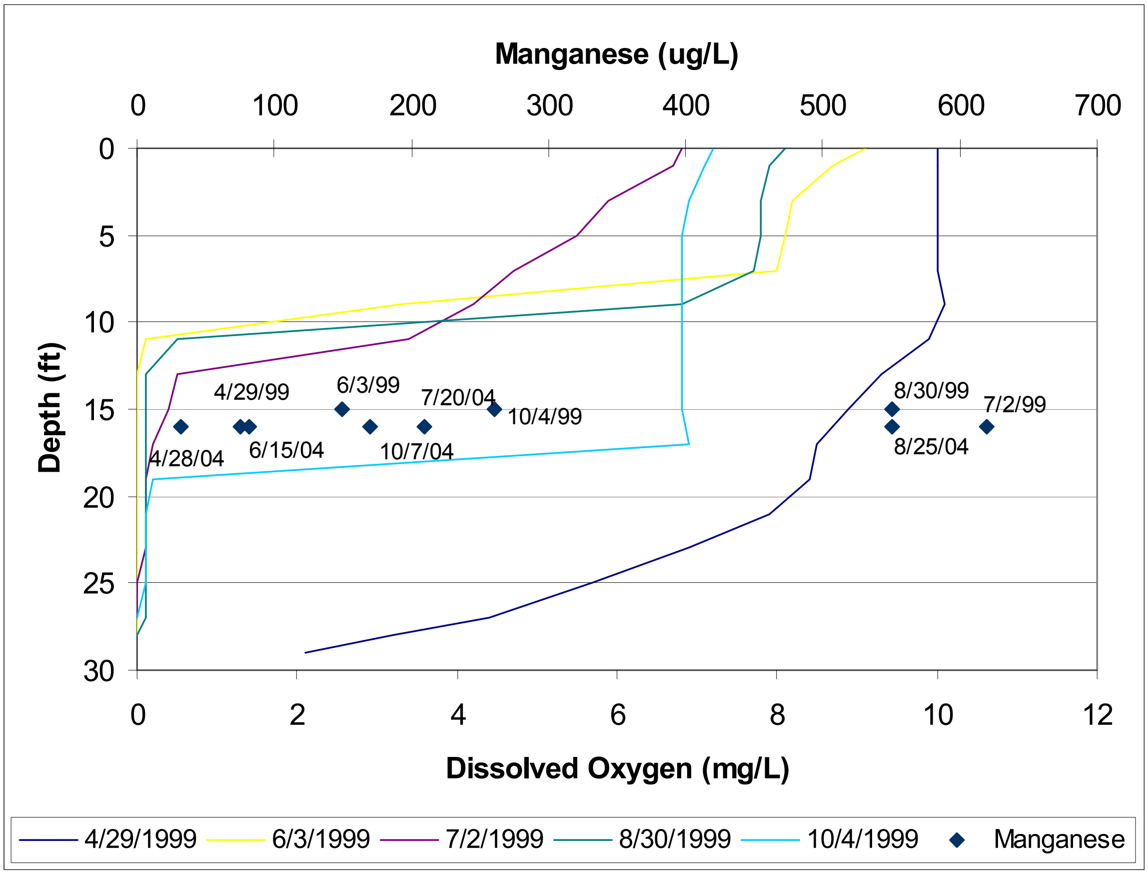
Sources of manganese in SOB include seasonal reduction of manganese in lake sediment during summer anoxia, and pumping of water containing Mn from the Loy Pit and from East Fork Kaskaskia River.

The drainage area to SOB is limited to the immediate shoreline area and local runoff is a very minor portion of the lake's water budget. Erosion from the drainage will contain negligible amounts of manganese. The Village of Farina pumps water from the East Fork Kaskaskia River to supplement SOB. This pumping is not metered, but occurs principally during moderate flow periods (i.e. generally not summer, as the stream may be dry). Data from STORET for the East Fork Kaskaskia River at station OK01 has a long-term average total manganese concentration of 526 μg/L. The Village also pumps from the Loy Pit to supplement their water supply. This pumping is also not metered, and no data on Mn concentrations in Loy Pit are available. The system is managed to maintain SOB as full as possible. Interviews with the operators revealed that they estimate that about

50% of the supply is pumped from the Loy Pit and about 50% from the East Fork Kaskaskia River.

Figure 5 illustrates two years of available data on midwater Mn concentrations from Farina Lake, together with one year of DO profiles.

Figure 5. DO (mg/L) and Manganese (μg/L) Concentrations in SOB



Infiltration of shallow groundwater to SOB may be a source of Mn, but no data on groundwater infiltration rates or Mn concentrations in shallow groundwater are available. Neither coal mining nor point sources discharge to SOB or the Loy Pit. Manganese in Farina Lake sediment was measured by the ALMP in 2004 as 430 mg/kg (dry wt basis).

4. ALLOCATIONS

4.1 Total Maximum Daily Load

A TMDL is the sum of the individual waste load allocations (WLA) for point sources and load allocations (LA) for nonpoint sources and natural background (40 CFR 130.2). The sum of these allocations may not result in an exceedence of water quality standards for that water body. To protect against exceedences, the TMDL includes a margin of safety (MOS) that accounts for uncertainties in the relationship between pollutant loads and the receiving water body. Mathematically, the TMDL is expressed as:

$$TMDL = \sum WLA + \sum LA + MOS \qquad \text{(Eq. 1)}$$

Because none of the four lakes have waste loads, Equation 1 reduces to:

$$TMDL = \sum LA + MOS \qquad \text{(Eq. 2)}$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while maintaining water quality standards. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure. The TMDL, or loading capacity, of the four lakes is developed from the 150 µg Mn/L standard and the assimilative volume of the lake (Appendix A). During the period of time that the lake is not stratified, the assimilative volumes were calculated as the sum of lake volume and inflows. During summer stratification, the assimilative volume was taken as the volume of the hypolimnion and inflows. Thermal stratification is a seasonal phenomenon, and the assimilative lake volume will vary during the course of a year from the entire lake (and any flow-through volumes) to late summer just prior to lake turn-over, when the hypolimnion volume is a minimum. For the purposes of Mn TMDL development, the summer stratification period is considered a critical condition, when the lake's assimilative capacity is at a minimum.

Table 3
SEASONAL MANGANESE LOADING CAPACITY (LC) (lb/d)

Waterbody	Summer	Winter
SOB – Farina	0.25	0.43
ROZY – Kinmundy Old	0.40	1.01
SOG – Kinmundy Borrow Pit	0.07	0.17
SOF – Kinmundy New	1.47	5.53

4.2 Waste Load Allocations

There are no point sources discharging to any of the four lakes, so waste load allocations are zero for all four lakes.

4.3 Load Allocations

Load allocation (LA) is that portion of a receiving water body's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. Load allocations are best estimates of the allowable loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and techniques used to predict the loading. All Mn loads to the four water supply lakes are nonpoint, and for the most part, are seasonal.

Manganese load allocations are given for the four water supply lakes below (Table 4), and represent the difference between the load capacity and the MOS.

4.4 Seasonal Variation

Manganese is the pollutant of concern for all four water supply lakes due to thermal stratification and hypolimnetic reduction processes. This seasonal phenomenon is the primary cause of the Mn-impairments. The load estimates and allocations were based on the critical conditions (worst-case seasonal conditions) that occur during a typical summer.

The goal of this TMDL is to eliminate, to the extent practicable, those conditions leading to seasonably high Mn concentrations in the four lakes. Since hypolimnetic Mn reduction is a seasonal phenomenon, the preventative measures will be designed to control Mn reduction during periods of thermal stratification.

4.5 Margin of Safety

A Margin of Safety (MOS) is included in TMDLs to account for uncertainties in calculations of loads and predictions of receiving water quality. The most significant sources of uncertainty in these TMDLs are the following:

1. Lack of data to estimate pumping of water between the East Fork Kaskaskia River and Farina Lake (SOB) and pumping of water between SOB and Loy Pit.
2. Lack of data to estimate pumping of water between Kinmundy Old (SOF) and Kinmundy Borrow Pit (SOG)
3. Few water quality measurements were taken during non-stratified periods
4. Lack of data on the potential contribution of shallow groundwater to the water and manganese budgets of the four lakes. This source is likely greater in the two borrow pits than the two impoundments.
5. Potential transport of hypolimnetic dissolved manganese across the thermocline due to epilimnetic water withdrawals, storm events, power boating, and other lake mixing phenomena.

There are two methods for incorporating a MOS in the TMDL analysis:

1. Implicitly incorporate the MOS using conservative assumptions for development of the allocations; or
2. Explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations

There are elements of implicit and explicit MOS factors in each of these TMDLs. Conservative assumptions were generally made in the calculations. An example of conservatism is the use of late summer stratification data to estimate the lake assimilative volume, rather than a summer average, i.e. a critical condition. The calculation of assimilative volumes assumed that the lakes were strongly stratified for 215 days each year (Appendix A), which results in an overestimation of the LA and the required percent reductions. In actuality, lake thermal stratification develops gradually as the weather warms in spring; in other words, summer lake assimilative volumes gradually approach those tabulated in A-3. Conversely, fall turnover in lakes occurs rapidly, and the summer LC does indeed rapidly increase to the winter LA values. Another example of conservatism in the calculations is related to uncertainty #5 above; we assumed that there is no transport of Mn across the thermocline. This assumption also tends to overestimate the LA and required load reductions.

In addition to these examples of implicit MOS, we opted to add an additional 40% MOS to these TMDLs. This additional MOS is justified because of the lack of information on mechanisms and magnitudes of Mn transport that are listed above. These mechanisms are important and the TMDLs are sensitive to these unknowns. An explicit MOS of 40% is included in the TMDL for each lake (Table 4) to account for the uncertainties listed above.

4.6 TMDL Summary

Table 4 contains the LA, MOS and percent reductions required for each of the four lakes, during winter (mixed water column) and summer (stratified, critical condition). The range of required manganese load reductions is from zero during winter at Farina Lake (SOB) and Kinmundy Borrow Pit (SOG), to as much as 86% during summer at Kinmundy Old (ROZY).

Table 4
TMDL SUMMARY
(lb/d, except where indicated otherwise)

Lake	Season	Existing Load	LC	WLA	LA	MOS	% Reduction
SOB	Winter	0.16	0.43	0	0.26	0.17	-
	Summer	0.46	0.25	0	0.15	0.10	67%
ROZY	Winter	1.35	1.01	0	0.61	0.40	55%
	Summer	1.74	0.40	0	0.24	0.16	86%
SOG	Winter	0.10	0.17	0	0.10	0.07	-
	Summer	0.09	0.07	0	0.04	0.03	52%
SOF	Winter	5.90	5.53	0	3.32	2.21	44%
	Summer	4.32	1.47	0	0.88	0.59	80%

5. REFERENCES

Cole, G. A. 1994. Textbook of Limnology. Waveland Press, Inc., Chicago, Illinois.

Davison, W. 1985. Conceptual Models for Transport at a Redox Boundary. Chemical Processes in Lakes, edited by W. Stumm. John Wiley, New York.

Harza (Harza Engineering Company, Inc.) 2003. East Fork Kaskaskia River (ILOK01) TMDL and Implementation Plan. Prepared for the Illinois EPA by Harza Engineering Company, Chicago, Illinois. Available at http://www.epa.state.il.us/water/tmdl/tmdl-reports.html.

APPENDIX A – COMPUTATION OF LOADS AND ALLOCATIONS

APPENDIX A
COMPUTATION OF LOADS AND ALLOCATIONS

A.1 Assimilative Volumes

For the purposes of estimating loads, we defined the lake assimilative volume as the sum of a seasonally-based lake volume estimate, natural inflows, and pumping. This definition assumes that inflows and pumping represented water available to manganese from the internal lake loading. During winter, this assumption clearly is valid. During summer, we assume that the inflows and pumping mix with the hypolimnion. We performed the computations for two seasons, winter and summer, representing two extreme conditions:

- A mixed unstratified period representing winter (150 days – November through March)
- A stratified period representing summer (215 days – April through October)

Lake volumes were estimated as cubic functions of depth (Table A-1). Farina Lake was assumed to be shaped as a frustrum of a right circular cone, with a maximum depth of 32 feet and maximum volume of 30 million gallons. Kinmundy Borrow Pit was estimated as a pyramidal frustrum with maximum depth of 11 feet and full volume of 17 million gallons.

Table A-1
LAKE DEPTH-VOLUME RELATIONSHIPS

Name	Segment ID	Function
Farina	SOB	Vol (gal) = 9020 + 909.4 Depth(ft)^3
Kinmundy Old	ROZY	Vol (gal) = -276081 + 10641 Depth(ft)^3
Kinmundy Borrow Pit	SOG	Vol (gal) = 1772891 + 11784 Depth ^3
Kinmundy New	SOF	Vol (gal) = -15917933 + 20867 Depth (ft)^3

During winter, lake assimilative volumes were taken as full pool volume. During summer, the assimilative volume was seasonally adjusted, estimated using the above functions and the depth of the thermoclines measured by the ALMP.

Natural inflows were estimated by transposing mean monthly flows as measured at the USGS gage on the East Fork Kaskaskia River at Sandoval, IL (05592900). Pumping estimates are shown in Table A-2. Average monthly evaporation rates were taken from the Illinois Climate Network's monitoring station at Olney, IL.

Table A-2
ESTIMATION OF THE PUMPED WATER COMPONENT OF ASSIMILATIVE VOLUME

Lake	Winter Season	Summer Season
SOB	Daily water use	Daily water use plus evaporative losses
ROZY	None	None
SOG	None	Replacement of evaporative losses
SOF	None	None

Seasonally-based lake assimilative volumes, computed in this method, are tabulated below.

Table A-3
ESTIMATED SEASONAL ASSIMILATIVE VOLUME
(in million gallons)

Lake	Winter Season	Summer Season
SOB	52	44
ROZY	121	69
SOG	20	12
SOF	663	252

A.2 Estimation of Existing Loads

We estimated Mn loads as the product of the seasonally-based assimilative volume and seasonal Mn concentrations. This approach balances mass and produced reasonable estimates of the loads to these lakes (Table A-4). Mn concentration values for winter were the ALMP measurements for April (no wintertime measurements are available); values for summer were taken from Table 2.

Table A-4
ESTIMATED SEASONAL MANGANESE LOADS

Lake	Concentration (µg/L)	Load (g/d)	Load (lb/d)
Winter			
SOB – Farina	54	7.08E+01	0.16
ROZY – Kinmundy Old	200	6.10E+02	1.35
SOG – Kinmundy Borrow Pit	87	4.32E+01	0.10
SOF – Kinmundy New	160	2.68E+03	5.90
Summer			
SOB – Farina	270	2.08E+02	0.46
ROZY – Kinmundy Old	652	7.88E+02	1.74
SOG – Kinmundy Borrow Pit	188	4.07E+01	0.09
SOF – Kinmundy New	442	1.96E+03	4.32

A.3 Estimation of Load Capacity and Allocations

Load Capacity (LC), or the TMDL, was estimated in a manner similar to the existing load, but the concentration term was replaced with the water quality standard.

The Load Allocation (LA) was estimated as the difference between the MOS and the LC (Table A-5).

Table A-5
TMDL SUMMARY
(lb/d, except where indicated otherwise)

Lake	Season	Existing Load	LC	WLA	LA	MOS	% Reduction
SOB	Winter	0.16	0.43	0	0.26	0.17	-
	Summer	0.46	0.25	0	0.15	0.10	67%
ROZY	Winter	1.35	1.01	0	0.61	0.40	55%
	Summer	1.74	0.40	0	0.24	0.16	86%
SOG	Winter	0.10	0.17	0	0.10	0.07	-
	Summer	0.09	0.07	0	0.04	0.03	52%
SOF	Winter	5.90	5.53	0	3.32	2.21	44%
	Summer	4.32	1.47	0	0.88	0.59	80%

APPENDIX B – RESPONSIVENESS SUMMARY

APPENDIX B
RESPONSIVENESS SUMMARY

Stages One and Three of this TMDL effort have both included public participation. This responsiveness summary outlines the efforts to involve the public in this TMDL. It also responds to substantive questions and comments received during the Stage 3 public comment period from July 25, 2005, through August 24, 2005, postmarked, including those from the August 8, 2005, public meeting discussed below.

C.1 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 Illinois EPA will be developing a plan to implement the East Fork Kaskaskia River Watershed TMDL detailing the actions necessary to reduce pollutant loads to the impaired water bodies and 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.

C.2 Background

The watershed targeted for TMDL development is East Fork Kaskaskia River (HUC 0714020205), which occupies portions of Clinton, Fayette and Marion Counties in Illinois. The East Fork Kaskaskia River Watershed encompasses an area of approximately 82,254 acres. Land use is predominately agricultural, with extensive soybean and corn production. In the East Fork Kaskaskia Watershed, five water bodies have been identified as being water quality limited and are on Illinois" 2004 303(d) list. A segment of the East Fork Kaskaskia River is impaired by fecal coliform bacteria and dissolved oxygen deficits; a TMDL for these impairments will be the subject of a separate report.

TMDLs developed for the other four impaired water bodies in the East Fork Kaskaskia River watershed include Farina Lake (SOB), Kinmundy Borrow Pit (SOG), Kinmundy Lake New (SOF), and Kinmundy Lake Old (ROZY). In the 2004 Section 303(d) List, Farina Lake (SOB) was listed as impaired for the following parameters: manganese, copper, total phosphorus (numeric standard). Kinmundy Borrow Pit (SOG) was listed as impaired for the following parameters: manganese. Kinmundy Lake New (SOF) was listed as impaired for the following parameters: manganese. Kinmundy Lake Old (ROZY) was listed as impaired for the following parameters: manganese. 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. Therefore, TMDLs were only developed for manganese for Farina Lake (SOB), Kinmundy Borrow Pit (SOG), Kinmundy Lake New (SOF), and Kinmundy Lake Old (ROZY). The Illinois EPA contracted with Limno-Tech, Inc., to prepare a TMDL report for the East Fork Kaskaskia River watershed; Limno-Tech's subcontractor for this TMDL is Baetis Environmental Services, Inc.

C.3 Public Participation

Stage One of this TMDL development effort included opportunities to involve local watershed institutions and the general public. 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. That report is attached as Appendix B.

In February 2005, a public meeting was announced scheduling the presentation of the Stage One findings. The 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 Thursday, March 17, 2005 in Patoka, Illinois at the Village Civic Center. In addition to the meeting's sponsors, 18 individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program and the Stage One findings. This was followed by a general question and answer session.

The Agency entertained questions and concerns from the public at least through April 18, 2005. While there were several general questions, the Village of Farina expressed specific concerns regarding the limited data to support the listing of Farina Lake (SOB) and its Mn-caused impairment. Subsequently, the Village was informed that additional water quality data were collected in 2004 by the Agency. These data were made available for use in formulating this Mn TMDL. Farina also reported that they recently began monitoring ammonia nitrogen and fecal coliform bacteria in the Village's WWTP effluent and would be willing to share these data with the Agency for TMDL development.

Additional opportunities for stakeholder involvement occurred during Stage Three. The Illinois EPA provided public notice for the August 8, 2005, meeting by advertising in the *Centralia Morning Sentinel* and the *Salem Time-Commoner* on July 25, 2005. The 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 52 individuals and organizations were also sent the public notice by first class mail. The draft TMDL Report was available for review at the Kinmundy City Hall offices and also on the Agency's web page at http://www.epa.state.il.us/water/tmdl.

In July 2005, a draft TMDL report was posted on the Agency's website for public review. A public meeting was announced for August 8 in Kinmundy. The meeting was held at 6:30 pm in the Kinmundy Community Center and concluded at 8:45 pm. In addition to the meeting's sponsors, four individuals attended the meeting. After registration of the attendees, the TMDL consultant reviewed the Stage Three findings. This was followed by a general question and answer session and specific discussions regarding implementation planning. Written comments on the TMDL were accepted through August 24. Neither the Illinois EPA nor their consultant received written substantive questions and comments during the public comment period.

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Illinois
Environmental
Protection Agency

TMDL Implementation Plans

Project Watershed HUC 0714020205 (East Fork Kaskaskia River)

Farina Lake (SOB), Kinmundy Old (ROZY), Kinmundy New (SOF), Kinmundy Borrow Pit (SOG)

Prepared by

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ENVIRONMENTAL SERVICES, INC.
Chicago, Illinois

On behalf of Limno-Tech, Inc., Ann Arbor, Michigan

March 2006

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TMDL IMPLEMENTATION PLANS

FARINA LAKE (SOB), KINMUNDY OLD (ROZY), KINMUNDY NEW (SOF), AND KINMUNDY BORROW PIT (SOG)

SUMMARY

In September 2005, a Total Maximum Daily Load (TMDL) was approved for four water supply lakes in Marion County, Illinois (Baetis 2005b). The TMDL required up to 86% reduction in seasonally high manganese (Mn) concentrations. This report identifies and evaluates alternative actions for implementing the TMDLs. The information is directed to key local stakeholders for their discussion and action.

Five alternatives were identified to reduce Mn in the lakes. As described in detail in the Stage 1 report for the East Fork Kaskaskia River Watershed TMDL (Baetis 2005a), Mn concentrations are inherently linked to eutrophication at all four lakes. The alternatives evaluated herein include: lake aeration/destratification, operational changes at the water plants, phosphorus inactivation, dredging, and nutrient management measures. Some of these alternatives reach beyond the cause of impairment (i.e. Mn) and address the issue of eutrophication.

SUMMARY OF TMDL IMPLEMENTATION ALTERNATIVES

Alternative	Capital Costs / Lake	Comments
Aeration/Destratification	\$10,000 to \$50,000	• Mixed effects on algal ecology
Water Supply Operational Changes	n/a	• Applicable only to SOB and SOG
Phosphorus Inactivation	\$6,500 to \$45,000	• Dose tests required for each lake
Dredging	High	• Not recommended
Nutrient Management Plans	Low	• Applicable only to SOF and ROZY • Recommended, but in concert with additional in-lake alternatives

1. INTRODUCTION

The State of Illinois assesses its water bodies for compliance with water quality standards established to protect their designated uses. This assessment is required by the federal Clean Water Act. Section 303(d) of the Clean Water Act requires states to identify waters which will not attain applicable water quality standards with technology-based controls alone. Water bodies so identified are placed on a 303(d) list and prioritized to have a Total Maximum Daily Load (TMDL) developed. The TMDL is specific to the water quality constituent(s) that is in violation of the water quality standard. 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 in-stream or in-lake water quality conditions. This allows water quality-based controls to be developed to reduce pollution and to restore and maintain water quality.

In the East Fork Kaskaskia Watershed, five water bodies have been identified as being water quality limited and are on Illinois' 2004 303(d) list. A segment of the East Fork Kaskaskia River is impaired by fecal coliform bacteria and dissolved oxygen deficits; a TMDL for these impairments is currently under development. The water quality impairment in the four other listed waterbodies is caused by manganese (Mn). TMDLs for manganese in Farina Lake (termed segment SOB), Old Kinmundy Lake (segment ROZY), New Kinmundy Lake (SOF) and Kinmundy Borrow Pit (SOG) were established in 2005 (Baetis 2005b).

The next step in the TMDL process is to develop a voluntary implementation plan for the TMDL that includes both accountability and the potential for adaptive management. Adaptive management involves 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 plans for Farina Lake (SOB), Old Kinmundy Lake (ROZY), New Kinmundy Lake (SOF), and Kinmundy Borrow Pit (SOG).

1.1 Lake and Watershed Descriptions

The East Fork Kaskaskia Watershed (HUC 0714020205) is 82,254 acres (33,288 ha) in area. It is largely agricultural, with extensive soybean and corn production on its fertile glacial till soils. The watershed is described in detail in the TMDL Report (Baetis 2005).

The specific drainages to each of the four water supply lakes are relatively small, and in the cases of the two borrow pits, not much larger than the lakes themselves. Figure 1 shows the locations of the four lakes.

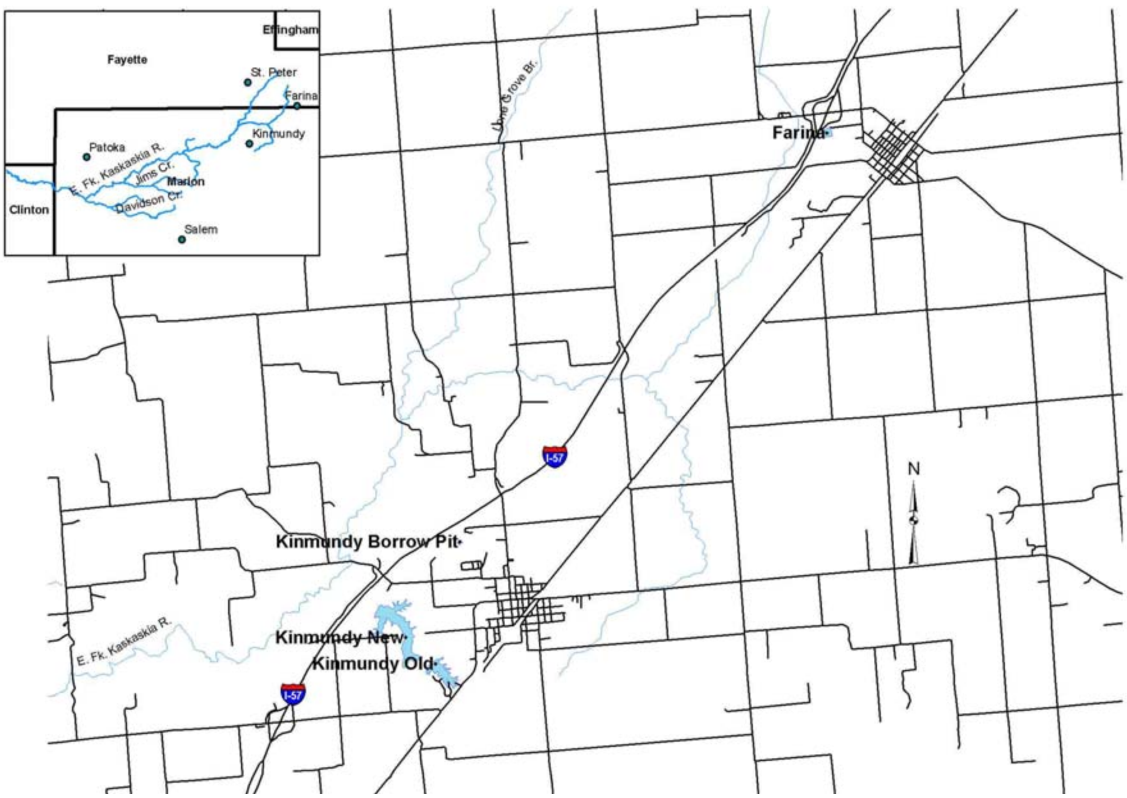

Figure 1. Location Map

Table 1
KEY WATERBODY CHARACTERISTICS
(Source: IEPA 2004, Baetis 2005b)

Segment	Waterbody Name	Area	Volume (gal)	Maximum Depth (ft)
SOB	Farina Lake	4 ac	30 million	32
SOG	Kinmundy Borrow Pit	5 ac	17 million	11
SOF	Kinmundy Lake New	107 ac	400 million	27
ROZY	Kinmundy Lake Old	20 ac	43.4 million	16

1.2 Water Quality Standard

The impaired designated use for these four lakes is public water supply. This designated use, as stated in Title 35 of the Illinois Administrative Code, is established to protect waters withdrawn for treatment and distribution as a potable supply or for food processing. The numeric standard for total Mn in untreated public water supplies is 0.15 mg/L. As detailed in the TMDL report, Mn in the lakes exceeds this standard during summer anoxia periods. However, it is important to note that the water treatment process removes the excess Mn prior to distribution to customers. There have been no complaints regarding the color of the water or staining of laundry. Further, annual testing of finished water in Farina and Kinmundy by the Illinois EPA does not indicate any violations of the 0.15 mg/L standard. Maximum concentration of Mn in finished water in Farina over the last ten years is 0.092 mg/L; maximum concentration of Mn in finished water in Kinmundy over the same period is 0.029 mg/L (www.epa.state.il.us/drinking-water-watch/). Median measurements at both plants are less than the 0.015 mg/L reporting limit.

1.3 TMDL Summary

Table 2 contains the Load Allocations (LA), Waste Load Allocations (WLA), Margin of Safety (MOS) and percent reductions in Mn required for each of the four lakes during winter (mixed water column) and summer (stratified, critical condition). The range of required Mn load reductions is from zero during winter at Farina Lake (SOB) and

Kinmundy Borrow Pit (SOG), to as much as 86% during summer at Kinmundy Old (ROZY).

Table 2
TMDL SUMMARY
(in lb/d, except where indicated otherwise)

Lake	Season	Existing Load	LC	WLA	LA	MOS	% Reduction
Farina SOB	Winter	0.16	0.43	0	0.26	0.17	-
	Summer	0.46	0.25	0	0.15	0.10	67%
Old Kinmundy -ROZY	Winter	1.35	1.01	0	0.61	0.40	55%
	Summer	1.74	0.40	0	0.24	0.16	86%
Kinmundy Borrow Pit - SOG	Winter	0.10	0.17	0	0.10	0.07	-
	Summer	0.09	0.07	0	0.04	0.03	52%
New Kinmundy - SOF	Winter	5.90	5.53	0	3.32	2.21	44%
	Summer	4.32	1.47	0	0.88	0.59	80%

2. IMPLEMENTATION PLAN APPROACH

Our approach to TMDL development and implementation planning is taken from discussions with Illinois EPA and its Scientific Advisory Committee. The approach generally consists of the following steps:

1. Use existing data to define overall pollutant loads, in contrast to watershed modeling that might define individual loading sources.
2. Apply relatively simple computation procedures (e.g. mass balance) to define the load-response relationship and define the maximum allowable pollutant load that the lakes can assimilate and still meet water quality standards.
3. Compare the maximum allowable load to the existing load to define the necessary reduction in manganese to comply with the water quality standard.
4. Develop a voluntary implementation plan that includes both accountability and, where necessary, the flexibility for adaptive management.

This approach puts local decision-makers at the forefront of nonpoint source controls and water quality restoration. Also, the adaptive management approach recognizes that models used for decision-making are approximations, and that there is never enough data to eliminate TMDL uncertainties. The adaptive process allows decision-makers to proceed with TMDL implementation based on limited data and modeling, and to update those decisions as local experience and knowledge improve.

Steps 1 through 3 described above have been completed and documented in the TMDL report (Baetis 2005b). This plan represents Step 4.

Guidance for attainment of designated uses of Illinois' waterbodies was published in 1998 (IEPA 1998). This guidance specifies ten elements for implementation plans:

1. Mission statement
2. Watershed description
3. Watershed activities
4. Watershed resource inventory
5. Problem statement
6. Goals and objectives for the implementation plan
7. Implementation strategies
8. Cost summary
9. Implementation strategy selection
10. Measuring progress and success

Most of these elements were included in the Stage 3 report (Baetis 2005b); the balance is addressed below.

3. ALTERNATIVES FOR TMDL IMPLEMENTATION

Based on the TMDL for each lake, information obtained at the public meetings and during interviews with water plant operators, our experience in other lakes and watersheds, a number of alternatives have been identified for the implementation phase of these TMDLs. These alternatives are focused on those sources suspected of contributing nutrients and manganese loads to the lake. We have included nutrient reduction alternatives because of the role of eutrophication in seasonal lake anoxia and its associated release of manganese from sediments. The implementation alternatives identified are:

- Aeration/Destratification
- Water Supply Operational Changes
- Phosphorus Inactivation
- Dredging
- Nutrient Management Plans

Each of these alternatives is described briefly below, including information about their costs and effectiveness in reducing manganese concentrations in the lakes.

3.1 Aeration / Destratification

As noted in the TMDL reports (Baetis 2005a, b), the existing sediments are a significant seasonal source of manganese. When the hypolimnion of the lakes becomes anoxic during summer, Mn is reduced and released to the water column from the sediments. Limnologists term this process internal loading. Control of internal loads of Mn can be accomplished by preventing anoxic conditions from occurring. Lake aeration and destratification will accomplish this.

Aeration is the dissolution of air in lake water to raise dissolved oxygen (DO) concentrations. Destratification is a process in which the lake water is mixed in order to eliminate thermally stratified layers. Aerators and destratifiers have been installed in Illinois lakes with success. Bubble plumes are the most common method and involve the release of compressed air from diffusers on the lake bottom. The rising air bubbles increase DO and destratify the lake. Another technique involves mechanical stirrers, usually large low-speed impellers designed to force the bottom water upwards or the surface water downwards.

Aeration or destratification of any of the four lakes should help to mitigate the Mn impairments. This will be accompanied by changes in other water quality parameters of the lakes, some of which are important to public water supply. Destratification of Lake Eureka in Woodford County, Illinois, was implemented together with algaecide use. The Illinois State Water Survey studied the effects, and found that manganese and iron in deep waters were reduced by 95 to 97% (Raman 1987). Aeration of Lake Evergreen in McLean County was moderately successful at reducing summertime hypolimnetic anoxia (Raman *et al.* 1998); unfortunately the researchers did not measure Mn concentrations during their study.

In other states, researchers have also evaluated the effects of aeration or destratification on water quality. Osgood and Stiefler (1990) reported higher nutrient and chlorophyll concentrations (and lower Secchi disk transparency) for Crystal Lake (Minnesota) with artificial circulation. Lackey (1972, 1973) studied the effects of destratification on Parvin Lake in Colorado and found it to eliminate seasonal increases in hypolimnetic Mn, as well as to reduce phytoplankton abundance. Lackey did not find proportional decreases in blue-green algae, a group of algae important to water supply qualities. Conversely, Cowell et al. (1987) found that aeration of Lake Brooker in Florida eliminated hypolimnetic anoxia and halved blue-green algae abundance, but did not alter total chlorophyll concentrations. Clearly, the effects of lake aeration on algal ecology vary from lake to lake.

Capital costs for lake aeration systems range from \$10,000 to \$50,000 for each of the four lakes, depending on the type and size specified, availability of electric power at the site, and other factors. Annual costs will vary, and include general maintenance, diffuser type and whether or not the system is removed for winter, power, and other factors.

3.2 Water Supply Operational Changes

Farina (SOB) and Kinmundy Borrow Pit (SOG) derive portions of their manganese load from water that is pumped from other sources. The City of Kinmundy pumps water back and forth from Kinmundy Borrow Pit (SOG) to New Kinmundy Lake (SOF) to manage storage. The Village of Farina pumps from the East Fork Kaskaskia River and another nearby borrow pit (the Loy Pit) to Farina Lake (SOB) for water supply purposes as well. Because of these operations, changes to pumping times, rates or water sources would alter the manganese budget and possibly result in lower seasonal Mn concentrations in SOB or SOG.

Neither municipality measures pumped volumes nor Mn concentrations in the pumped water, and as such, there as uncertainties in the Mn budget for these waterbodies, as indicated in the TMDL report. Adaptive management for water quality improvement allows for monitoring and gradual progress. With water quality and pumping data, some load reductions to the lakes are possible. Meters will need to be installed on the pumps, and read occasionally, and Mn in the pumped water will need to be quantified seasonally. Whether operational changes will be sufficient to reach the Mn standard in Farina Lake (SOB) or Kinmundy Borrow Pit (SOG) remains uncertain, but progress towards use attainment could be made.

3.3 Phosphorus Inactivation

Inorganic phosphate, the limiting algal nutrients in the lakes, can be reduced by applying alum (aluminum sulfate) or other salts. Alum strongly binds phosphates. When added to water, alum undergoes a series of hydrolysis reactions and forms aluminum hydroxide [$Al(OH)_3$]. Aluminum hydroxide is highly effective at coagulating and adsorbing phosphorus within a pH range of 6 – 8. In the case of alum, this binding is essentially nonreversible. Alum applications may be single-dose treatments of the whole lake or continuous doses using metered systems. Other chemicals that have been used to inactivate phosphorus include iron salts and lime. Phosphorus inactivation using alum can be effective at reducing internal phosphorus (P) loads for several years, depending on the relative scale of external P loads.

Whole-lake treatments with alum will greatly improve water clarity and will likely reduce seasonal anoxia and hypolimnetic Mn concentrations. An ongoing Illinois Clean Lakes Project combining alum treatment with external P load reductions at Meadow Lake in DuPage County, Illinois led to elimination of seasonal anoxia in the first year (Pott 2006).

The literature suggests that alum treatments will likely need to be performed every three to five years. Treatment should be performed in late spring, before significant populations of buoyant algae develop in the lake, which generally impair flocculation and settling of the alum.

A whole-lake treatment entails application of liquid alum to the water column. Alum doses on the order of 500 lbs per acre are typical in Illinois, but this dose will need to be determined individually for each lake. Additionally, without elimination of external P loads, the alum treatment will require repetition. Estimates for one-time whole-lake applications are tabulated below.

Table 3
COSTS OF PHOSPHORUS INACTIVATION FOR FOUR IMPAIRED LAKES

Waterbody	Alum ($)	Mobilization/ Demobilization	Cost
Old Kinmundy (ROZY)	$ 7,500	$ 5,000	$12,500
New Kinmundy (SOF)	$ 40,125	$ 5,000	$45,125
Kinmundy Borrow Pit (SOG)	$ 1,875	$ 5,000	$ 6,875
Farina (SOB)	$ 1,500	$ 5,000	$ 6,500

3.4 Dredging

Lake sediments are the principal source of manganese in all four water supply lakes. Dredging of the sediments is an alternative to address this source. Dredging is an expensive alternative, generally more than $\$10/yd^3$, and may only be effective temporally, if at all. By removing organic sediments from the lake bottom, anoxia would be reduced, and possibly eliminated for one or more years. However, Mn is a natural component of soils and would remain available for reduction and dissolution, depending on the effectiveness of dredging at eliminating anoxia. Given this uncertainty, and the high cost of dredging, we do not recommend this alternative for TMDL implementation.

3.5 Nutrient Management Plans

Nutrient management optimizes the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments (NRCS 2002). Nutrient management plans are designed to minimize nutrient losses from agricultural lands, and therefore minimize the amount of phosphorus transported to the lakes. The watersheds of Farina Lake (SOB) and Kinmundy Borrow Pit (SOG) are very small and nutrient management is not expected to be effective in these watersheds. Nutrient management however may be effective in reducing phosphorus loads to Old and New Kinmundy Lakes because of their larger watersheds. A Clean Lakes Diagnostic-Feasibility Study is still underway for Old Kinmundy, which may provide additional detail or recommendations for both the old and the new lakes (ROZY and SOF).

Nutrient management on agricultural lands can reduce phosphorus loads delivered to the ROZY and SOF. The focus of a nutrient management plan is to increase the efficiency with which applied nutrients are used by crops, thereby reducing the amount potentially lost to soil erosion. Nutrient management plans help guide landowners by analyzing agricultural practices and suggesting appropriate nutrient reduction techniques. This typically involves managing the type, amount, and timing of fertilizer applications to agricultural lands in the watershed. Nutrient management plans are tailored for specific soils, fields, and crops, and therefore generally require data collection specific to the field. Data collection generally involves the following:

- Maps on the field/farm size, type of crops grown, and crop rotations
- Past yields and future yield expectations
- Nutrients in the soil and types and quantities of nutrients available to the farmer
- Provisions for operation, including calibration, of fertilizer application equipment
- Annual reviews

These nutrient management plans guide farmers on fertilizer use in fields and pragmatic crop yields.

The interactive Illinois Agronomy Handbook is the most specific reference currently available on nutrient management planning specific to Illinois farms (Hoeft and Nafziger, available online at http://www.aces.uiuc.edu/iah/index.php). The NRCS Conservation Practice Standard for nutrient management planning also summarizes this practice, and includes the Illinois Phosphorus Assessment Procedure (IPAP). These information resources, as well as agency extension personnel, technical service providers, and cost sharing are available to targeted TMDL watersheds in Illinois.

In 2003, the Illinois Department of Agriculture, in cooperation with the Illinois EPA, began targeting the East Fork Kaskaskia River watershed in the Conservation Practices Program for nutrient management. Cost share finds include $2/acre for plan development, up to $5/acre producer payments for initiating implementation, plus up to 60% of the cost for any BMP implemented for the control of phosphorus movement in phosphorus-impaired watersheds.

Nutrient management planning is also an eligible conservation practice for cost sharing under the Environment Quality Incentives Program (EQIP) in Illinois. Current cost sharing limits are 60% of the actual cost not to exceed the county average cost, and limited to $10 per acre for up to 400 acres. Practice costs are also offset by environmental benefits and savings associated with the use of less fertilizer.

3.6 Summary of Alternatives

We identified and evaluated five viable TMDL implementation alternatives (Table 4).

Table 4
SUMMARY OF TMDL IMPLEMENTATION ALTERNATIVES

Alternative	Capital Costs / Lake	Comments
Aeration/Destratification	$10,000 to $50,000	• Mixed effects on algal ecology
Water Supply Operational Changes	n/a	• Adaptive management • Applicable only to SOB and SOG
Phosphorus Inactivation	$6,500 to $45,000	• Dose tests required for each lake
Dredging	High	• Not recommended
Nutrient Management Plans	Low	• Applicable only to SOF and ROZY • Recommended, but in concert with additional in-lake alternatives

4. REASONABLE ASSURANCE

Reasonable assurances provide a level of confidence that the waste load allocations and load allocations in TMDLs will be implemented by Federal, State, or local authorities and/or by voluntary action. Reasonable assurance for reductions in nonpoint source loadings may be non-regulatory or incentive-based, and consistent with applicable laws and regulations. Non-enforceable, nonpoint source control assurances include:

- Demonstration of adequate funding,
- Process by which agreements/arrangements between appropriate parties (e.g. IEPA, City of Kinmundy, Village of Farina Water Department) will be reached,

- Assessment of the future of government programs which contribute to implementation actions, and
- Demonstration of anticipated effectiveness of the actions.

Principal among these assurances are funding and institutional programs. Detailed described are provided below.

4.1 Illinois Nutrient Management Planning Program

The Illinois Department of Agriculture (IDA) and IEPA cosponsor cropland Nutrient Management Plan programs in watersheds with approved phosphorus TMDLs. While the East Fork Kaskaskia Watershed does not have 303(d)-listed waterbodies with phosphorus impairments, the eutrophication-driven anoxia in these lakes warrants nutrient BMPs. Financial and technical assistance are available to landowners in the East Fork Kaskaskia watershed. Technical Service Providers (TSP), certified by the US Department of Agriculture, are utilized to supplement NRCS and IDA extension services. This program provides incentive payments to have Nutrient Management Plans developed and implemented on eligible farm lands, as well as traditional erosion control practices. Cost share finds include $2/acre for plan development by TSPs, up to $5/acre producer payments for initiating implementation, plus up to 60% of the cost for any BMP implemented for the control of phosphorus movement in phosphorus-impaired watersheds.

4.2 Clean Water Act Section 319 Grants

Section 319 of the Clean Water Act is specific to nonpoint sources of water pollution. Under 319, States may reallocate federal funds through grants to public and private entities, including local governments and watershed stakeholder groups. Section 319 funding is being used across the nation to implement TMDLs. These Mn TMDLs are eligible for 319 grants. A successful proposal would require a 40% local cost share.

Illinois' 319 Program funds a Watershed Liaison through the Illinois Association of Soil and Water Conservation Districts. The Watershed Liaison assists the Illinois EPA in implementing Illinois' Nonpoint Source Management Program. The Liaison provides educational, informational and technical assistance to Soil and Water Conservation Districts (SWCDs), agricultural producers and other interested parties to help them better understand programs implemented under Sections 319(h), 305(b) and 303(d) of the Clean

Water Act. The Liaison also encourages SWCDs and producers to participate in watershed planning and nutrient management planning where appropriate. The results of this activity will include a watershed-based plan that meets USEPA's nine minimum elements. The liaison will act as a coordinating mechanism for the delivery of federal/state water quality related programs (i.e. EQIP, CPP, SSRP, CREP, 319 and ICLP). The liaison will advertise programs, give talks, meet with landowners and act as a tool to spread the word about how each of these programs can benefit water quality. The liaison will act as an overall facilitator for water quality coordination between SWCDs, Illinois EPA and other state/federal agencies.

4.3 Conservation 2000

Conservation 2000 is a state program. It is a multi-million dollar initiative designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water resources. It currently expires in 2009.

The Conservation 2000 Program funds nine programs across three state agencies, and includes the Illinois Clean Lakes and the IDA Conservation Practices Cost-Share Programs. The Illinois Clean Lakes Program is modeled after its federal counterpart (Section 314 of the Clean Water Act). The Illinois Clean Lakes Program includes the following funding components:

- Priority Lake and Watershed Implementation Program
- Illinois Clean Lakes Phases I, II and III Projects
- Volunteer and Ambient Lakes Monitoring
- Lake Education Assistance Program

The Priority Lake and Watershed Implementation Program (PLWIP) began in July 1997 with funds provided through "Conservation 2000" PLWIP is a reimbursement grant program designed to support lake protection, restoration and enhancement activities at "priority" lakes where causes and sources of problems are apparent, project sites are highly accessible, project size is relatively small and local entities are in a position to quickly implement needed treatments.

The Illinois Clean Lakes Program (ICLP) is a financial assistance grant program for Phase I (diagnostic-feasibility studies), implementation of lake protection/restoration practices (Phase II), and follow-up monitoring activities (Phase III). The ICLP provides up to 60 percent of the Phase I study cost with the lake owner and/or other sources providing the remaining portion. The maximum amount of state funds is $75,000 for any Phase I project. Phase II grants are available to any lake owner who has completed an ICLP Phase I study. 50 percent of the Phase II study cost is provided by the state ICLP with the lake owner and/or other sources providing the remaining portion. The maximum amount of state funds is $300,000 for any Phase II project. Grant availability in any given year will depend on the level of ICLP funding appropriated by the state legislature.

Old Kinmundy Lake has been studied under a Phase I Diagnostic-Feasibility grant. Findings of this study remain outstanding. Findings of this study can be integrated into the implementation plan through the adaptive management process.

Implementation of the Mn TMDLs could be funded, in part, through the Illinois Clean Lakes Program. A local cost-share match is required.

4.4 Agricultural Watershed Programs

There are several state and federal programs for soil and nutrient conservation in agricultural watersheds, including the Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), Environmental Quality Incentive Program (EQIP), and Conservation 2000 programs. These programs can assist in meeting the TMDL implementation needs at Old and New Kinmundy Reservoirs. The drainage areas of the two borrow pits are too small to receive significant benefits from watershed controls.

CRP is a voluntary program encouraging landowners for long-term conservation of soils, water, and wildlife resources. CRP is the USDA's single largest environmental improvement program. It is administered through the Farm Service Agency (FSA) and involves 10 to 15 year contracts.

The WRP is also a voluntary program. WRP also provides technical and financial assistance to eligible landowners to restore, enhance, and protect wetlands. At least 70 percent of each project area will be restored to the original natural condition, to the extent practicable. Landowners enroll eligible lands through permanent easements, 30-year easements, or restoration cost-share agreements. The program is offered on a continuous sign-up basis and is available nationwide. It is administered through the NRCS.

The Environmental Quality Incentive Program (EQIP) is another voluntary USDA conservation program for farmers faced with serious threats to soil, water, and related natural resources. It provides technical, financial, and educational assistance primarily in designated "priority areas", including TMDL watersheds. Landowners, in consultation with a local NRCS representative or technical service provider, are responsible for development of a site-specific conservation plan, including nutrient management planning.

4.5 Legal Authority

Because neither Illinois EPA, county SWCDs, nor other governmental entities have direct authority over the identified nonpoint sources, it will be important to coordinate activities with entities that have programs in place to implement the nonpoint source actions.

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Illinois
Environmental
Protection Agency

Final Approved Stage Three Report
TMDLs for Target Watersheds

Project Watershed HUC 0714020205 (East Fork Kaskaskia River)
Stream Segments IL_OK-01 and IL-OK-02

Prepared by

Baetis
ENVIRONMENTAL SERVICES, INC.
Chicago, Illinois

On behalf of Limno-Tech, Inc., Ann Arbor, Michigan
September 2006

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EAST FORK KASKASKIA RIVER TMDLS
(IL_OK-01 and IL_OK-02)

Prepared Under Contract to

Illinois Environmental Protection Agency

and
Approved by US EPA

Prepared By

Baetis Environmental Services, Inc.
Chicago, Illinois

In Support Of

Limno-Tech, Inc.
Ann Arbor, Michigan

September 2006

EXECUTIVE SUMMARY

The report recommends Total Maximum Daily Loads (TMDLs) for fecal coliform bacteria and dissolved oxygen for the East Fork Kaskaskia River in Marion, Clinton and Fayette Counties, Illinois. Stream segment IL_OK-01 is impaired by fecal coliform bacteria and dissolved oxygen deficits, and segment IL_OK-02 is impaired by dissolved oxygen deficits. Herein are an evaluation of current water quality in the river, identification of appropriate TMDL endpoints, pollutant source assessments, linkages between pollutant sources and instream water quality, and pollutant allocations.

The fecal coliform bacteria TMDL was developed using a load duration analysis. This analysis clearly shows that the majority of water quality impairments occur under high and mid-range flows, with all coliform measurements that have been taken in very high flows exceeding the water quality standard. The increased fecal coliform load is the result of pollutant delivery associated with rainfall and runoff, particularly runoff from riparian areas. The pollutant allocation should reflect these processes. All wastewater treatment plants (WWTP) in the watershed have effluent disinfection waivers. The sum of their coliform discharges is set as the wasteload allocation (WLA) and is constant across all flow levels. Load allocations (LA), which apply to nonpoint loads from natural sources, livestock, pets, and failing septic systems, are established such that required pollutant reductions range from 99% during high flow periods to 0% during very low flows.

TMDLs for dissolved oxygen (DO) in East Fork Kaskaskia River segments IL-OK-01 and IL_OK-02 were developed for critical aquatic conditions using the model QUAL2E. The model incorporates WWTP discharges, nonpoint sources of BOD and ammonia, and sediment oxygen demand (SOD). The model was calibrated to field measurements taken during 2005, when the watershed was experiencing drought conditions. The DO mass balance indicates that SOD was the dominant source of the oxygen deficit under these critical conditions (i.e. very low stream flow), and that DO standards could only be attained by uniformly reducing SOD by 75%. SOD, or benthic particulate organic matter, originates from several sources, namely leaf fall, settling of BOD from upstream wasteloads, nonpoint loads from agricultural activities (e.g. plant matter, livestock wastes), and instream autochthonous production (algae). The principal cause for the dissolved oxygen deficit in the East Fork Kaskaskia River is the SOD when the stream has very low discharge. Under these conditions, SOD greatly controls DO in overlying water. 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.

Using an adaptive implementation approach, alternatives for implementing this TMDL will be developed and evaluated later this year.

DEVELOPMENT OF TMDLS FOR THE EAST FORK KASKASKIA RIVER WATERSHED

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LIST OF ACRONYMS

ALUS	Aquatic Life Use Support
AWQMN	Ambient Water Quality Monitoring Network
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
DO	Dissolved Oxygen
HUC	Hydrologic Unit Code
IEPA	Illinois Environmental Protection Agency
LA	Load Allocation
MOS	Margin of Safety
NPDES	National Pollutant Discharge Elimination System
SOD	Sediment Oxygen Demand
STORET	Storage And Retreival Database
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WLA	Wasteload Allocation

1.0 INTRODUCTION

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 waterbodies that are not meeting applicable water quality standards or designated uses under technology-based controls. TMDLs specify the maximum amount of a pollutant which a waterbody can assimilate and still meet water quality standards. Based upon a calculation of a waterbody's total capacity for assimilating a specific pollutant, TMDLs allocate pollutant loads to sources (individual point sources and nonpoint sources) and a margin of safety (MOS). This study will determine allowable limits for pollutant loadings to meet water quality standards in waterbody segments IL_OK-01 and IL_OK-02 of the East Fork Kaskaskia River.

1.1 GOALS OF THE TMDL PROGRAM

The TMDL process links both point and nonpoint pollution sources as they contribute to water use impairment. The goals of the TMDL program include establishing allowable pollutant loadings or other quantifiable parameters for a waterbody, providing States a tool for implementing water quality-based controls, and offering a forum for public participation on watershed issues. Key principles of the TMDL development process include making restoration of impaired waters a high priority, communication with the public, stakeholder involvement and federal government support (USEPA 1998). 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. The objective of the process is the restoration of a waterbody to meet water quality standards and support designated uses.

1.2 APPROACH TO TMDL DEVELOPMENT

Baetis and Limno-Tech have followed a three-stage approach to developing this and other TMDLs for the Agency. Stage One involved watershed characterization, confirmation of water use impairments, and formulation of a technical approach for the TMDLs. A Stage One report for this watershed was published in April 2005. Stage Two was subsequently authorized by the Agency and involved field data collection. This report presents Stage 3.

Technically, the general components of a TMDL are:

- Problem Identification
- Identification of Water Quality Target Values
- Source Assessment
- Linkage between Water Quality Targets and Sources
- Load Allocations

The subsequent chapters of this report are organized accordingly.

1.3 SOURCES OF INFORMATION

Table 1 lists data, by source, that were obtained and reviewed during the course of preparing these TMDLs. These and other references have complete citations at the end of this report.

Table 1

DATA SOURCES, EAST FORK KASKASKIA RIVER WATERSHED

Data	Source
Land Use/Land Cover	Critical Trends Assessment Land Cover Database of Illinois, 1991-1995, Illinois Natural History Survey, Illinois State Geological Survey, Illinois Department of Natural Resources, March 1996.
NPDES Permit Conditions and Excursion Data, Effluent Quality Data	IEPA NPDES permit files, Envirofacts Data Warehouse, Village of Farina, City of Kinmundy
STORET data	Hardcopy and electronic format from IEPA. Also available from USEPA at http://www.epa.gov/owow/storet
Stream discharge	http://waterdata.usgs.gov/nwis-w/il
Watershed boundaries	Provided by the IEPA headquarters
GIS Coverages of County Boundaries, Highways, Towns, and River Reaches	Illinois Natural Resources Geospatial Data Clearinghouse http://www.isgs.uiuc.edu/nsdihome/isgsindex.html
GIS USGS Quad Map coverages	http://www.isgs.uiuc.edu/nsdihome/isgsindex.html
Livestock census data	http://www.nass.usda.gov/census/census02/volume1/il/

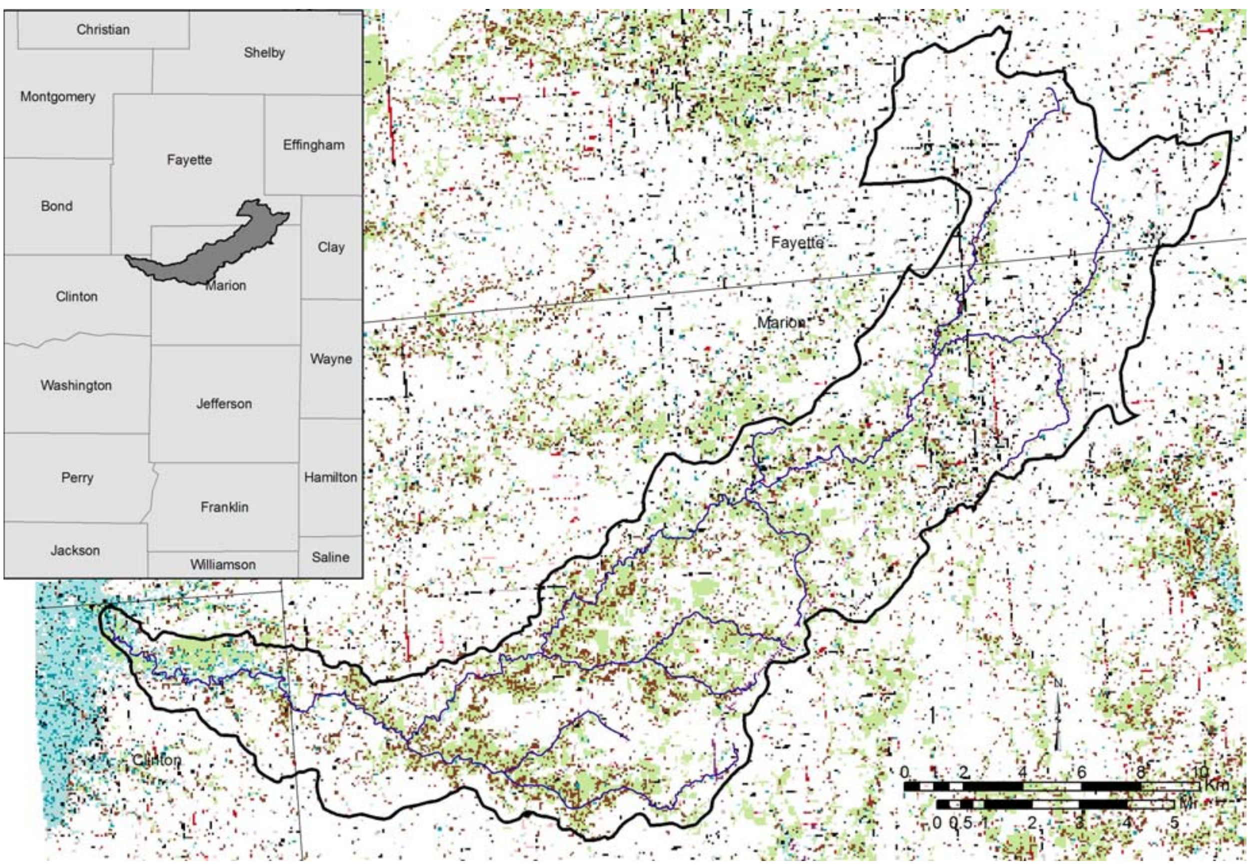
2.0 PROBLEM IDENTIFICATION

This chapter documents the nature of water quality impairment in the East Fork Kaskaskia River and assesses the watershed's general characteristics.

2.1 DESCRIPTION OF THE WATERSHED

The 82,254-acre watershed is located in Clinton, Fayette, and Marion Counties. The main settlements in the watershed are Farina, Kinmundy, St. Peter and Alma. Figure 1 is a location map.

Figure 1. Location Map

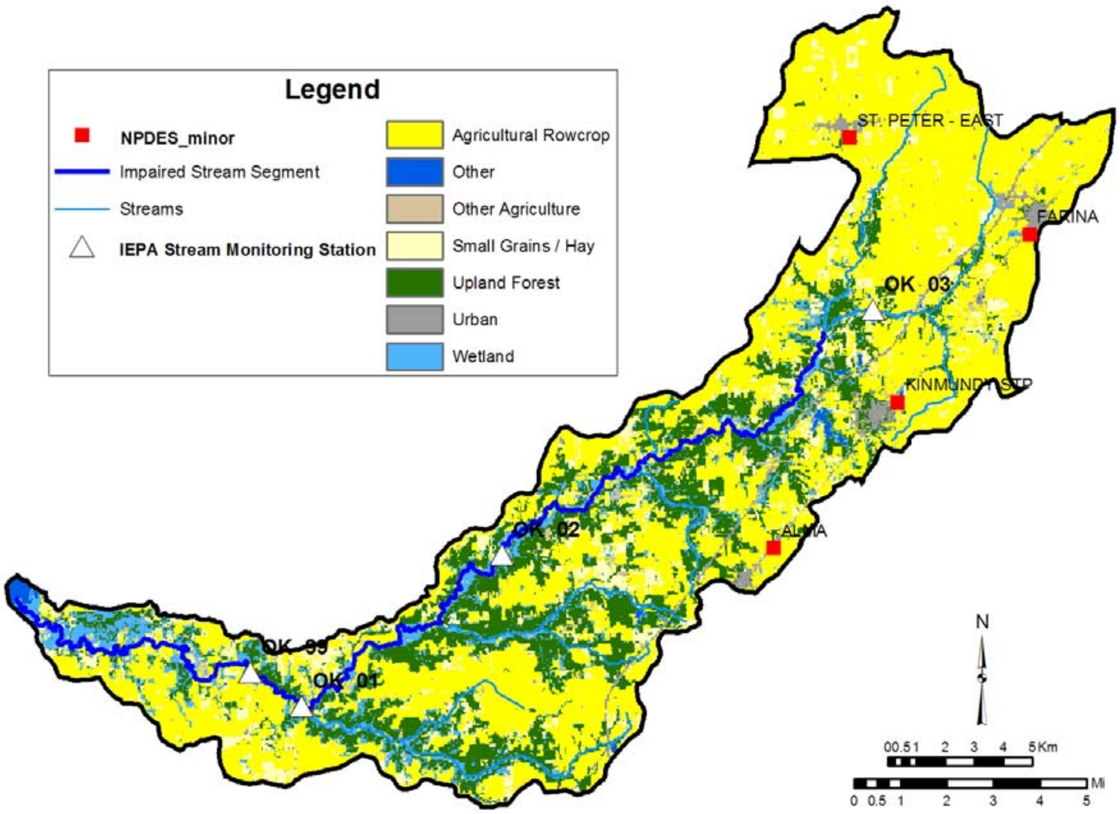


The East Fork Kaskaskia River is part of HUC 0714020205. This HUC also includes the North Fork Kaskaskia River. This targeted watershed was divided for TMDL development, and this report addresses the East Fork Kaskaskia River watershed. The East Fork Kaskaskia River includes six subwatersheds: 071402020503, 071402020504, 071402020505, 071402020506, 071402020507, and 071402020508 (Figure 2).

Figure 2. Subwatersheds and Impaired Stream Segments

The watershed is largely used for corn and soybean production, with about 69% of the land overall used for agriculture (Harza 2003). Figure 3 is a map of current land cover / land use in the project watershed. Figure 3 also shows point source discharges, impaired waterbody segments, monitoring sites, and other watershed characteristics.

Figure 3. Point Source Discharges, IEPA Monitoring Stations, and Land Use and Cover Map



Streamflow data for the watershed are available from a gage on the East Fork Kaskaskia River near Sandoval, IL (USGS Station 05592900). The gage is located on the left bank at U.S. Highway 51, at river mile 9.9. The drainage area of this gage is reported by the USGS to be 113 square miles (72,320 acres). There are daily discharge records from October 1979 to present.

Population statistics and projections are available on a county basis. Most of the targeted watershed is in Marion County. Marion County's population has declined in nearly every census since 1940, when it had 47,989 residents. In 1990, Marion County had a population of 41,561. In the 2000 census, 41,691 were counted by the US Census Bureau. The Illinois State Data Center projects the trend in declining population in Marion County to continue through 2020, when 38,275 residents are predicted (IDCCA 1997).

Major roads through the watershed include Interstate 57 and Illinois Route 37, both of which trend northeast-southwest, along the length of the watershed. Through traffic generally utilizes these two routes.

2.2 Stream Classifications and Uses

Title 35 of the Illinois Administrative Code, Subtitle C, Part 303 contains water use designations which determine for a given body of water which set of water quality standards (found in Part 302) applies. Unless expressly stated, water bodies designated for specific uses must meet the most restrictive water quality standards for any specified use, in addition to meeting the general standards of Part 302. There are no specially designated uses for ILOK01, and therefore, the river must meet the most restrictive water quality standards in Part 302. Uses of the East Fork Kaskaskia River that have been identified to be impaired include aquatic life use support (ALUS) and primary contact recreation (Table 2).

Table 2

EAST FORK KASKASKIA RIVER USE DESIGNATION AND USE SUPPORT STATUS

Segment ID	Year First Listed	Designated Use	Use Support	Potential Cause
IL_OK-01	2004	ALUS	Partial	Dissolved Oxygen
IL_OK-01	2004	Primary Contact	Partial	Pathogens
IL_OK-01	2004	ALUS	Partial	Total Phosphorus
IL_OK-02	2006	ALUS	Partial	Dissolved Oxygen

This report proposes dissolved oxygen (DO) and pathogen TMDLs for the IL_OK-01 segment and a DO TMDL for the IL_OK-02 segment. The phosphorus impairment has been identified as an exceedance of a statistical guideline. While the Agency is currently not developing TMDLs for water use impairments that are identified using the statistical guidelines, implementation of siltation, DO and fecal coliform bacteria TMDLs in the East Fork Kaskaskia watershed should reduce loadings of other pollutants, like phosphorus, as well.

3.0 IDENTIFICATION OF WATER QUALITY TARGETS

Water quality standards are levels of individual constituents or water quality characteristics, or descriptions of conditions of a waterbody that, if met, will generally protect the designated uses of the water. Standards are promulgated by States to protect designated uses of water. The State of Illinois has narrative and numeric standards that form the basis for the State's NPDES water quality-based permit limits for point source discharges. Numeric standards are also the water quality endpoints used for TMDLs.

The standard for aquatic life use support (ALUS) for dissolved oxygen (DO) mandates that waters shall contain no 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 water quality target for DO is therefore 6.0 mg/L.

Primary contact use support is assessed in Illinois using fecal coliform bacteria. Fecal coliforms are indicator organisms for pathogens. Fecal coliform bacteria are found in the intestines and feces of all warm-blooded animals (birds and mammals). The standard for fecal coliform bacteria is based upon an assumed warm-weather swimming season. During the months May through October, based on a minimum of five samples taken over not more than a 30 day period, fecal coliform are not to exceed a geometric mean of 200/100 mL, nor shall more than 10% of the samples during any 30-day period exceed 400/100 mL in protected waters. The water quality target for pathogens is 200 fecal coliform colonies per 100 mL for 100% of the time between May and October.

Illinois water quality standards are written to apply at all times when flows are equal to or greater than the minimum mean seven consecutive day drought flow with a ten-year return frequency (7Q10).

4.0 SOURCE ASSESSMENT

This chapter presents a pollutant source assessment. The objective of a source assessment is to identify and quantify significant sources of the pollutant causing ALUS impairment.

4.1 Watershed Waste Loads

Within the target subwatershed containing stream segment IL_OK-01, there are no permitted point sources of fecal coliform bacteria or oxygen depleting substances (or BOD, biochemical oxygen demand). Upstream, there are currently three small aerated lagoon wastewater treatment plants (WWTP). These three WWTPs discharge to the tributaries of the river, and belong to St. Peter (NPDES Permit No. ILG580007), Kinmundy (ILG580123), and Farina (ILG580047). Figure 3 shows the locations of these discharges. Each of these plants has been approved to discharge to the East Fork Kaskaskia year-round without disinfecting the effluent.

The Village of Alma, also in the targeted watershed, is currently on septic systems. A collection system and treatment plant is being built for the Village. In February 2005 the Agency issued NPDES Permit No. IL0076422 to Alma.

Each of the WWTPs is regulated by a National Pollutant Discharge Elimination System (NPDES) permit that limits weekly maximum carbonaceous BOD (CBOD) discharges to 40 mg/L and average monthly concentrations to 25 mg/L. Monthly average permitted CBOD waste loads for these four permitted facilities are tabulated below.

Table 3

WASTEWATER TREATMENT FACILITY INFORMATION

Facility	Average Flow	Subwatershed	Average CBOD Load
St. Peter	0.042 MGD	071402020504	35 lb/d
Kinmundy	0.146 MGD	071402020503	92 lb/d
Farina	0.105 MGD	071402020503	129 lb/d
Alma	0.050 MGD	071402020505	4.2 lb/d

A siltation TMDL for this watershed recommended that the Farina WWTP, clearly exceeding its suspended solids limits on a regular basis, be examined for possible upgrading (Harza 2003).

Fecal coliform bacteria are not regulated under these NPDES permits and have not been routinely monitored by the owners. In recent months, Farina began monitoring their effluent for coliform bacteria and ammonia nitrogen (Table 4). Farina had the testing performed by the Animal Disease Laboratory in Centralia. This lab uses a method that is specific to *Escherichia coli*, which is a portion of the total fecal coliform bacteria count[1]. None of the three plants chlorinate their effluent to disinfect it prior to discharge.

Table 4

FARINA WWTP EFFLUENT QUALITY

(source: Village of Farina)

Date of Sample	5-day BOD (mg/L)	*E. coli* (cfu/100 mL)	Ammonia N (mg/L)
4 Nov 2004	29.2		0.28
1 Dec 2004	15.9		0.66
20 Jan 2005	12.0		5.6
9 Feb 2005	21.6		7.2
10 Mar 2005	34.6	8	4.2
14 Apr 2005		182	
10 May 2005		708	

Stage 2 of this TMDL effort also collected samples from the Farina plant effluent, as well as the Kinmundy and St. Peter WWTPs (Table 5). The Animal Disease Lab also performed the bacteria enumeration.

[1] Fecal coliform bacteria are members of the coliform group (family Enterobacteriaceae) that have the ability to ferment lactose at an elevated temperature when using a standard media. Fecal coliform bacteria, as a group, are dominated by one organism, *E. coli*, but other organisms are usually present as well. The proportion of fecal coliform bacteria that are *E. coli* ranges from about 60 to 90%. Many states use a conversion factor of 63%, based upon the ratio of the fecal coliform criterion (200/100 mL) and the *E. coli* criterion (125/100 mL).

Table 5

STAGE 2 EFFLUENT QUALITY DATA
(mg/L except where indicated)

Effluent	Date	NO2+NO3-N	Ammonia N	5-day BOD	*E. coli* (cfu/100mL)
St Peter WWTP	23 Aug 2005	0.17	0.41	8.4	263
St Peter WWTP	24 Aug 2005				82
Kinmundy WWTP	23 Aug 2005	0.28	7.6	20.6	649
Farina WWTP	23 Aug 2005	0.027	6.2	31.8	108

4.2 Watershed Loads

Pollutant loads to surface water can originate from several nonpoint sources. The primary mechanism for transport of BOD and fecal coliform bacteria from nonpoint sources to streams is surface runoff. In its biennial water quality reports, Illinois EPA has identified potential nonpoint sources of pollutants impairing the East Fork Kaskaskia River as coming from non-irrigated rowcrop production and unknown sources. Other nonpoint sources of BOD and coliform bacteria exist, including failing septic systems, livestock, wildlife, land application of biosolids, pets, and natural, or background, sources.

Livestock may be confined, grazing in pastures or watering in streams. Confined feedlots generally capture the waste and apply it later to agricultural lands. In open feedlots and pastures, livestock waste is deposited on the land surface where storm water can cause pollutant runoff. No specific information is available to the Illinois EPA on manure application quantity and location. Table 6 presents data on the numbers of livestock in the three counties spanned by the watershed. The watershed covers about 21% of these three counties, so the estimated numbers of livestock actually in the watershed would be reduced by about four-fifths. Among the three counties, Clinton County dominates livestock production, particularly hogs and poultry. The narrow downstream end of the watershed is in Clinton County and is largely forested wetland. Further, the watershed includes only 1.6% of Clinton County. Therefore, very few of these animals are actually in the targeted watershed.

Table 6

LIVESTOCK AND POULTRY
IN CLINTON, FAYETTE AND MARION COUNTIES
(Source: USDA 2002)

Livestock Numbers	Clinton	Fayette	Marion	Total
Beef Cows	2,242	6,249	5,238	13,729
Milk Cows	15,080	1,721	226	17,027
Hogs	177,880	11,208	8,601	197,689
Poultry	590,305	812	84	591,201
Horses	402	722	834	1,958
Sheep	430	979	331	1,740
Goats	475	541	167	1,183
Total	786,814	22,232	15,481	824,527

Septic systems can fail and potentially contribute significant pathogen, BOD and other pollutant loads to waterways. No site specific health information on septic systems is available. Estimates of failing septic systems were developed from a report published by the National Small Flow Clearinghouse (NSFC 2001). These authors report an average of 42 septic systems fail per county. East Fork Kaskaskia River watershed covers approximately 21 percent of 3 counties; so nine systems are estimated to have failed in the watershed. According to the NSFC, because 19 percent of failures were documented groundwater or surface water contamination, 1 or 2 households in the watershed are estimated to have failing septic systems contaminating the East Fork Kaskaskia River.

Biosolids can be applied on the land surface where it may be transported to streams through storm water runoff. The lagoon systems operated by Farina, Kinmundy and St. Peter are periodically cleaned and the sludge is applied to agricultural lands at rates not to exceed the agronomic nitrogen demand of the crop grown. An egg producer in Farina also produces biosolids, some of which is applied to land. Proper land application will greatly reduce fecal coliform numbers, BOD and other pollutants that may contaminate runoff orders of magnitude. The availability of cropland is also a consideration in the rate and placement of manure and other biosolids to land.

Like livestock, wildlife and humans, pets also generate wastes. The number of pets was estimated based on the number of households in the watershed. According to the

American Veterinary Medical Association, there are 1.6 dogs and 2.1 cats per household (referenced in IEPA 2005). As there are approximately 3,129 households in the watershed, we estimate the presence of 5,007 dogs and 6,572 cats. Given that the waste of many house cats is collected in litter and disposed of, dogs generally present a larger pollution threat than cats.

As shown in Figure 3, riparian forests are along much of the lower portion of the river. The riparian forest offers suitable habitat for a variety of mammals, birds, reptiles and amphibians. No wildlife population estimates are available for the watershed.

In addition to wildlife, natural sources of BOD to waterways include direct leaf fall, wash-off of plant materials from the watershed, and benthic autochthonous production (algae).

5.0 TMDL DEVELOPMENT

The pollutant allocation, or TMDL, is composed of the sum of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, natural background levels, and a margin of safety (MOS). The MOS is required to account for major uncertainties concerning the relationship between pollutant loads and instream water quality, for urban growth and development, and or seasonal variation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

In stream segment IL_OK-01, pollutant allocation is required to identify the maximum allowable loads and wasteloads that are necessary to the meet the water quality endpoints for DO and fecal coliform bacteria.

A Stage 1 report recommended development of fecal coliform bacteria and DO TMDLs using two tools: load duration analysis and QUAL2E, respectively. The load duration analysis tool, developed in Kansas for pathogen TMDLs, is described in detail by Cleland (2003). QUAL2E (Brown and Barnwell 1987) is a one-dimensional water quality model that assumes steady-state flow but allows simulation of diurnal variations for dissolved oxygen modeling.

5.1 Fecal Coliform Bacteria TMDL

The load duration curve approach pairs historic streamflow data with water quality measurements to gain insight into the flow conditions resulting in stream use impairment, that is, exceedances of the water quality standard. This approach identifies broad categories of sources over the entire range of flows, and the extent of controls required from these source categories to attain stream use support. A load duration curve is developed by:

1. Ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results;
2. Translating the resulting flow duration curve into a load duration curve by multiplying the flows by the water quality target (200 cfu/100mL); and,
3. Overlaying observed pollutant loads (measured concentrations multiplied by stream discharge) on the same graph.

Observed coliform loads that fall above the curve exceed the water quality target, while those that fall on or below the line are in compliance. An analysis of the observed loads relative to the flow duration interval provides information on whether the pollutant source is point or nonpoint in nature.

A preliminary load duration curve was presented in the Stage 1 report. Some additional data has become available to supplement the Stage 1 analysis. Figure 4 is an updated load duration curve. The S-shaped curve represents the 200 cfu/100mL water quality target, calculated as the product of the 200 cfu/100mL seasonal fecal coliform bacteria limit and the flow duration interval. Fecal coliform bacteria load as measured by the Agency at IL_OK-01 are shown as squares or squares with crosses. As indicated above, load measurements above the target load indicate an exceedance of the primary recreation water quality standard at a given flow. This figure illustrates that the standard is exceeded across the entire range of flows, but principally during wet periods. Table 7 presents statistics on exceedence of the water quality target (for the May to October recreation season). This implies that both dry weather bacteria sources (such as wastewater treatment plants or instream wildlife) and wet weather bacteria sources such as storm runoff are contributing to the use impairment. Further, the relative distance of the measured load data points from the bacteria standard (or target) reflects the necessary reduction in loads and wasteloads required to restore use support.

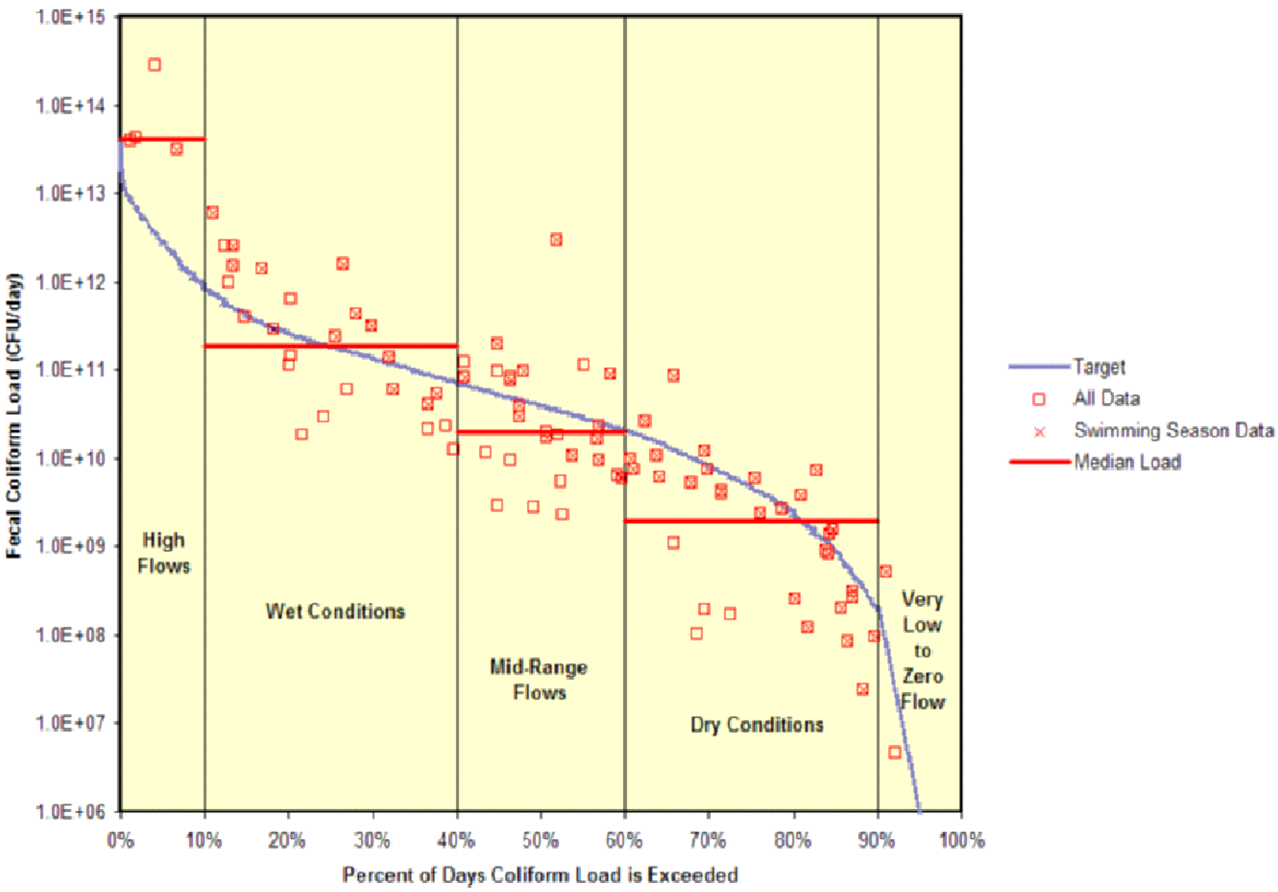
Table 7

FLOW DURATION INTERVALS AND WATER QUALITY STANDARD EXCEEDANCES

Hydrologic Condition	Flow Interval	No. Measurements	No. Exceedances (%)
Very High Flows	0 – 10%	1	1 (100%)
Wet Conditions	10 – 40%	13	9 (69%)
Mid-Range Flows	40 – 60%	15	5 (33%)
Dry Conditions	60 – 90%	27	8 (30%)
Low to Zero Flow	90 – 100%	1	1 (100%)

Figure 4 and Table 7 clearly show that the likelihood of water quality impairment occurs under high and mid-range flows. The increased fecal coliform load is therefore likely the result of pollutant delivery associated with rainfall and runoff. The pollutant allocation and implementation plan should reflect these processes.

Figure 4. Fecal Coliform Bacteria Load Duration Curve, IL_OK-01



The wastewater treatment plants in the upper watershed define the wasteload allocation (WLA) for the TMDL (Table 8). The WWTPs have disinfection waivers from the Agency. The WLA is based upon meeting the water quality target at the downstream end of end reach exempted by the WWTP's disinfection waiver. The sum of the WLA for the three existing plants is 2.2 billion CFU per day, and is constant across all flow levels. The Alma WWTP will begin operating soon and is given an additional WLA of 0.38 billion CFU per day. The total WLA is therefore 2.6 billion CFU per day.

Table 8

FECAL COLIFORM BACTERIA WASTELOAD ALLOCATIONS

Discharger	Avg WWTP Flow (MGD)	Coliform Limit† (CFU/100 mL)	WLA (CFU/day)
Farina WWTP	0.105	200	7.9 E+08
Alma WWTP	0.05	200	3.8 E+08
Kinmundy WWTP	0.146	200	1.1 E+09
St Peter WWTP	0.042	200	3.2 E+08

† Each plant has a disinfection waiver for some distance downstream of outfall. The coliform limits apply to the downstream end of the stream reach as defined in each plant's disinfection waiver.

Table 9 summarizes the TMDL across five flow interval categories. Between 1990 and 2005, the maximum load observed during the swimming season ranged from 5×10^{8} to 3×10^{14} CFU/100mL. The load capacity for the watershed is a product of the water quality target and discharge. The difference between the load capacity and the historic maximum load is defined here as the required pollutant load reductions, which range from 84% to 99%, depending on the flow interval. The load allocation is derived as the difference between the load capacity and the WLA. Further, given that the stream has no flow during most of the lowest flow interval (90th to 100th percentile), we therefore do not present the TMDL or make load reduction recommendations for this interval.

The remaining component of the TMDL is the margin of safety (MOS). A MOS reflects scientific uncertainty, future growth potential, and seasonal variation. The MOS for this TMDL is implicitly included in the WLA. There are multiple conservative assumptions included in its development. 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). The required reductions shown in Table 9 are computed from the historic maximum load, which does not represent typical (or median) conditions. Further, the load duration curve approach does not factor in the significant die-off of bacteria between the WWTP discharge points and the compliance point at OK-01. This stream distance is 18.5 to 24 miles (time of travel varies with flow), and as pointed out in the Agency's granting of disinfection waivers, significant die-off will occur during transport downstream from the plants. This margin of safety can be reviewed in the future as new data are developed.

Table 9

MAXIMUM LOADS, LOAD CAPACITY, REDUCTIONS AND ALLOCATIONS

	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)
Historic Maximum (CFU/day)	3 E+14	6 E+12	3 E+12	8 E+10
Load Capacity (CFU/day)	3 E+12	7 E+11	4 E+10	1 E+10
Required Reduction (%)	99%	88%	99%	84%
WLA (CFU/day)	3 E+09	3 E+09	3 E+09	3 E+09
LA (CFU/day)	3 E+12	7 E+11	4 E+10	1 E+10

TMDLs must take into account critical environmental conditions, intended to protect water quality when it is most vulnerable. In the targeted watershed, intermittent or episoidic coliform sources that result in the highest probability of stream use impairment occur during high flows. TMDL development under the load duration approach applies to the full range of flow conditions between May and October; therefore critical conditions are addressed under this TMDL.

Seasonality in this fecal coliform TMDL is addressed by expressing the TMDL in terms of a contact recreation season, defined as May 1 through October 31.

5.2 Dissolved Oxygen TMDL

The QUAL2E water quality model was used to define the relationship between oxygen-demanding loads and the concentrations of dissolved oxygen in the East Fork Kaskaskia River. QUAL2E is a one-dimensional stream water quality model for well-mixed streams; this model has been in common use for over 30 years. QUAL2E 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.

Input data required for development of a QUAL2E model for IL_OK-01 include:

- Model options
- Stream reach segmentation
- Hydraulic characteristics
- Initial conditions
- Incremental inflow conditions
- Point source loads

Model options for QUAL2E included a steady state simulation of biochemical oxygen demand, nitrogen and dissolved oxygen. Metric units were selected for our simulations. The river was simulated having three headwaters to accommodate the existing WWTPs. The East Fork Kaskaskia River QUAL2E model consists of thirteen reaches, which are comprised of a varying number of computational elements. Tributaries were an additional five reaches. Each reach was segmented into computational elements of 0.2 km. Model segmentation is summarized in Table 10. Reach segmentation was based on principally on review of data on channel slope and morphology, and QUAL2E's maximum of 20 computational elements per reach.

Table 10

QUAL2E STREAM SEGMENTATION

Reach	Stream Km	No. Elements	Name	Comment
1	41.6 – 40.0	8	East Fork Kaskaskia River	Headwater, includes Farina WWTP
2	40.0 – 37.0	15	East Fork Kaskaskia	
3	3.4 – 0.0	17	Schneider Springs	Headwater, includes Kinmundy WWTP
4	37.0 – 34.8	11	East Fork Kaskaskia	OK-03
5	7.4 – 5.2	11	Lone Grove Branch	Headwater, includes St. Peter WWTP
6	5.2 – 2.6	13	Lone Grove Branch	
7	2.6 – 1.4	6	Lone Grove Branch	
8	1.4 – 0.0	7	Lone Grove Branch	Junction with EFKR
9	34.8 – 32.6	11	East Fork Kaskaskia	
10	32.6 – 28.6	20	East Fork Kaskaskia	
11	28.6 – 24.6	20	East Fork Kaskaskia	Includes Alma WWTP
12	24.6 – 20.6	20	East Fork Kaskaskia	
13	20.6 – 16.6	20	East Fork Kaskaskia	
14	16.6 – 14.6	10	East Fork Kaskaskia	
15	14.6 – 11.8	14	East Fork Kaskaskia	OK-02
16	11.8 – 7.8	20	East Fork Kaskaskia	
17	7.8 – 3.8	20	East Fork Kaskaskia	
18	3.8 – 0.0	19	East Fork Kaskaskia	OK-01

QUAL2E simulated hydraulics by assuming a trapezoidal channel, and specified velocity, depth, roughness, and side slopes for each reach. Incremental inflows, which are analogous to nonpoint sources, were calculated from the measured flows. Observed increases in flows were added to each reach incrementally. The point source loads were included in reaches 1, 3 and 5 in the calibration and verification runs. The proposed Alma WWTP point source was added to reach 11 for the TMDL runs. Data on these wasteloads were taken from field surveys in August 2005 or from permits or DMR data provided by the Agency.

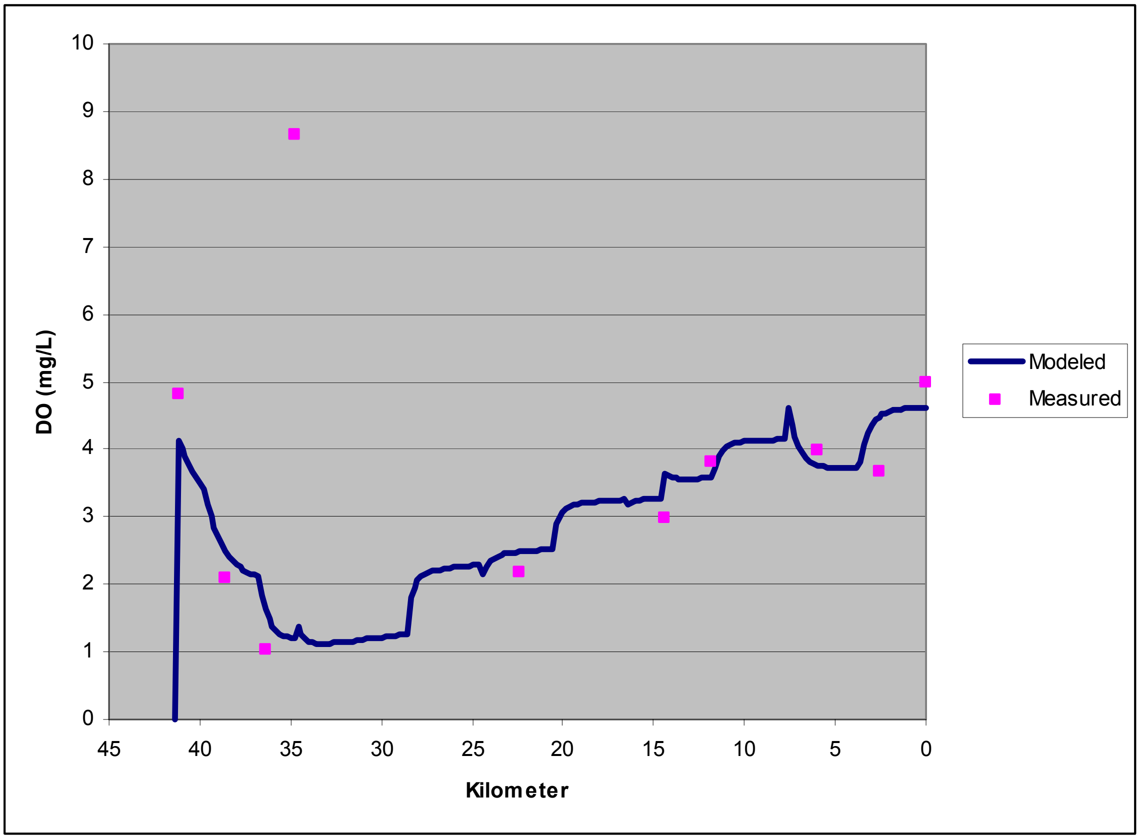
QUAL2E model calibration involved the usual procedure of constructing the input data deck using available site specific data and literature values of reaction rates, comparison of results to water quality data collected during in the low flow August 22-24, 2005, and adjusting model coefficients to provide the best match between model predictions and observations. The reaeration equations developed by Melching and Flores (1999) were used to derive initial reaeration rates.

QUAL2E initially overpredicted observed dissolved oxygen concentrations. The dissolved oxygen mass balance component analysis indicated that the most important source of dissolved oxygen was reaeration and the most important sink was sediment oxygen demand. Calibration involved adjusting the following parameters: reaeration rate, sediment oxygen demand (SOD), BOD decay rate coefficient, and ammonia oxidation rate. SOD levels greater than the Stage 2 measured value at the US 51 bridge were required in several reaches in order to match water quality observations. The resulting dissolved oxygen and BOD predictions compared well to the measured concentrations (Figures 5 and 6). Continuous DO monitoring at OK-01 (river kilometer 2.6) on August 23-24, 2005 found DO to range from 3.2 mg/L to 5.2 mg/L during the course of a day. The DO sag in the East Fork Kaskaskia River was reasonably well reproduced by QUAL2E.

Interestingly, BOD in the East Fork Kaskaskia River was found during field surveys to increase downstream of the WWTPs. Given that there are no known point sources downstream of those in our records, we accounted for this in QUAL2E by setting BOD concentrations in incremental flows sufficiently high to match the field measurements. Instream processes that occur in late summer after an extended period of very low flows (as in August 2005) can lead to high autochthonous production and extreme DO fluctuation; our diurnal monitoring at OK-01 found diurnal fluctuations to be around 2 mg/L.

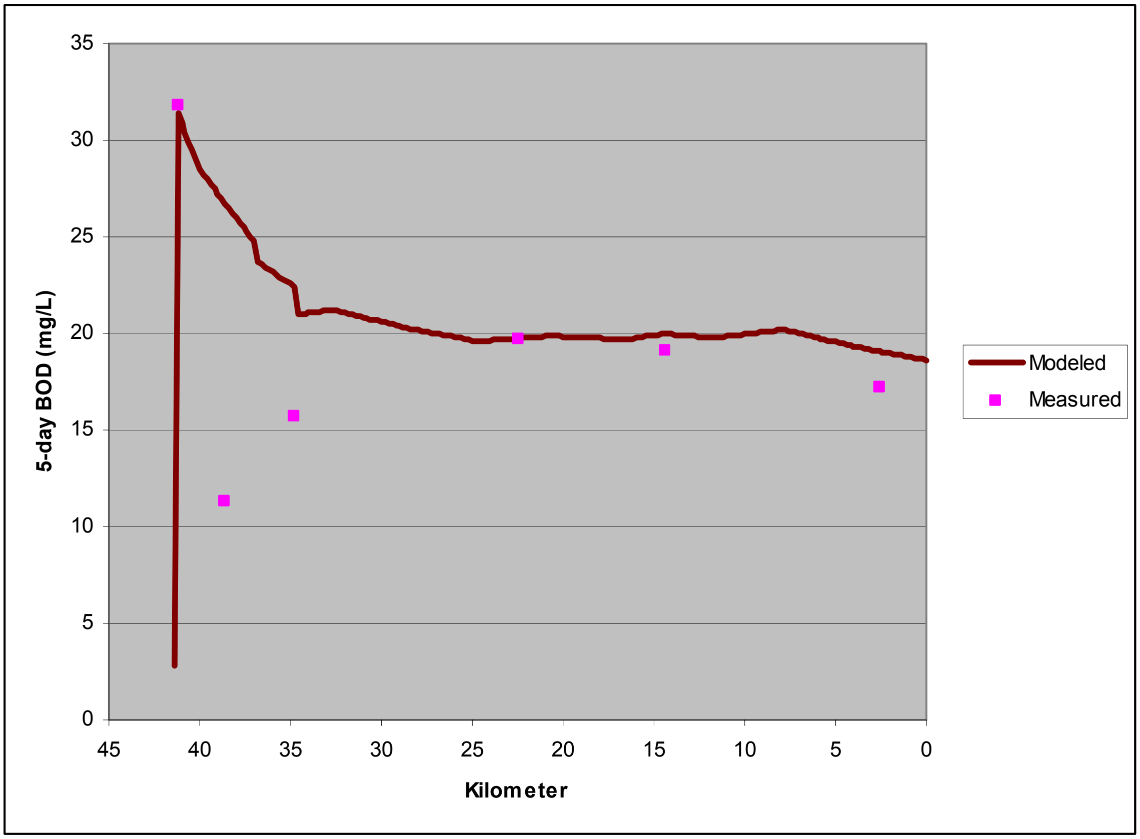
Overall, the QUAL2E calibration is acceptable. Model verification followed using data from the IEPA Ambient Water Quality Monitoring Program, leaving rate coefficients unchanged.

Figure 5. Comparison of Modeled and Observed Dissolved Oxygen Concentrations



Model verification was complicated by collecting the data for model calibration during the drought of 2005. Instream processes that occur in late summer after an extended period of very low flows (as in August 2005) can lead to high autochthonous production and build-up of particulate organic matter. Without occasional high flows to scour the stream bed, detritus and other oxygen demanding materials can accumulate in the stream bed. 2005 included an extended drought, and no high flows had occurred in the East Fork Kaskaskia River for over four months, allowing for build-up of particulate organic matter in the stream. AWQMN data from other recent years were representative of more normal water years.

Figure 6. Comparison of Modeled and Observed BOD Concentrations



The calibrated QUAL2E model was rerun to simulate water quality during two past dates when low flows were recorded. Model inputs that were changed included point source concentrations and flows. BOD concentrations for the WWTPs are not available for these dates. On May 15, 2001, discharge at OK-01 was 1.6 cfs (0.045 m^3/s); and on September 21, 2000 discharge was 2.0 cfs (0.056 m^3/s). In comparison to 2005, 2001 and 2000 were more normal water years and did not have similar extended low flow periods. Periodic high flows will scour stream beds and reduce the build-up of particulate organic matter. We therefore attribute the verification runs' underprediction of DO (Table 11) to the lessened accumulation of benthic oxygen-demanding matter.

Table 11

QUAL2E VERIFICATION

Scenario	DO at OK-01
QUAL2E verification run	3.3 mg/L
May 15, 2001 Measurement	5.5 mg/L
September 21, 2000 Measurement	3.7 mg/L

5.2.1 Load Capacity

A stream's load capacity is the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. External sources of oxygen-demanding substances (BOD and ammonia) were initially reduced to determine whether these reductions would result in the river attaining 6.0 mg/L DO. QUAL2E simulations showed that, even with these loads set to zero, compliance with the dissolved oxygen standards was not attained. The QUAL2E DO mass balance indicates that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit under critical (very low flow) conditions, and that DO standards could only be attained by reducing SOD[2]. SOD was uniformly reduced across all stream reaches until model results demonstrated attainment of the DO target throughout stream segments OK-02 and OK-01. Model results indicated a 75% reduction would be required.

The maximum SOD that results in compliance with water quality standards was used as the basis for determining the waterbody's loading capacity. Simulations determined that it was necessary to reduce SOD, that is, benthic particulate organic matter, by 75 percent to meet the TMDL target for dissolved oxygen in stream segments OK-02 and OK-01. Benthic particulate organic matter originates from:

- Leaf fall
- Settling of BOD from upstream wasteloads

[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) and/or periodic scour. 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.

- Non-point loads from agricultural activities (e.g. plant matter, livestock wastes)
- Instream autochthonous production (algae)

The relative proportions of each of these origins have not been determined, and likely differ from reach to reach. We recommend additional analysis on the influence of extended periods of very low flows on DO compliance at OK-01. An analysis using logistic regression techniques may enlighten our understanding of low DO occurrences in this and similar systems. Periodic high flows that scour the stream bed and transport particulate organic matter downstream may be an important factor in the frequency of DO non-compliance in similar Illinois streams.

5.2.2 Wasteload Allocation

Analysis of receiving water quality indicates that the WWTPs do not significantly contribute to DO impairments in OK-01 or OK-02. Therefore the current NPDES permit limits are appropriate wasteload allocations for these sources. The Farina, Kinmundy and St. Peter WWTPs do not have ammonia nitrogen limits. The Alma WWTP has an ammonia WLA equivalent to its NPDES permit limits. The WLA for stream segment IL_OK-02 is tabulated below.

Table 12

WASTELOAD ALLOCATION FOR STREAM SEGMENT IL_OK-02

Source	CBOD	Ammonia Nitrogen
Farina WWTP	207 lb/d	N/A
Alma WWTP	8.3 lb/d	6.3 lb/d
Kinmundy WWTP	147 lb/d	N/A
St. Peter WWTP	57 lb/d	N/A
Total WLA	362 lb/d	6.3 lb/d

Segment IL_OK-01 has no wasteloads and the WLA is not calculated. The WLAs for the four WWTPs were taken into consideration in the TMDL calculation for the IL_OK-02 segment, which is upstream of the segment IL_OK-01. Since QUAL2E allows for loads from the upstream segment (IL_OK-02) to be taken into consideration for the determination of allowable loads of the downstream segment (IL_OK-01), this indirectly allows for the WLAs for the four WWTPs to already be taken into consideration in the

TMDL calculation of the IL_OK-01 segment. Therefore, since there are no other point source contributions, there is no need to include additional waste loads in the TMDL calculation for the IL_OK-01 segment. And, the WLA for segment IL_OK-01 is equal to zero.

5.2.3 Load Allocation and MOS

The load allocation (LA) is that portion of the TMDL allocated to existing or future nonpoint sources and natural background. For this TMDL, we calculated LA as the amount of oxygen consuming material the stream can assimilate during critical conditions (i.e. analogous to the August 2005 survey conditions). For purposes of QUAL2E modeling, SOD was set to zero, WLA set to the NPDES permit limits in Table 12, and BOD was added incrementally through all reaches until a minimum 6 mg/L DO was met. Nonpoint loads in the reaches were summed for the IEPA stream segments in the watershed, and the LA was taken as 75% of this value and the MOS as 25% (Table 13).

Table 13

LOAD ALLOCATIONS AND MOS FOR SEGMENTS IL_OK-01 AND IL_OK-02

(lbs BOD per day)

Segment ID	Load Allocation	Margin of Safety
IL_OK-02	357	119
IL_OK-01	76	25

A margin of safety is an accounting for the uncertainty about the relationship between pollutant loads and receiving water quality. A portion of the loading capacity in a TMDL is assigned to account for the MOS, which in this case, has been explicitly defined, as shown above. An additional MOS is implicitly included in the use of 6 mg/L as the TMDL endpoint. The water quality standard requires 6 mg/L during 16 of 24 hours allowing a minimum of 5 mg/L for up to 8 hours each day. Therefore, using the 6 mg/L endpoint 100% of the time lends additional conservatism and MOS to the TMDL.

This level of MOS is significant, and considered appropriate in light of the uncertainty in the TMDL. The principal sources of uncertainty are:

- The QUAL2E calibration data set was collected during a critical condition in the East Fork Kaskaskia River, during late summer after an extended drought. The model calibrated with such data may underpredict receiving water DO during more normal conditions.
- SOD was found to control DO in the East Fork Kaskaskia River during critical conditions. This complicated the TMDL computations. The extended period of low flows (prior to the August 2005 field survey) led to the accumulation of particulate organic matter in the stream and a dominance of SOD in the DO mass balance. One measurement of SOD was made in stream segment IL_OK-01; additional measurements could confirm the significance of SOD in the system. SOD was measured at the US 51 bridge to be 1.3 $g/m^2/d$, a reasonable value compared to those of Butts and Evans (1978).
- Unknown source(s) of BOD downstream of known WWTP discharges.

Table 14 summarizes the DO TMDL. The principal cause for the dissolved oxygen deficit in the East Fork Kaskaskia River is the SOD under very low flow conditions. SOD results from the biological respiration from benthic organisms and from the biochemical (i.e., bacterial) decay processes in the surficial layer of bed sediment. Primary sources of SOD are the anaerobic chemical compounds in the riverbed sediments and particulate BOD (including algae and other sources of organic matter such as plant matter and livestock waste from agricultural activity) that settle out of the water column.

Table 14

DO TMDL FOR SEGMENTS IL_OK-01 AND IL_OK-02

(lbs BOD per day)

Segment ID	TMDL	WLA	LA	MOS
IL_OK-01	101	0	76	25
IL_OK-02	719	362	357	119

5.2.4 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. Low DO in the East Fork Kaskaskia River occurs during very low flow conditions. To effectively consider critical conditions, this TMDL is based upon the flows and temperatures measured during the August 2005 survey.

5.3 Reasonable Assurance

Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permits for the point source dischargers in the watershed will be modified if necessary as part of the permit review process (typically every 5 years), to ensure that they are consistent with the applicable wasteload allocations.

Reasonable assurance for nonpoint source controls, 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
- Fund nonpoint source controls through grant programs

The involvement of local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. From interviews with the SWCD and internet searches, we have identified two institutions that are active in or near the project watershed: Carlyle Lake Ecosystem Partnership and Kaskaskia Watershed Association. 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 a 6-county watershed area, Illinois Department of Natural

Resources, and other interested organizations to form the Carlyle Lake Ecosystem Partnership. As indicated on their website, http://dnr.state.il.us/orep/c2000/ecosystem/partnerships/carlyle/carlyle1.htm, Conservation 2000 grants have funded 39 projects to date.

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

6.0 PUBLIC PARTICIPATION

The TMDL process includes several opportunities for local watershed institutions, resource agencies, 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.

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 Thursday, March 17, 2005 in Patoka, Illinois at the Village Civic Center. In addition to the meeting's sponsors, 18 individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program and the Stage One findings. This was followed by a general question and answer session.

Another public meeting was held on August 17, 2006 in Patoka to present the TMDL, receive the public's comments, and discuss the planned implementation of the TMDL. Three individuals attended, each representing a resource management agency.

7.0 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. load duration curves, 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 are part of implementation.

As indicated in Section 2.2, TMDLs are currently only being developed for pollutants that have numerical water quality standards. Many of the controls that will be implemented to address these TMDLs will reduce other pollutants as well. For example, any implementation efforts and controls (BMPs) to reduce suspended solids, BOD or fecal coliform bacteria loads from the watershed sources (stream bank erosion, runoff, etc.) would also serve to reduce phosphorus loads to the East Fork Kaskaskia River.

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APPENDICES

APPENDIX A – LOAD DURATION ANALYSIS

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LOAD DURATION SUMMARY

Peak to Low	*cfs*	*mm*	*Load*
0.011%	7,660	64.035	7.5E+13
0.01%	7,537	63.009	7.4E+13
0.10%	2,800	23.407	2.7E+13
1%	1,724	14.408	1.7E+13
5%	551	4.602	5.4E+12
10%	186	1.551	1.8E+12
15%	90	0.752	8.8E+11
20%	55	0.460	5.4E+11
25%	38	0.318	3.7E+11
30%	28	0.234	2.7E+11
35%	20	0.169	2.0E+11
40%	15	0.125	1.5E+11
45%	11	0.092	1.1E+11
50%	8	0.070	8.2E+10
55%	6	0.052	6.1E+10
60%	5	0.038	4.4E+10
65%	3	0.024	2.8E+10
70%	2	0.014	1.7E+10
75%	1	0.008	9.8E+09
80%	0	0.004	4.8E+09
85%	0	0.002	1.8E+09
90%	0	0.000	3.9E+08
95%	0	0.000	1.0E+06
99%	0	0.0000	0.0E+00
100%	0	0.0000	0.0E+00

Station ID: 05592900

Station name: East Fork Kaskaskia River near Sandoval, IL

113.0 = Drainage Area *(square miles)*

High	Moist	Mid	Dry	Low
551	38	8.4	1.0	0.0
4.602	0.318	0.070	0.008	0.000
5387388537600	371881497600	82205383680	9786355200	1000000.00

400 ***WQ Criteria***

Key Loading Equations

Bacteria Load (counts/day)

*= Criteria * Flow * ((28317/100)*60*60*24)*

Note : 1 ft^3 = 28,317 mL

Stream Name	*East Fork Kaskaskia River near Sandova*
Site ID	*OK-01*
USGS Gage	*05592900*
8-Digit HUC	*7140202*
Drainage Area	*113*

Season: *M* *to* *O*

E. Coli Load	Sample Date	Sample Time	Flow *(cfs)*	Flow Rank	Flow Rank *(%)*	Fecal Coliform (CFU/100mL)	E. Coli Load	All Data	Seasonal	Flag	Flow Rank *(%)*
9.39E+07	10/13/2005	10:00	0.06		90%	64	9.39E+07	9.39E+07	9.39E+07	***	90%
0.00E+00	9/13/2005	10:30	0		100%	70	0.00E+00			***	100%
3.08E+08	8/17/2005	11:30	0.12		87%	105	3.08E+08	3.08E+08	3.08E+08	***	87%
5.87E+09	06/22/05	14:00	1		75%	240	5.87E+09	5.87E+09	5.87E+09	***	75%
2.67E+09	06/15/05	13:50	0.62		79%	176	2.67E+09	2.67E+09	2.67E+09	***	79%
2.04E+08	06/08/05	14:00	0.16		86%	52	2.04E+08	2.04E+08	2.04E+08	***	86%
8.44E+08	05/31/05	2:00	0.23		84%	150	8.44E+08	8.44E+08	8.44E+08	***	84%
2.57E+08	05/25/05	1:00	0.5		80%	21	2.57E+08	2.57E+08	2.57E+08	***	80%
1.08E+10	05/04/05	9:30	6.9		54%	64	1.08E+10	1.08E+10	1.08E+10	***	54%
2.33E+10	12/16/04	13:00	17		39%	56	2.33E+10	2.33E+10			39%
5.95E+12	10/18/04	12:00	152		11%	1600	5.95E+12	5.95E+12	5.95E+12	***	11%
1.41E+11	08/31/04	11:15	25		32%	230	1.41E+11	1.41E+11	1.41E+11	***	32%
2.40E+09	07/20/04	10:00	0.89		76%	110	2.40E+09	2.40E+09	2.40E+09	***	76%
1.67E+10	06/08/04	12:00	5.7		57%	120	1.67E+10	1.67E+10	1.67E+10	***	57%
2.38E+11	05/04/04	11:30	36		26%	270	2.38E+11	2.38E+11	2.38E+11	***	26%
9.42E+09	03/23/04	10:45	11		46%	35	9.42E+09	9.42E+09			46%
1.88E+10	02/24/04	10:30	48		22%	16	1.88E+10	1.88E+10			22%
3.99E+13	01/06/04	11:15	1630		1%	1000	3.99E+13	3.99E+13			1%
2.80E+14	11/18/03	12:45	674		4%	17000	2.80E+14	2.80E+14			4%
2.33E+10	10/21/03	11:15	5.6		57%	170	2.33E+10	2.33E+10	2.33E+10	***	57%
2.14E+10	04/02/03	10:30	19		37%	46	2.14E+10	2.14E+10			37%
1.15E+10	03/10/03	12:10	13		43%	36	1.15E+10	1.15E+10			43%
1.03E+08	01/15/03	11:45	2.1		69%	2	1.03E+08	1.03E+08			69%
8.49E+10	10/29/02	11:30	2.8		66%	1240	8.49E+10	8.49E+10	8.49E+10	***	66%
0.00E+00	08/28/02	10:00	0		100%	46	0.00E+00			***	100%
5.98E+09	06/04/02	8:00	4.7		60%	52	5.98E+09	5.98E+09	5.98E+09	***	60%
4.09E+10	05/23/02	10:00	19		37%	88	4.09E+10	4.09E+10	4.09E+10	***	37%
9.90E+11	04/10/02	10:00	114		13%	355	9.90E+11	9.90E+11			13%
1.43E+11	03/06/02	10:00	53		20%	110	1.43E+11	1.43E+11			20%
2.86E+09	01/09/02	10:00	9		49%	13	2.86E+09	2.86E+09			49%
9.03E+10	10/24/2001		5.1		58%	724	9.03E+10	9.03E+10	9.03E+10	***	58%
9.63E+10	8/28/2001		9.6		48%	410	9.63E+10	9.63E+10	9.63E+10	***	48%
2.60E+10	7/31/2001		3.8		62%	280	2.60E+10	2.60E+10	2.60E+10	***	62%
9.90E+09	6/14/2001		4.4		61%	92	9.90E+09	9.90E+09	9.90E+09	***	61%
4.31E+09	5/15/2001		1.6		71%	110	4.31E+09	4.31E+09	4.31E+09	***	71%
1.74E+10	8/15/2000		8.1		51%	88	1.74E+10	1.74E+10	1.74E+10	***	51%
1.22E+10	9/21/2000		2		69%	250	1.22E+10	1.22E+10	1.22E+10	***	69%
1.08E+10	6/6/2000		3.4		64%	130	1.08E+10	1.08E+10	1.08E+10	***	64%
7.80E+10	5/17/2000		11		46%	290	7.80E+10	7.80E+10	7.80E+10	***	46%
0.00E+00	9/9/1999		0		100%	184	0.00E+00			***	100%
1.54E+09	8/11/1999		0.21		85%	300	1.54E+09	1.54E+09	1.54E+09	***	85%
1.54E+12	7/1/1999		105		13%	600	1.54E+12	1.54E+12	1.54E+12	***	13%
8.44E+10	5/20/1999		15		41%	230	8.44E+10	8.44E+10	8.44E+10	***	41%
5.29E+09	9/24/1998		2.3		68%	94	5.29E+09	5.29E+09	5.29E+09	***	68%
7.60E+09	8/20/1998		4.2		61%	74	7.60E+09	7.60E+09	7.60E+09	***	61%

Stream Name	*East Fork Kaskaskia River near Sandova*
Site ID	*OK-01*
USGS Gage	*05592900*
8-Digit HUC	*7140202*
Drainage Area	*113*

Season: *M* *to* *O*

E. Coli Load	Sample Date	Sample Time	Flow *(cfs)*	Flow Rank	Flow Rank *(%)*	Fecal Coliform (CFU/100mL)	E. Coli Load	All Data	Seasonal	Flag	Flow Rank *(%)*
1.56E+12	7/1/1998		34		26%	1880	1.56E+12	1.56E+12	1.56E+12	***	26%
4.40E+11	6/4/1998		31		28%	580	4.40E+11	4.40E+11	4.40E+11	***	28%
1.14E+11	4/8/1997		54		20%	86	1.14E+11	1.14E+11			20%
3.88E+09	8/12/1996		0.44		81%	360	3.88E+09	3.88E+09	3.88E+09	***	81%
6.14E+09	6/25/1996		3.3		64%	76	6.14E+09	6.14E+09	6.14E+09	***	64%
2.93E+11	5/13/1996		63		18%	190	2.93E+11	2.93E+11	2.93E+11	***	18%
1.25E+10	4/9/1996		16		40%	32	1.25E+10	1.25E+10			40%
1.10E+09	2/8/1996		2.8		66%	16	1.10E+09	1.10E+09			66%
1.96E+08	1/10/1996		2		69%	4	1.96E+08	1.96E+08			69%
4.65E+06	11/20/1995		0.01		92%	19	4.65E+06	4.65E+06			92%
0.00E+00	10/26/1995		0		100%	2	0.00E+00			***	100%
1.21E+08	9/11/1995		0.38		82%	13	1.21E+08	1.21E+08	1.21E+08	***	82%
1.94E+11	8/9/1995		12		45%	660	1.94E+11	1.94E+11	1.94E+11	***	45%
6.47E+09	6/20/1995		4.9		59%	54	6.47E+09	6.47E+09	6.47E+09	***	59%
3.09E+13	5/10/1995		371		7%	3400	3.09E+13	3.09E+13	3.09E+13	***	7%
2.35E+09	4/6/1995		7.4		53%	13	2.35E+09	2.35E+09			53%
4.32E+13	3/8/1995		1260		2%	1400	4.32E+13	4.32E+13			2%
9.69E+10	2/2/1995		12		45%	330	9.69E+10	9.69E+10			45%
8.34E+10	12/20/1994		11		46%	310	8.34E+10	8.34E+10			46%
4.07E+09	11/14/1994		1.6		71%	104	4.07E+09	4.07E+09			71%
2.42E+07	9/15/1994		0.09		88%	11	2.42E+07	2.42E+07	2.42E+07	***	88%
2.64E+08	7/18/1994		0.12		87%	90	2.64E+08	2.64E+08	2.64E+08	***	87%
5.28E+10	6/23/1994		18		38%	120	5.28E+10	5.28E+10	5.28E+10	***	38%
2.94E+10	5/23/1994		10		47%	120	2.94E+10	2.94E+10	2.94E+10	***	47%
5.50E+09	11/1/1993		7.5		52%	30	5.50E+09	5.50E+09			52%
1.41E+12	9/29/1993		72		17%	800	1.41E+12	1.41E+12	1.41E+12	***	17%
6.35E+11	1/11/1993		53		20%	490	6.35E+11	6.35E+11			20%
3.01E+12	9/10/1992		7.7		52%	16000	3.01E+12	3.01E+12	3.01E+12	***	52%
0.00E+00	8/18/1992		0		100%	380	0.00E+00			***	100%
1.40E+09	6/17/1992		0.22		84%	260	1.40E+09	1.40E+09	1.40E+09	***	84%
2.57E+12	5/14/1992		105		13%	1000	2.57E+12	2.57E+12	2.57E+12	***	13%
2.55E+12	4/22/1992		124		12%	840	2.55E+12	2.55E+12			12%
2.94E+09	2/26/1992		12		45%	10	2.94E+09	2.94E+09			45%
5.28E+10	1/27/1992		18		38%	120	5.28E+10	5.28E+10			38%
1.98E+10	12/18/1991		8.1		51%	100	1.98E+10	1.98E+10			51%
1.14E+11	11/6/1991		6.3		55%	740	1.14E+11	1.14E+11			55%
5.14E+08	9/19/1991		0.03		91%	700	5.14E+08	5.14E+08	5.14E+08	***	91%
9.17E+08	7/17/1991		0.25		84%	150	9.17E+08	9.17E+08	9.17E+08	***	84%
9.59E+09	5/30/1991		5.6		57%	70	9.59E+09	9.59E+09	9.59E+09	***	57%
3.91E+10	5/1/1991		10		47%	160	3.91E+10	3.91E+10	3.91E+10	***	47%
3.94E+11	3/20/1991		92		15%	175	3.94E+11	3.94E+11			15%
6.06E+10	2/13/1991		33		27%	75	6.06E+10	6.06E+10			27%
2.94E+10	1/23/1991		40		24%	30	2.94E+10	2.94E+10			24%
1.71E+08	11/14/1990		1.4		73%	5	1.71E+08	1.71E+08			73%
7.13E+09	10/10/1990		0.31		83%	940	7.13E+09	7.13E+09	7.13E+09	***	83%
8.56E+07	8/27/1990		0.14		86%	25	8.56E+07	8.56E+07	8.56E+07	***	86%
7.67E+09	7/18/1990		1.9		70%	165	7.67E+09	7.67E+09	7.67E+09	***	70%
3.15E+11	6/11/1990		28		30%	460	3.15E+11	3.15E+11	3.15E+11	***	30%
6.17E+10	5/9/1990		24		32%	105	6.17E+10	6.17E+10	6.17E+10	***	32%
1.25E+11	3/26/1990		15		41%	340	1.25E+11	1.25E+11			41%
1.86E+10	2/13/1990		7.6		52%	100	1.86E+10	1.86E+10			52%

2.E+12	*2.E+14*	*2.06E+12*	*1.18E+11*	*1.07E+10*	*4.63E+08*	*90th Percentile*
2.E+10	*4.E+13*	*1.90E+11*	*1.98E+10*	*1.97E+09*	*2.59E+08*	*Median*
91	*4*	*26*	*27*	*32*	*2*	*Number of Values*

Value	High Flows *(0-10)*	Moist *(10-40)*	Mid-Range *(40-60)*	Dry *(60-90)*	Low Flows *(90-100)*		
9.39E+07				9.39E+07		209178449222400.00	41518611936000.00
						209178449222400.00	41518611936000.00
3.08E+08				3.08E+08		2056113227520.00	190222279200.00
5.87E+09				5.87E+09		2056113227520.00	190222279200.00
2.67E+09				2.67E+09		118346393433.60	19817369280.00
2.04E+08				2.04E+08		118346393433.60	19817369280.00
8.44E+08				8.44E+08		10722909392.64	1968280689.60
2.57E+08				2.57E+08		10722909392.64	1968280689.60
1.08E+10			1.08E+10			462870135.07	259216083.36
2.33E+10		2.33E+10				462870135.07	259216083.36
5.95E+12		5.95E+12					
1.41E+11		1.41E+11					
2.40E+09				2.40E+09			
1.67E+10			1.67E+10				
2.38E+11		2.38E+11					
9.42E+09			9.42E+09				
1.88E+10		1.88E+10					
3.99E+13	3.99E+13						
2.80E+14	2.80E+14						
2.33E+10			2.33E+10				
2.14E+10		2.14E+10					
1.15E+10			1.15E+10				
1.03E+08				1.03E+08			
8.49E+10				8.49E+10			
5.98E+09			5.98E+09				
4.09E+10		4.09E+10					
9.90E+11		9.90E+11					
1.43E+11		1.43E+11					
2.86E+09			2.86E+09				
9.03E+10			9.03E+10				
9.63E+10			9.63E+10				
2.60E+10				2.60E+10			
9.90E+09				9.90E+09			
4.31E+09				4.31E+09			
1.74E+10			1.74E+10				
1.22E+10				1.22E+10			
1.08E+10				1.08E+10			
7.80E+10			7.80E+10				
1.54E+09				1.54E+09			
1.54E+12		1.54E+12					
8.44E+10			8.44E+10				
5.29E+09				5.29E+09			
7.60E+09				7.60E+09			

2.E+12	*2.E+14*	*2.06E+12*	*1.18E+11*	*1.07E+10*	*4.63E+08*	*90th Percentile*
2.E+10	*4.E+13*	*1.90E+11*	*1.98E+10*	*1.97E+09*	*2.59E+08*	*Median*
91	*4*	*26*	*27*	*32*	*2*	*Number of Values*

Value	High Flows *(0-10)*	Moist *(10-40)*	Mid-Range *(40-60)*	Dry *(60-90)*	Low Flows *(90-100)*
1.56E+12		1.56E+12			
4.40E+11		4.40E+11			
1.14E+11		1.14E+11			
3.88E+09				3.88E+09	
6.14E+09				6.14E+09	
2.93E+11		2.93E+11			
1.25E+10		1.25E+10			
1.10E+09				1.10E+09	
1.96E+08				1.96E+08	
4.65E+06					4.65E+06
1.21E+08				1.21E+08	
1.94E+11			1.94E+11		
6.47E+09			6.47E+09		
3.09E+13	3.09E+13				
2.35E+09			2.35E+09		
4.32E+13	4.32E+13				
9.69E+10			9.69E+10		
8.34E+10			8.34E+10		
4.07E+09				4.07E+09	
2.42E+07				2.42E+07	
2.64E+08				2.64E+08	
5.28E+10		5.28E+10			
2.94E+10			2.94E+10		
5.50E+09			5.50E+09		
1.41E+12		1.41E+12			
6.35E+11		6.35E+11			
3.01E+12			3.01E+12		
1.40E+09				1.40E+09	
2.57E+12		2.57E+12			
2.55E+12		2.55E+12			
2.94E+09			2.94E+09		
5.28E+10		5.28E+10			
1.98E+10			1.98E+10		
1.14E+11			1.14E+11		
5.14E+08					5.14E+08
9.17E+08				9.17E+08	
9.59E+09			9.59E+09		
3.91E+10			3.91E+10		
3.94E+11		3.94E+11			
6.06E+10		6.06E+10			
2.94E+10		2.94E+10			
1.71E+08				1.71E+08	
7.13E+09				7.13E+09	
8.56E+07				8.56E+07	
7.67E+09				7.67E+09	
3.15E+11		3.15E+11			
6.17E+10		6.17E+10			
1.25E+11			1.25E+11		
1.86E+10			1.86E+10		

	Swimming Season TMDL				
	High Flows (0-10)	**Moist (10-40)**	**Mid-Range (40-60)**	**Dry (60-90)**	**Low Flows (90-100)**
Maximum Load (CFU/day)	3.E+14	6.E+12	3.E+12	8.E+10	5.E+08
90th Percentile Load (CFU/day)	2.E+14	2.E+12	1.E+11	1.E+10	5.E+08
Load Capacity (CFU/day)	7.E+12	1.E+12	8.E+10	3.E+10	3.E+08
Required Reduction (%)	97%	28%	36%	0%	37%
WLA (CFU/day)	5.E+09	5.E+09	5.E+09	5.E+09	5.E+09
LA (CFU/day)	7.E+12	1.E+12	7.E+10	2.E+10	-5.E+09
NPDES Dischargers	**WWTP Capacity (MGD)**	**Coliform Limit (CFU/100 mL)**	**WLA (CFU/day)**		
Farina	0.105	400	1.6.E+09		
Alma	0.05	400	7.6.E+08		
Kinmundy	0.146	400	2.2.E+09		
St Peter	0.042	400	6.4.E+08		
			5.193.E+09		

APPENDIX B – QUAL2E INPUT AND OUTPUT FILES

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                              * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                                         Version 3.21  -  Feb. 1995

 $$$ (PROBLEM TITLES) $$$

CARD TYPE                             QUAL-2E PROGRAM TITLES
TITLE01              East Fork Kaskaskia River 050822
TITLE02
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
WRITE OPTIONAL SUMMARY       0.00000                                    0.00000
NO FLOW AUGMENTATION         0.00000                                    0.00000
STEADY STATE                 0.00000                                    0.00000
TRAPAZOIDAL                  0.00000                                    0.00000
NO PRINT LCD/SOLAR DATA      0.00000                                    0.00000
NO PLOT DO AND BOD DATA      0.00000                                    0.00000
FIXED DNSTM CONC (YES=1)=    1.00000         5D-ULT BOD CONV K COEF  =   0.23000
INPUT METRIC            =    1.00000         OUTPUT METRIC           =   1.00000
NUMBER OF REACHES       =   18.00000         NUMBER OF JUNCTIONS     =   2.00000
NUM OF HEADWATERS       =    3.00000         NUMBER OF POINT LOADS   =   6.00000
TIME STEP (HOURS)       =    1.00000         LNTH. COMP. ELEMENT (DX)=   0.20000
MAXIMUM ROUTE TIME (HRS)=   30.00000         TIME INC. FOR RPT2 (HRS)=   1.00000
LATITUDE OF BASIN (DEG) =   38.80000         LONGITUDE OF BASIN (DEG)=  89.00000
STANDARD MARIDIAN (DEG) =   75.00000         DAY OF YEAR START TIME  = 233.00000
EVAP. COEF.,(AE)        =    0.00000         EVAP. COEF.,(BE)        =   0.00002
ELEV. OF BASIN (ELEV)   =  304.79999         DUST ATTENUATION COEF.  =   0.15000
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)   =    1.6000         O UPTAKE BY ALGAE (MG O/MG A)  =    2.0000
N CONTENT OF ALGAE (MG N/MG A) =    0.0850         P CONTENT OF ALGAE (MG O/MG A) =    0.0140
ALG MAX SPEC GROWTH RATE(1/DAY)=    2.5000         ALGAE RESPIRATION RATE (1/DAY) =    0.0500
N HALF SATURATION CONST (MG/L) =    0.2000         P HALF SATURATION CONST (MG/L) =    0.0400
LIN ALG SHADE CO (1/M-UGCHA/L) =    0.0025         NLIN SHADE (1/M-(UGCHA/L)**2/3)=    0.0000
LIGHT FUNCTION OPTION (LFNOPT) =    1.0000         LIGHT SAT'N COEF (LANGLEYS/MIN)=    0.0299
DAILY AVERAGING OPTION (LAVOPT)=    2.0000         LIGHT AVERAGING FACTOR (AFACT) =    0.9200
NUMBER OF DAYLIGHT HOURS (DLH) =   14.0000         TOTAL DAILY SOLR RAD (LANGLEYS)=  352.8200
ALGY GROWTH CALC OPTION(LGROPT)=    2.0000         ALGAL PREF FOR NH3-N (PREFN)   =    0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4400         NITRIFICATION INHIBITION COEF  =   10.0000
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        1.060     DFLT
THETA( 5)      ORGN DEC        1.047     DFLT
THETA( 6)      ORGN SET        1.024     DFLT
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THETA(7)	NH3 DECA	1.083	DFLT
THETA(8)	NH3 SRCE	1.074	DFLT
THETA(9)	NO2 DECA	1.047	DFLT
THETA(10)	PORG DEC	1.047	DFLT
THETA(11)	PORG SET	1.024	DFLT
THETA(12)	DISP SRC	1.074	DFLT
THETA(13)	ALG GROW	1.047	DFLT
THETA(14)	ALG RESP	1.047	DFLT
THETA(15)	ALG SETT	1.024	DFLT
THETA(16)	COLI DEC	1.047	DFLT
THETA(17)	ANC DECA	1.000	DFLT
THETA(18)	ANC SETT	1.024	DFLT
THETA(19)	ANC SRCE	1.000	DFLT
ENDATA1B			

$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE	REACH ORDER AND IDENT				R. MI/KM		R. MI/KM
STREAM REACH	1.0	RCH=	Farina	FROM	41.6	TO	40.0
STREAM REACH	2.0	RCH=	EFKR	FROM	40.0	TO	37.0
STREAM REACH	3.0	RCH=	Schneider Sprin	FROM	3.4	TO	0.0
STREAM REACH	4.0	RCH=	OK03	FROM	37.0	TO	34.8
STREAM REACH	5.0	RCH=	St Peter	FROM	7.4	TO	5.2
STREAM REACH	6.0	RCH=	OKE12	FROM	5.2	TO	2.6
STREAM REACH	7.0	RCH=	Lone Grove Br2	FROM	2.6	TO	1.4
STREAM REACH	8.0	RCH=	Lone Grove Br1	FROM	1.4	TO	0.0
STREAM REACH	9.0	RCH=	OK14	FROM	34.8	TO	32.6
STREAM REACH	10.0	RCH=	Reach 10	FROM	32.6	TO	28.6
STREAM REACH	11.0	RCH=	Reach 11	FROM	28.6	TO	24.6
STREAM REACH	12.0	RCH=	OK13	FROM	24.6	TO	20.6
STREAM REACH	13.0	RCH=	Reach 13	FROM	20.6	TO	16.6
STREAM REACH	14.0	RCH=	OK02	FROM	16.6	TO	14.6
STREAM REACH	15.0	RCH=	OK12	FROM	14.6	TO	11.8
STREAM REACH	16.0	RCH=	Reach 16	FROM	11.8	TO	7.8
STREAM REACH	17.0	RCH=	Reach 17	FROM	7.8	TO	3.8
STREAM REACH	18.0	RCH=	OK01 OK99	FROM	3.8	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.	1.6.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	2.	15.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.3.0.0.0.0.0.
FLAG FIELD	3.	17.	1.6.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.
FLAG FIELD	4.	11.	4.2.2.2.2.2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.
FLAG FIELD	5.	11.	1.6.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.
FLAG FIELD	6.	13.	2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.
FLAG FIELD	7.	6.	2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	8.	7.	2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	9.	11.	4.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.
FLAG FIELD	10.	20.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD	11.	20.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD	12.	20.	2.2.2.2.2.2.2.2.2.6.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD	13.	20.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD	14.	10.	2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	15.	14.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
FLAG FIELD	16.	20.	2.2.2.2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD	17.	20.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD	18.	19.	2.2.2.2.2.2.2.2.6.2.2.2.2.2.2.2.2.2.5.0.
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	SS1	SS2	WIDTH	SLOPE	CMANN
HYDRAULICS	1.	60.00	1.000	1.000	0.600	0.001	0.030
HYDRAULICS	2.	60.00	1.000	1.000	0.750	0.001	0.030
HYDRAULICS	3.	60.00	1.000	1.000	1.200	0.001	0.030

HYDRAULICS	4.	60.00	1.000	1.000	2.300	0.000	0.030
HYDRAULICS	5.	60.00	1.000	1.000	0.600	0.001	0.030
HYDRAULICS	6.	60.00	1.000	1.000	0.600	0.001	0.030
HYDRAULICS	7.	60.00	1.000	1.000	1.000	0.000	0.030
HYDRAULICS	8.	60.00	1.000	1.000	1.000	0.001	0.030
HYDRAULICS	9.	60.00	1.000	1.000	6.000	0.000	0.030
HYDRAULICS	10.	60.00	1.000	1.000	6.000	0.000	0.030
HYDRAULICS	11.	60.00	1.000	1.000	6.000	0.001	0.030
HYDRAULICS	12.	60.00	1.000	1.000	6.000	0.000	0.035
HYDRAULICS	13.	60.00	1.000	1.000	4.100	0.000	0.035
HYDRAULICS	14.	60.00	1.000	1.000	4.150	0.001	0.035
HYDRAULICS	15.	60.00	1.000	1.000	3.800	0.000	0.035
HYDRAULICS	16.	60.00	1.000	1.000	4.250	0.000	0.035
HYDRAULICS	17.	60.00	1.000	1.000	3.800	0.000	0.035
HYDRAULICS	18.	60.00	1.000	1.000	4.000	0.000	0.035
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	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	2.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	3.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	4.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	5.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	6.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	7.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	8.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	9.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	10.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	11.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	12.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	13.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	14.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	15.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	16.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	17.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
TEMP/LCD	18.	304.80	0.15	0.80	30.00	22.00	1016.00	2.00	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF OR FOR OPT 8	EXPQK2 SLOPE FOR OPT 8
REACT COEF	1.	0.50	0.50	4.000	1.	15.00	0.000	0.00000
REACT COEF	2.	0.30	0.10	3.500	1.	10.00	0.000	0.00000
REACT COEF	3.	0.10	0.00	4.000	1.	66.00	0.000	0.00000
REACT COEF	4.	0.35	0.00	4.500	1.	15.00	0.000	0.00000
REACT COEF	5.	0.60	0.00	2.500	1.	67.00	0.000	0.00000
REACT COEF	6.	0.60	0.00	2.500	1.	90.00	0.000	0.00000
REACT COEF	7.	0.60	0.00	2.500	1.	36.00	0.000	0.00000
REACT COEF	8.	0.60	0.00	2.500	1.	79.00	0.000	0.00000
REACT COEF	9.	0.10	0.00	4.000	1.	20.00	0.000	0.00000
REACT COEF	10.	0.10	0.00	4.000	1.	19.00	0.000	0.00000
REACT COEF	11.	0.10	0.00	3.000	1.	18.00	0.000	0.00000
REACT COEF	12.	0.10	0.00	3.500	1.	18.00	0.000	0.00000
REACT COEF	13.	0.13	0.00	4.000	1.	17.00	0.000	0.00000
REACT COEF	14.	0.10	0.00	4.500	1.	23.00	0.000	0.00000
REACT COEF	15.	0.10	0.00	4.000	1.	13.00	0.000	0.00000
REACT COEF	16.	0.10	0.00	4.000	1.	23.00	0.000	0.00000
REACT COEF	17.	0.10	0.00	2.300	1.	10.00	0.000	0.00000
REACT COEF	18.	0.10	0.00	2.500	1.	15.00	0.000	0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000	0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	2.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	3.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00

N AND P COEF	4.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	5.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	6.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	7.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	8.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	9.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	10.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	11.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	12.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	13.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	14.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	15.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	16.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	17.	0.02	0.00	0.40	0.20	1.00	0.00	0.00	0.00
N AND P COEF	18.	0.02	0.00	0.40	0.20	1.00	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 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	2.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	3.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	4.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	5.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	6.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	7.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	8.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	9.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	10.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	11.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	12.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	13.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	14.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	15.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	16.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	17.	10.00	0.30	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	18.	10.00	0.30	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.	21.00	4.80	31.80	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	2.	21.00	4.80	31.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	3.	21.00	4.90	20.60	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	4.	21.00	4.80	31.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	5.	21.00	1.88	8.40	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	6.	21.00	1.88	8.40	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	7.	21.00	1.88	8.40	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	8.	21.00	1.88	8.40	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	9.	21.00	3.00	15.70	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	10.	21.00	3.00	15.70	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	11.	21.00	3.00	15.70	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	12.	21.00	3.00	15.70	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	13.	21.00	3.00	15.70	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	14.	21.00	3.00	15.70	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	15.	21.00	3.00	15.70	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	16.	21.00	3.00	15.70	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	17.	21.00	3.00	15.70	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	18.	21.00	3.00	15.70	0.00	0.00	0.00	0.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	2.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	3.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	4.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	5.	0.00	1.00	0.25	0.05	0.05	0.00	0.00

INITIAL COND-2	6.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	7.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	8.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	9.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	10.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	11.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	12.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	13.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	14.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	15.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	16.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	17.	0.00	1.00	0.25	0.05	0.05	0.00	0.00
INITIAL COND-2	18.	0.00	1.00	0.25	0.05	0.05	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	15.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.000	15.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.000	15.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	4.	0.000	15.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	5.	0.000	15.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	6.	0.000	15.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.000	15.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	8.	0.000	15.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	9.	0.000	15.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	10.	0.000	15.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	11.	0.000	15.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	12.	0.000	15.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	13.	0.000	15.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	14.	0.000	15.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	15.	0.000	15.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	16.	0.000	15.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	17.	0.000	15.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	18.	0.000	15.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INCR INFLOW-2	1.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	2.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	3.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	4.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	5.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	6.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	7.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	8.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	9.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	10.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	11.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	12.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	13.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	14.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	15.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	16.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	17.	0.00	0.10	0.25	0.05	0.05	0.00	0.00
INCR INFLOW-2	18.	0.00	0.10	0.25	0.05	0.05	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
STREAM JUNCTION	1.	JNC=	1	23.	41.	40.
STREAM JUNCTION	2.	JNC=	2	51.	89.	88.
ENDATA9	0.			0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWTR ORDER	NAME	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3

HEADWTR-1	1.	Farina	0.00	21.00	5.00	5.00	0.00	0.00	0.00
HEADWTR-1	2.	Schneider Sprin	0.00	21.00	5.00	5.00	0.00	0.00	0.00
HEADWTR-1	3.	St Peter	0.00	21.00	5.00	5.00	0.00	0.00	0.00
ENDATA10	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	0.00	0.00	0.00	0.10	0.25	0.05	0.05	0.00	0.00
HEADWTR-2	2.	0.00	0.00	0.00	0.10	0.25	0.05	0.05	0.00	0.00
HEADWTR-2	3.	0.00	0.00	0.00	0.10	0.25	0.05	0.05	0.00	0.00
ENDATA10A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

CARD TYPE	POINT LOAD ORDER	NAME	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
POINTLD-1	1.	Farina WWTP	0.00	0.01	21.00	4.80	31.80	0.00	0.00	0.00
POINTLD-1	2.	Kinmundy WWT	0.00	0.00	21.00	4.91	20.60	0.00	0.00	0.00
POINTLD-1	3.	St Peter WWT	0.00	0.00	21.00	1.88	8.40	0.00	0.00	0.00
POINTLD-1	4.	Warren Branc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POINTLD-1	5.	Jims Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POINTLD-1	6.	Davidson Cre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA11	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	POINT LOAD ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	N03-N	ORG-P	DIS-P
POINTLD-2	1.	0.00	0.00	0.00	5.00	0.41	0.00	0.17	0.00	0.00
POINTLD-2	2.	0.00	0.00	0.00	5.00	7.60	0.00	0.28	0.00	0.00
POINTLD-2	3.	0.00	0.00	0.00	5.00	6.20	0.00	0.03	0.00	0.00
POINTLD-2	4.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POINTLD-2	5.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POINTLD-2	6.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA11A	0.	0.00	0.00	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
DOWNSTREAM BOUNDARY-1	25.00	5.00	18.00	0.00	0.00	0.00	0.00	0.00
ENDATA13								

$$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

CARD TYPE	CHL-A	ORG-N	NH3-N	NO2-N	NH3-N	ORG-P	DIS-P
DOWNSTREAM BOUNDARY-2	0.00	0.00	0.16	0.01	0.20	0.00	0.00
ENDATA13A							

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STREAM QUALITY SIMULATION — OUTPUT PAGE NUMBER 1
QUAL-2E STREAM QUALITY ROUTING MODEL — Version 3.21 - Feb. 1995

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC	END LOC	FLOW	POINT SRCE	INCR FLOW	VEL	TRVL TIME	DEPTH	WIDTH	VOLUME	BOTTOM AREA	X-SECT AREA	DSPRSN COEF

			KILO	KILO	CMS	CMS	CMS	MPS	DAY	M	M	K-CU-M	K-SQ-M	SQ-M	SQ-M/S
1	1	1	41.60	41.40	0.00	0.00	0.00	0.018	0.132	0.003	0.603	0.00	0.12	0.00	0.00
2	1	2	41.40	41.20	0.01	0.01	0.00	0.169	0.014	0.096	0.696	0.01	0.17	0.07	0.14
3	1	3	41.20	41.00	0.01	0.00	0.00	0.169	0.014	0.096	0.696	0.01	0.17	0.07	0.14
4	1	4	41.00	40.80	0.01	0.00	0.00	0.169	0.014	0.096	0.696	0.01	0.17	0.07	0.14
5	1	5	40.80	40.60	0.01	0.00	0.00	0.170	0.014	0.097	0.697	0.01	0.17	0.07	0.14
6	1	6	40.60	40.40	0.01	0.00	0.00	0.170	0.014	0.097	0.697	0.01	0.17	0.07	0.14
7	1	7	40.40	40.20	0.01	0.00	0.00	0.170	0.014	0.097	0.697	0.01	0.17	0.07	0.14
8	1	8	40.20	40.00	0.01	0.00	0.00	0.170	0.014	0.097	0.697	0.01	0.17	0.07	0.14
9	2	1	40.00	39.80	0.01	0.00	0.00	0.143	0.016	0.095	0.845	0.02	0.20	0.08	0.11
10	2	2	39.80	39.60	0.01	0.00	0.00	0.143	0.016	0.095	0.845	0.02	0.20	0.08	0.11
11	2	3	39.60	39.40	0.01	0.00	0.00	0.143	0.016	0.095	0.845	0.02	0.20	0.08	0.11
12	2	4	39.40	39.20	0.01	0.00	0.00	0.143	0.016	0.095	0.845	0.02	0.20	0.08	0.11
13	2	5	39.20	39.00	0.01	0.00	0.00	0.143	0.016	0.096	0.846	0.02	0.20	0.08	0.11
14	2	6	39.00	38.80	0.01	0.00	0.00	0.143	0.016	0.096	0.846	0.02	0.20	0.08	0.11
15	2	7	38.80	38.60	0.01	0.00	0.00	0.143	0.016	0.096	0.846	0.02	0.20	0.08	0.11
16	2	8	38.60	38.40	0.01	0.00	0.00	0.143	0.016	0.096	0.846	0.02	0.20	0.08	0.11
17	2	9	38.40	38.20	0.01	0.00	0.00	0.143	0.016	0.096	0.846	0.02	0.20	0.08	0.11
18	2	10	38.20	38.00	0.01	0.00	0.00	0.143	0.016	0.096	0.846	0.02	0.20	0.08	0.11
19	2	11	38.00	37.80	0.01	0.00	0.00	0.143	0.016	0.096	0.846	0.02	0.20	0.08	0.11
20	2	12	37.80	37.60	0.01	0.00	0.00	0.143	0.016	0.096	0.846	0.02	0.20	0.08	0.12
21	2	13	37.60	37.40	0.01	0.00	0.00	0.144	0.016	0.096	0.846	0.02	0.20	0.08	0.12
22	2	14	37.40	37.20	0.01	0.00	0.00	0.144	0.016	0.096	0.846	0.02	0.20	0.08	0.12
23	2	15	37.20	37.00	0.01	0.00	0.00	0.144	0.016	0.097	0.847	0.02	0.20	0.08	0.12
24	3	1	3.40	3.20	0.00	0.00	0.00	0.016	0.144	0.002	1.202	0.00	0.24	0.00	0.00
25	3	2	3.20	3.00	0.00	0.00	0.00	0.069	0.034	0.014	1.214	0.00	0.25	0.02	0.01
26	3	3	3.00	2.80	0.00	0.00	0.00	0.069	0.034	0.014	1.214	0.00	0.25	0.02	0.01
27	3	4	2.80	2.60	0.00	0.00	0.00	0.069	0.033	0.014	1.214	0.00	0.25	0.02	0.01
28	3	5	2.60	2.40	0.00	0.00	0.00	0.070	0.033	0.014	1.214	0.00	0.25	0.02	0.01
29	3	6	2.40	2.20	0.00	0.00	0.00	0.070	0.033	0.014	1.214	0.00	0.25	0.02	0.01
30	3	7	2.20	2.00	0.00	0.00	0.00	0.071	0.033	0.015	1.215	0.00	0.25	0.02	0.01
31	3	8	2.00	1.80	0.00	0.00	0.00	0.071	0.032	0.015	1.215	0.00	0.25	0.02	0.01
32	3	9	1.80	1.60	0.00	0.00	0.00	0.072	0.032	0.015	1.215	0.00	0.25	0.02	0.01
33	3	10	1.60	1.40	0.00	0.00	0.00	0.072	0.032	0.015	1.215	0.00	0.25	0.02	0.01
34	3	11	1.40	1.20	0.00	0.00	0.00	0.073	0.032	0.015	1.215	0.00	0.25	0.02	0.01
35	3	12	1.20	1.00	0.00	0.00	0.00	0.073	0.032	0.015	1.215	0.00	0.25	0.02	0.01
36	3	13	1.00	0.80	0.00	0.00	0.00	0.073	0.032	0.015	1.215	0.00	0.25	0.02	0.01
37	3	14	0.80	0.60	0.00	0.00	0.00	0.074	0.031	0.015	1.215	0.00	0.25	0.02	0.01
38	3	15	0.60	0.40	0.00	0.00	0.00	0.074	0.031	0.016	1.216	0.00	0.25	0.02	0.01
39	3	16	0.40	0.20	0.00	0.00	0.00	0.075	0.031	0.016	1.216	0.00	0.25	0.02	0.01
40	3	17	0.20	0.00	0.00	0.00	0.00	0.075	0.031	0.016	1.216	0.00	0.25	0.02	0.01

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC KILO	END LOC KILO	FLOW CMS	POINT SRCE CMS	INCR FLOW CMS	VEL MPS	TRVL TIME DAY	DEPTH M	WIDTH M	VOLUME K-CU-M	BOTTOM AREA K-SQ-M	X-SECT AREA SQ-M	DSPRSN COEF SQ-M/S
41	4	1	37.00	36.80	0.01	0.00	0.00	0.097	0.024	0.058	2.358	0.03	0.49	0.14	0.05
42	4	2	36.80	36.60	0.01	0.00	0.00	0.097	0.024	0.058	2.358	0.03	0.49	0.14	0.05
43	4	3	36.60	36.40	0.01	0.00	0.00	0.097	0.024	0.058	2.358	0.03	0.49	0.14	0.05
44	4	4	36.40	36.20	0.01	0.00	0.00	0.097	0.024	0.058	2.358	0.03	0.49	0.14	0.05
45	4	5	36.20	36.00	0.01	0.00	0.00	0.097	0.024	0.058	2.358	0.03	0.49	0.14	0.05
46	4	6	36.00	35.80	0.01	0.00	0.00	0.097	0.024	0.058	2.358	0.03	0.49	0.14	0.05
47	4	7	35.80	35.60	0.01	0.00	0.00	0.097	0.024	0.058	2.358	0.03	0.49	0.14	0.05
48	4	8	35.60	35.40	0.01	0.00	0.00	0.097	0.024	0.058	2.359	0.03	0.49	0.14	0.05
49	4	9	35.40	35.20	0.01	0.00	0.00	0.097	0.024	0.058	2.359	0.03	0.49	0.14	0.05
50	4	10	35.20	35.00	0.01	0.00	0.00	0.097	0.024	0.058	2.359	0.03	0.49	0.14	0.05
51	4	11	35.00	34.80	0.01	0.00	0.00	0.097	0.024	0.058	2.359	0.03	0.49	0.14	0.05

52	5	1	7.40	7.20	0.00	0.00	0.00	0.016	0.143	0.003	0.603	0.00	0.12	0.00	0.00
53	5	2	7.20	7.00	0.00	0.00	0.00	0.041	0.056	0.013	0.613	0.00	0.13	0.01	0.01
54	5	3	7.00	6.80	0.00	0.00	0.00	0.042	0.055	0.014	0.614	0.00	0.13	0.01	0.01
55	5	4	6.80	6.60	0.00	0.00	0.00	0.043	0.054	0.014	0.614	0.00	0.13	0.01	0.01
56	5	5	6.60	6.40	0.00	0.00	0.00	0.044	0.053	0.015	0.615	0.00	0.13	0.01	0.01
57	5	6	6.40	6.20	0.00	0.00	0.00	0.045	0.052	0.015	0.615	0.00	0.13	0.01	0.01
58	5	7	6.20	6.00	0.00	0.00	0.00	0.046	0.051	0.015	0.615	0.00	0.13	0.01	0.01
59	5	8	6.00	5.80	0.00	0.00	0.00	0.047	0.050	0.016	0.616	0.00	0.13	0.01	0.01
60	5	9	5.80	5.60	0.00	0.00	0.00	0.047	0.049	0.016	0.616	0.00	0.13	0.01	0.01
61	5	10	5.60	5.40	0.00	0.00	0.00	0.048	0.048	0.017	0.617	0.00	0.13	0.01	0.01
62	5	11	5.40	5.20	0.00	0.00	0.00	0.049	0.047	0.017	0.617	0.00	0.13	0.01	0.01
63	6	1	5.20	5.00	0.00	0.00	0.00	0.058	0.040	0.015	0.615	0.00	0.13	0.01	0.01
64	6	2	5.00	4.80	0.00	0.00	0.00	0.059	0.039	0.015	0.615	0.00	0.13	0.01	0.01
65	6	3	4.80	4.60	0.00	0.00	0.00	0.060	0.039	0.016	0.616	0.00	0.13	0.01	0.01
66	6	4	4.60	4.40	0.00	0.00	0.00	0.061	0.038	0.016	0.616	0.00	0.13	0.01	0.01
67	6	5	4.40	4.20	0.00	0.00	0.00	0.062	0.038	0.016	0.616	0.00	0.13	0.01	0.01
68	6	6	4.20	4.00	0.00	0.00	0.00	0.062	0.037	0.017	0.617	0.00	0.13	0.01	0.01
69	6	7	4.00	3.80	0.00	0.00	0.00	0.063	0.037	0.017	0.617	0.00	0.13	0.01	0.01
70	6	8	3.80	3.60	0.00	0.00	0.00	0.064	0.036	0.017	0.617	0.00	0.13	0.01	0.01
71	6	9	3.60	3.40	0.00	0.00	0.00	0.065	0.036	0.018	0.618	0.00	0.13	0.01	0.01
72	6	10	3.40	3.20	0.00	0.00	0.00	0.065	0.035	0.018	0.618	0.00	0.13	0.01	0.01
73	6	11	3.20	3.00	0.00	0.00	0.00	0.066	0.035	0.018	0.618	0.00	0.13	0.01	0.01
74	6	12	3.00	2.80	0.00	0.00	0.00	0.067	0.035	0.019	0.619	0.00	0.13	0.01	0.01
75	6	13	2.80	2.60	0.00	0.00	0.00	0.067	0.034	0.019	0.619	0.00	0.13	0.01	0.01
76	7	1	2.60	2.40	0.00	0.00	0.00	0.029	0.080	0.027	1.027	0.01	0.22	0.03	0.01
77	7	2	2.40	2.20	0.00	0.00	0.00	0.029	0.079	0.027	1.027	0.01	0.22	0.03	0.01
78	7	3	2.20	2.00	0.00	0.00	0.00	0.030	0.078	0.028	1.028	0.01	0.22	0.03	0.01
79	7	4	2.00	1.80	0.00	0.00	0.00	0.030	0.078	0.028	1.028	0.01	0.22	0.03	0.01
80	7	5	1.80	1.60	0.00	0.00	0.00	0.030	0.077	0.028	1.029	0.01	0.22	0.03	0.01

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC KILO	END LOC KILO	FLOW CMS	POINT SRCE CMS	INCR FLOW CMS	VEL MPS	TRVL TIME DAY	DEPTH M	WIDTH M	VOLUME K-CU-M	BOTTOM AREA K-SQ-M	X-SECT AREA SQ-M	DSPRSN COEF SQ-M/S
81	7	6	1.60	1.40	0.00	0.00	0.00	0.030	0.076	0.029	1.029	0.01	0.22	0.03	0.01
82	8	1	1.40	1.20	0.00	0.00	0.00	0.056	0.042	0.016	1.016	0.00	0.21	0.02	0.01
83	8	2	1.20	1.00	0.00	0.00	0.00	0.056	0.041	0.016	1.016	0.00	0.21	0.02	0.01
84	8	3	1.00	0.80	0.00	0.00	0.00	0.057	0.041	0.017	1.017	0.00	0.21	0.02	0.01
85	8	4	0.80	0.60	0.00	0.00	0.00	0.057	0.041	0.017	1.017	0.00	0.21	0.02	0.01
86	8	5	0.60	0.40	0.00	0.00	0.00	0.057	0.040	0.017	1.017	0.00	0.21	0.02	0.01
87	8	6	0.40	0.20	0.00	0.00	0.00	0.058	0.040	0.017	1.017	0.00	0.21	0.02	0.01
88	8	7	0.20	0.00	0.00	0.00	0.00	0.058	0.040	0.018	1.018	0.00	0.21	0.02	0.01
89	9	1	34.80	34.60	0.01	0.00	0.00	0.072	0.032	0.033	6.033	0.04	1.22	0.20	0.02
90	9	2	34.60	34.40	0.01	0.00	0.00	0.072	0.032	0.033	6.033	0.04	1.22	0.20	0.02
91	9	3	34.40	34.20	0.01	0.00	0.00	0.072	0.032	0.033	6.033	0.04	1.22	0.20	0.02
92	9	4	34.20	34.00	0.01	0.00	0.00	0.072	0.032	0.033	6.033	0.04	1.22	0.20	0.02
93	9	5	34.00	33.80	0.01	0.00	0.00	0.072	0.032	0.033	6.033	0.04	1.22	0.20	0.02
94	9	6	33.80	33.60	0.01	0.00	0.00	0.072	0.032	0.033	6.034	0.04	1.22	0.20	0.02
95	9	7	33.60	33.40	0.01	0.00	0.00	0.072	0.032	0.034	6.034	0.04	1.22	0.20	0.02
96	9	8	33.40	33.20	0.01	0.00	0.00	0.072	0.032	0.034	6.034	0.04	1.22	0.20	0.02
97	9	9	33.20	33.00	0.01	0.00	0.00	0.072	0.032	0.034	6.034	0.04	1.22	0.20	0.02
98	9	10	33.00	32.80	0.01	0.00	0.00	0.072	0.032	0.034	6.034	0.04	1.22	0.20	0.02
99	9	11	32.80	32.60	0.01	0.00	0.00	0.072	0.032	0.034	6.034	0.04	1.22	0.20	0.02
100	10	1	32.60	32.40	0.01	0.00	0.00	0.069	0.034	0.035	6.035	0.04	1.22	0.21	0.02
101	10	2	32.40	32.20	0.01	0.00	0.00	0.069	0.034	0.035	6.035	0.04	1.22	0.21	0.02
102	10	3	32.20	32.00	0.01	0.00	0.00	0.069	0.034	0.035	6.036	0.04	1.22	0.21	0.02

103	10	4	32.00	31.80	0.01	0.00	0.00	0.069	0.034	0.036	6.036	0.04	1.22	0.21	0.02
104	10	5	31.80	31.60	0.01	0.00	0.00	0.069	0.034	0.036	6.036	0.04	1.22	0.21	0.02
105	10	6	31.60	31.40	0.01	0.00	0.00	0.069	0.034	0.036	6.036	0.04	1.22	0.21	0.02
106	10	7	31.40	31.20	0.01	0.00	0.00	0.069	0.034	0.036	6.036	0.04	1.22	0.21	0.02
107	10	8	31.20	31.00	0.01	0.00	0.00	0.069	0.034	0.036	6.036	0.04	1.22	0.22	0.02
108	10	9	31.00	30.80	0.01	0.00	0.00	0.069	0.034	0.036	6.036	0.04	1.22	0.22	0.02
109	10	10	30.80	30.60	0.01	0.00	0.00	0.069	0.034	0.036	6.036	0.04	1.22	0.22	0.02
110	10	11	30.60	30.40	0.01	0.00	0.00	0.069	0.034	0.036	6.036	0.04	1.22	0.22	0.02
111	10	12	30.40	30.20	0.01	0.00	0.00	0.069	0.034	0.036	6.036	0.04	1.22	0.22	0.02
112	10	13	30.20	30.00	0.01	0.00	0.00	0.069	0.033	0.036	6.036	0.04	1.22	0.22	0.02
113	10	14	30.00	29.80	0.01	0.00	0.00	0.069	0.033	0.036	6.036	0.04	1.22	0.22	0.02
114	10	15	29.80	29.60	0.01	0.00	0.00	0.069	0.033	0.036	6.036	0.04	1.22	0.22	0.02
115	10	16	29.60	29.40	0.01	0.00	0.00	0.069	0.033	0.036	6.036	0.04	1.22	0.22	0.02
116	10	17	29.40	29.20	0.02	0.00	0.00	0.069	0.033	0.036	6.036	0.04	1.22	0.22	0.02
117	10	18	29.20	29.00	0.02	0.00	0.00	0.069	0.033	0.036	6.036	0.04	1.22	0.22	0.02
118	10	19	29.00	28.80	0.02	0.00	0.00	0.069	0.033	0.036	6.036	0.04	1.22	0.22	0.02
119	10	20	28.80	28.60	0.02	0.00	0.00	0.069	0.033	0.036	6.036	0.04	1.22	0.22	0.02

STREAM QUALITY SIMULATION — OUTPUT PAGE NUMBER 4

QUAL-2E STREAM QUALITY ROUTING MODEL — Version 3.21 - Feb. 1995

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC KILO	END LOC KILO	FLOW CMS	POINT SRCE CMS	INCR FLOW CMS	VEL MPS	TRVL TIME DAY	DEPTH M	WIDTH M	VOLUME K-CU-M	BOTTOM AREA K-SQ-M	X-SECT AREA SQ-M	DSPRSN COEF SQ-M/S
120	11	1	28.60	28.40	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.02
121	11	2	28.40	28.20	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.02
122	11	3	28.20	28.00	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.03
123	11	4	28.00	27.80	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.03
124	11	5	27.80	27.60	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.03
125	11	6	27.60	27.40	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.03
126	11	7	27.40	27.20	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.03
127	11	8	27.20	27.00	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.03
128	11	9	27.00	26.80	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.03
129	11	10	26.80	26.60	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.03
130	11	11	26.60	26.40	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.03
131	11	12	26.40	26.20	0.02	0.00	0.00	0.076	0.030	0.033	6.033	0.04	1.22	0.20	0.03
132	11	13	26.20	26.00	0.02	0.00	0.00	0.077	0.030	0.033	6.033	0.04	1.22	0.20	0.03
133	11	14	26.00	25.80	0.02	0.00	0.00	0.077	0.030	0.033	6.033	0.04	1.22	0.20	0.03
134	11	15	25.80	25.60	0.02	0.00	0.00	0.077	0.030	0.033	6.033	0.04	1.22	0.20	0.03
135	11	16	25.60	25.40	0.02	0.00	0.00	0.077	0.030	0.033	6.033	0.04	1.22	0.20	0.03
136	11	17	25.40	25.20	0.02	0.00	0.00	0.077	0.030	0.033	6.033	0.04	1.22	0.20	0.03
137	11	18	25.20	25.00	0.02	0.00	0.00	0.077	0.030	0.033	6.033	0.04	1.22	0.20	0.03
138	11	19	25.00	24.80	0.02	0.00	0.00	0.077	0.030	0.033	6.033	0.04	1.22	0.20	0.03
139	11	20	24.80	24.60	0.02	0.00	0.00	0.077	0.030	0.033	6.033	0.04	1.22	0.20	0.03
140	12	1	24.60	24.40	0.02	0.00	0.00	0.064	0.036	0.040	6.040	0.05	1.22	0.24	0.03
141	12	2	24.40	24.20	0.02	0.00	0.00	0.064	0.036	0.040	6.040	0.05	1.22	0.24	0.03
142	12	3	24.20	24.00	0.02	0.00	0.00	0.064	0.036	0.040	6.040	0.05	1.22	0.24	0.03
143	12	4	24.00	23.80	0.02	0.00	0.00	0.064	0.036	0.040	6.040	0.05	1.22	0.24	0.03
144	12	5	23.80	23.60	0.02	0.00	0.00	0.064	0.036	0.040	6.040	0.05	1.22	0.24	0.03
145	12	6	23.60	23.40	0.02	0.00	0.00	0.064	0.036	0.040	6.040	0.05	1.22	0.24	0.03
146	12	7	23.40	23.20	0.02	0.00	0.00	0.064	0.036	0.040	6.040	0.05	1.22	0.24	0.03
147	12	8	23.20	23.00	0.02	0.00	0.00	0.064	0.036	0.040	6.040	0.05	1.22	0.24	0.03
148	12	9	23.00	22.80	0.02	0.00	0.00	0.064	0.036	0.040	6.040	0.05	1.22	0.24	0.03
149	12	10	22.80	22.60	0.02	0.00	0.00	0.064	0.036	0.040	6.040	0.05	1.22	0.24	0.03
150	12	11	22.60	22.40	0.02	0.00	0.00	0.064	0.036	0.040	6.040	0.05	1.22	0.24	0.03
151	12	12	22.40	22.20	0.02	0.00	0.00	0.065	0.036	0.040	6.040	0.05	1.22	0.24	0.03
152	12	13	22.20	22.00	0.02	0.00	0.00	0.065	0.036	0.040	6.040	0.05	1.22	0.24	0.03
153	12	14	22.00	21.80	0.02	0.00	0.00	0.065	0.036	0.040	6.040	0.05	1.22	0.24	0.03
154	12	15	21.80	21.60	0.02	0.00	0.00	0.065	0.036	0.040	6.040	0.05	1.22	0.24	0.03
155	12	16	21.60	21.40	0.02	0.00	0.00	0.065	0.036	0.040	6.040	0.05	1.22	0.24	0.03
156	12	17	21.40	21.20	0.02	0.00	0.00	0.065	0.036	0.040	6.040	0.05	1.22	0.24	0.03
157	12	18	21.20	21.00	0.02	0.00	0.00	0.065	0.036	0.040	6.040	0.05	1.22	0.24	0.03
158	12	19	21.00	20.80	0.02	0.00	0.00	0.065	0.036	0.041	6.041	0.05	1.22	0.24	0.03
159	12	20	20.80	20.60	0.02	0.00	0.00	0.065	0.036	0.041	6.041	0.05	1.22	0.24	0.03

160	13	1	20.60	20.40	0.02	0.00	0.00	0.067	0.035	0.057	4.158	0.05	0.85	0.24	0.04
161	13	2	20.40	20.20	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC KILO	END LOC KILO	FLOW CMS	POINT SRCE CMS	INCR FLOW CMS	VEL MPS	TRVL TIME DAY	DEPTH M	WIDTH M	VOLUME K-CU-M	BOTTOM AREA K-SQ-M	X-SECT AREA SQ-M	DSPRSN COEF SQ-M/S
162	13	3	20.20	20.00	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04
163	13	4	20.00	19.80	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04
164	13	5	19.80	19.60	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04
165	13	6	19.60	19.40	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04
166	13	7	19.40	19.20	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04
167	13	8	19.20	19.00	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04
168	13	9	19.00	18.80	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04
169	13	10	18.80	18.60	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04
170	13	11	18.60	18.40	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04
171	13	12	18.40	18.20	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04
172	13	13	18.20	18.00	0.02	0.00	0.00	0.067	0.034	0.057	4.158	0.05	0.85	0.24	0.04
173	13	14	18.00	17.80	0.02	0.00	0.00	0.068	0.034	0.058	4.158	0.05	0.85	0.24	0.04
174	13	15	17.80	17.60	0.02	0.00	0.00	0.068	0.034	0.058	4.158	0.05	0.85	0.24	0.04
175	13	16	17.60	17.40	0.02	0.00	0.00	0.068	0.034	0.058	4.158	0.05	0.85	0.24	0.04
176	13	17	17.40	17.20	0.02	0.00	0.00	0.068	0.034	0.058	4.158	0.05	0.85	0.24	0.04
177	13	18	17.20	17.00	0.02	0.00	0.00	0.068	0.034	0.058	4.158	0.05	0.85	0.24	0.04
178	13	19	17.00	16.80	0.02	0.00	0.00	0.068	0.034	0.058	4.158	0.05	0.85	0.24	0.04
179	13	20	16.80	16.60	0.02	0.00	0.00	0.068	0.034	0.058	4.158	0.05	0.85	0.24	0.04
180	14	1	16.60	16.40	0.02	0.00	0.00	0.083	0.028	0.047	4.199	0.04	0.86	0.20	0.04
181	14	2	16.40	16.20	0.02	0.00	0.00	0.083	0.028	0.047	4.199	0.04	0.86	0.20	0.04
182	14	3	16.20	16.00	0.02	0.00	0.00	0.083	0.028	0.047	4.199	0.04	0.86	0.20	0.04
183	14	4	16.00	15.80	0.02	0.00	0.00	0.083	0.028	0.047	4.199	0.04	0.86	0.20	0.04
184	14	5	15.80	15.60	0.02	0.00	0.00	0.083	0.028	0.047	4.199	0.04	0.86	0.20	0.04
185	14	6	15.60	15.40	0.02	0.00	0.00	0.083	0.028	0.047	4.199	0.04	0.86	0.20	0.04
186	14	7	15.40	15.20	0.02	0.00	0.00	0.083	0.028	0.047	4.199	0.04	0.86	0.20	0.04
187	14	8	15.20	15.00	0.02	0.00	0.00	0.084	0.028	0.047	4.199	0.04	0.86	0.20	0.04
188	14	9	15.00	14.80	0.02	0.00	0.00	0.084	0.028	0.047	4.199	0.04	0.86	0.20	0.04
189	14	10	14.80	14.60	0.02	0.00	0.00	0.084	0.028	0.047	4.199	0.04	0.86	0.20	0.04
190	15	1	14.60	14.40	0.02	0.00	0.00	0.052	0.044	0.081	3.881	0.06	0.81	0.32	0.04
191	15	2	14.40	14.20	0.02	0.00	0.00	0.052	0.044	0.081	3.881	0.06	0.81	0.32	0.04
192	15	3	14.20	14.00	0.02	0.00	0.00	0.052	0.044	0.081	3.881	0.06	0.81	0.32	0.04
193	15	4	14.00	13.80	0.02	0.00	0.00	0.052	0.044	0.081	3.881	0.06	0.81	0.32	0.04
194	15	5	13.80	13.60	0.02	0.00	0.00	0.052	0.044	0.081	3.882	0.06	0.81	0.32	0.04
195	15	6	13.60	13.40	0.02	0.00	0.00	0.052	0.044	0.082	3.882	0.06	0.81	0.32	0.04
196	15	7	13.40	13.20	0.02	0.00	0.00	0.052	0.044	0.082	3.882	0.06	0.81	0.32	0.04
197	15	8	13.20	13.00	0.02	0.00	0.00	0.052	0.044	0.082	3.882	0.06	0.81	0.32	0.04
198	15	9	13.00	12.80	0.02	0.00	0.00	0.052	0.044	0.082	3.882	0.06	0.81	0.32	0.04
199	15	10	12.80	12.60	0.02	0.00	0.00	0.052	0.044	0.082	3.882	0.06	0.81	0.32	0.04
200	15	11	12.60	12.40	0.02	0.00	0.00	0.053	0.044	0.082	3.882	0.06	0.81	0.32	0.04
201	15	12	12.40	12.20	0.02	0.00	0.00	0.053	0.044	0.082	3.882	0.06	0.81	0.32	0.04
202	15	13	12.20	12.00	0.02	0.00	0.00	0.053	0.044	0.082	3.882	0.06	0.81	0.32	0.04
203	15	14	12.00	11.80	0.02	0.00	0.00	0.053	0.044	0.082	3.882	0.06	0.81	0.32	0.04

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC	END LOC	FLOW	POINT SRCE	INCR FLOW	VEL	TRVL TIME	DEPTH	WIDTH	VOLUME	BOTTOM AREA	X-SECT AREA	DSPRSN COEF

			KILO	KILO	CMS	CMS	CMS	MPS	DAY	M	M	K-CU-M	K-SQ-M	SQ-M	SQ-M/S
204	16	1	11.80	11.60	0.02	0.00	0.00	0.078	0.030	0.050	4.301	0.04	0.88	0.21	0.04
205	16	2	11.60	11.40	0.02	0.00	0.00	0.078	0.030	0.050	4.301	0.04	0.88	0.21	0.04
206	16	3	11.40	11.20	0.02	0.00	0.00	0.078	0.030	0.050	4.301	0.04	0.88	0.21	0.04
207	16	4	11.20	11.00	0.02	0.00	0.00	0.078	0.030	0.050	4.301	0.04	0.88	0.21	0.04
208	16	5	11.00	10.80	0.02	0.00	0.00	0.078	0.030	0.050	4.302	0.04	0.88	0.22	0.04
209	16	6	10.80	10.60	0.02	0.00	0.00	0.078	0.030	0.050	4.302	0.04	0.88	0.22	0.04
210	16	7	10.60	10.40	0.02	0.00	0.00	0.078	0.030	0.050	4.302	0.04	0.88	0.22	0.04
211	16	8	10.40	10.20	0.02	0.00	0.00	0.078	0.030	0.050	4.302	0.04	0.88	0.22	0.04
212	16	9	10.20	10.00	0.02	0.00	0.00	0.078	0.030	0.050	4.302	0.04	0.88	0.22	0.04
213	16	10	10.00	9.80	0.02	0.00	0.00	0.079	0.029	0.050	4.302	0.04	0.88	0.22	0.04
214	16	11	9.80	9.60	0.02	0.00	0.00	0.079	0.029	0.050	4.302	0.04	0.88	0.22	0.04
215	16	12	9.60	9.40	0.02	0.00	0.00	0.079	0.029	0.050	4.302	0.04	0.88	0.22	0.04
216	16	13	9.40	9.20	0.02	0.00	0.00	0.079	0.029	0.050	4.302	0.04	0.88	0.22	0.04
217	16	14	9.20	9.00	0.02	0.00	0.00	0.079	0.029	0.050	4.302	0.04	0.88	0.22	0.04
218	16	15	9.00	8.80	0.02	0.00	0.00	0.079	0.029	0.050	4.302	0.04	0.88	0.22	0.04
219	16	16	8.80	8.60	0.02	0.00	0.00	0.079	0.029	0.050	4.302	0.04	0.88	0.22	0.04
220	16	17	8.60	8.40	0.02	0.00	0.00	0.079	0.029	0.050	4.302	0.04	0.88	0.22	0.04
221	16	18	8.40	8.20	0.02	0.00	0.00	0.079	0.029	0.050	4.302	0.04	0.88	0.22	0.04
222	16	19	8.20	8.00	0.02	0.00	0.00	0.079	0.029	0.050	4.302	0.04	0.88	0.22	0.04
223	16	20	8.00	7.80	0.02	0.00	0.00	0.079	0.029	0.051	4.302	0.04	0.88	0.22	0.04
224	17	1	7.80	7.60	0.02	0.00	0.00	0.070	0.033	0.063	3.863	0.05	0.80	0.24	0.05
225	17	2	7.60	7.40	0.02	0.00	0.00	0.070	0.033	0.063	3.863	0.05	0.80	0.24	0.05
226	17	3	7.40	7.20	0.02	0.00	0.00	0.070	0.033	0.063	3.864	0.05	0.80	0.24	0.05
227	17	4	7.20	7.00	0.02	0.00	0.00	0.070	0.033	0.063	3.864	0.05	0.80	0.24	0.05
228	17	5	7.00	6.80	0.02	0.00	0.00	0.070	0.033	0.063	3.864	0.05	0.80	0.24	0.05
229	17	6	6.80	6.60	0.02	0.00	0.00	0.070	0.033	0.063	3.864	0.05	0.80	0.25	0.05
230	17	7	6.60	6.40	0.02	0.00	0.00	0.070	0.033	0.063	3.864	0.05	0.80	0.25	0.05
231	17	8	6.40	6.20	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
232	17	9	6.20	6.00	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
233	17	10	6.00	5.80	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
234	17	11	5.80	5.60	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
235	17	12	5.60	5.40	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
236	17	13	5.40	5.20	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
237	17	14	5.20	5.00	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
238	17	15	5.00	4.80	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
239	17	16	4.80	4.60	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
240	17	17	4.60	4.40	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
241	17	18	4.40	4.20	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
242	17	19	4.20	4.00	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
243	17	20	4.00	3.80	0.02	0.00	0.00	0.071	0.033	0.064	3.864	0.05	0.80	0.25	0.05
244	18	1	3.80	3.60	0.02	0.00	0.00	0.078	0.030	0.055	4.056	0.04	0.83	0.22	0.05
245	18	2	3.60	3.40	0.02	0.00	0.00	0.078	0.030	0.055	4.056	0.04	0.83	0.22	0.05

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC KILO	END LOC KILO	FLOW CMS	POINT SRCE CMS	INCR FLOW CMS	VEL MPS	TRVL TIME DAY	DEPTH M	WIDTH M	VOLUME K-CU-M	BOTTOM AREA K-SQ-M	X-SECT AREA SQ-M	DSPRSN COEF SQ-M/S
246	18	3	3.40	3.20	0.02	0.00	0.00	0.078	0.030	0.055	4.056	0.04	0.83	0.22	0.05
247	18	4	3.20	3.00	0.02	0.00	0.00	0.079	0.029	0.055	4.056	0.04	0.83	0.22	0.05
248	18	5	3.00	2.80	0.02	0.00	0.00	0.079	0.029	0.055	4.056	0.04	0.83	0.22	0.05
249	18	6	2.80	2.60	0.02	0.00	0.00	0.079	0.029	0.055	4.056	0.04	0.83	0.22	0.05
250	18	7	2.60	2.40	0.02	0.00	0.00	0.079	0.029	0.055	4.056	0.04	0.83	0.22	0.05
251	18	8	2.40	2.20	0.02	0.00	0.00	0.079	0.029	0.055	4.056	0.05	0.83	0.23	0.05
252	18	9	2.20	2.00	0.02	0.00	0.00	0.079	0.029	0.056	4.056	0.05	0.83	0.23	0.05
253	18	10	2.00	1.80	0.02	0.00	0.00	0.079	0.029	0.056	4.056	0.05	0.83	0.23	0.05
254	18	11	1.80	1.60	0.02	0.00	0.00	0.079	0.029	0.056	4.056	0.05	0.83	0.23	0.05
255	18	12	1.60	1.40	0.02	0.00	0.00	0.079	0.029	0.056	4.056	0.05	0.83	0.23	0.05
256	18	13	1.40	1.20	0.02	0.00	0.00	0.079	0.029	0.056	4.056	0.05	0.83	0.23	0.05
257	18	14	1.20	1.00	0.02	0.00	0.00	0.079	0.029	0.056	4.056	0.05	0.83	0.23	0.05
258	18	15	1.00	0.80	0.02	0.00	0.00	0.079	0.029	0.056	4.056	0.05	0.83	0.23	0.05

259	18	16	0.80	0.60	0.02	0.00	0.00	0.079	0.029	0.056	4.056	0.05	0.83	0.23	0.05
260	18	17	0.60	0.40	0.02	0.00	0.00	0.079	0.029	0.056	4.056	0.05	0.83	0.23	0.05
261	18	18	0.40	0.20	0.02	0.00	0.00	0.079	0.029	0.056	4.057	0.05	0.83	0.23	0.05
262	18	19	0.20	0.00	0.02	0.00	0.00	0.079	0.029	0.056	4.057	0.05	0.83	0.23	0.05

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STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 8
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995

***** 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/M2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/M2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/M2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/M2D
1	1	8.47	1	16.71	0.62	0.56	5.22	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2	8.95	1	15.59	0.54	0.52	4.40	0.02	0.00	0.46	0.22	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	3	8.86	1	15.79	0.55	0.53	4.53	0.02	0.00	0.47	0.23	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	4	8.79	1	15.95	0.56	0.53	4.65	0.02	0.00	0.49	0.24	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	5	8.73	1	16.08	0.57	0.54	4.75	0.02	0.00	0.51	0.25	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	6	8.68	1	16.19	0.58	0.54	4.83	0.02	0.00	0.52	0.25	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	7	8.64	1	16.29	0.59	0.54	4.90	0.02	0.00	0.53	0.26	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	8	8.61	1	16.37	0.59	0.55	4.96	0.02	0.00	0.54	0.26	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1	8.58	1	13.70	0.36	0.11	4.38	0.02	0.00	0.54	0.26	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	8.56	1	11.00	0.36	0.11	4.42	0.02	0.00	0.55	0.27	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	3	8.54	1	11.03	0.36	0.11	4.45	0.02	0.00	0.56	0.27	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	4	8.52	1	11.06	0.36	0.11	4.48	0.02	0.00	0.56	0.27	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5	8.51	1	11.08	0.37	0.11	4.50	0.02	0.00	0.56	0.27	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	6	8.50	1	11.09	0.37	0.11	4.51	0.02	0.00	0.57	0.27	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	7	8.49	1	11.10	0.37	0.11	4.53	0.02	0.00	0.57	0.27	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	8	8.49	1	11.11	0.37	0.11	4.54	0.02	0.00	0.57	0.27	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	9	8.48	1	11.12	0.37	0.11	4.54	0.02	0.00	0.57	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	10	8.48	1	11.13	0.37	0.11	4.55	0.02	0.00	0.57	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	11	8.48	1	11.13	0.37	0.11	4.55	0.02	0.00	0.57	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	12	8.47	1	11.13	0.37	0.11	4.56	0.02	0.00	0.57	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	13	8.47	1	11.14	0.37	0.11	4.56	0.02	0.00	0.57	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	14	8.47	1	11.14	0.37	0.11	4.56	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	15	8.47	1	11.14	0.37	0.11	4.57	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	1	8.46	1	73.60	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2	8.57	1	72.40	0.12	0.00	5.02	0.02	0.00	0.55	0.26	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	8.48	1	73.36	0.12	0.00	5.19	0.02	0.00	0.57	0.27	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	4	8.47	1	73.56	0.12	0.00	5.22	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	5	8.46	1	73.60	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	6	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	7	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	8	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	9	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	10	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	11	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	12	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	13	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	14	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	15	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	16	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	17	8.46	1	73.61	0.12	0.00	5.23	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 9
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995

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

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT	K2 OPT	OXYGN REAIR	BOD DECAY	BOD SETT	SOD RATE	ORGN DECAY	ORGN SETT	NH3 DECAY	NH3 SRCE	NO2 DECAY	ORGP DECAY	ORGP SETT	DISP SRCE	COLI DECAY	ANC DECAY	ANC SETT	ANC SRCE

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/M2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/M2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/M2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/M2D
4	1	8.47	1	29.54	0.43	0.00	5.88	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	2	8.46	1	16.73	0.43	0.00	5.88	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	3	8.46	1	16.73	0.43	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	8.46	1	16.73	0.43	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	5	8.46	1	16.74	0.43	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	6	8.46	1	16.74	0.43	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	7	8.46	1	16.74	0.43	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	8	8.46	1	16.74	0.43	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	9	8.46	1	16.74	0.43	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	10	8.46	1	16.74	0.43	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	11	8.46	1	16.74	0.43	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1	8.47	1	74.62	0.74	0.00	3.26	0.02	0.00	0.57	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	2	8.53	1	73.97	0.73	0.00	3.19	0.02	0.00	0.56	0.27	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	3	8.48	1	74.56	0.74	0.00	3.25	0.02	0.00	0.57	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	4	8.47	1	74.64	0.74	0.00	3.26	0.02	0.00	0.57	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	5	8.47	1	74.65	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6	8.47	1	74.65	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	7	8.47	1	74.65	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	8	8.47	1	74.65	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	9	8.47	1	74.65	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	10	8.47	1	74.65	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	11	8.47	1	74.65	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	1	8.47	1	87.46	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	2	8.47	1	100.27	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	3	8.47	1	100.28	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	4	8.47	1	100.28	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	5	8.47	1	100.28	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	6	8.47	1	100.28	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	7	8.47	1	100.28	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	8	8.47	1	100.28	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	9	8.47	1	100.28	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	10	8.47	1	100.28	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	11	8.47	1	100.28	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	12	8.47	1	100.28	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	13	8.47	1	100.28	0.74	0.00	3.26	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	1	8.47	1	70.24	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	2	8.46	1	40.15	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	3	8.46	1	40.15	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	4	8.46	1	40.15	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	5	8.46	1	40.15	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***** 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/M2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/M2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/M2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/M2D
7	6	8.46	1	40.15	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1	8.46	1	64.12	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	2	8.46	1	88.09	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	3	8.46	1	88.09	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	4	8.46	1	88.09	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	5	8.46	1	88.09	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	6	8.46	1	88.09	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	7	8.46	1	88.09	0.74	0.00	3.27	0.02	0.00	0.58	0.28	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	1	8.46	1	37.38	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00

9	2	8.46	1	22.32	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	3	8.46	1	22.32	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	4	8.46	1	22.32	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	5	8.46	1	22.32	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	6	8.46	1	22.32	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	7	8.46	1	22.32	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	8	8.46	1	22.32	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	9	8.46	1	22.32	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	10	8.46	1	22.32	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	11	8.46	1	22.32	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	1	8.46	1	21.77	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	2	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	3	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	4	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	5	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	6	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	7	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	8	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	9	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	10	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	11	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	12	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	13	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	14	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	15	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	16	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	17	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	18	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	19	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	20	8.46	1	21.21	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***** 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/M2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/M2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/M2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/M2D
11	1	8.46	1	20.65	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	2	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	3	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	4	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	5	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	6	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	7	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	8	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	9	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	10	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	11	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	12	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	13	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	14	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	15	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	16	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	17	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	18	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	19	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	20	8.46	1	20.09	0.12	0.00	3.93	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	1	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	2	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	3	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	4	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	5	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00

12	6	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	7	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	8	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	9	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	10	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	11	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	12	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	13	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	14	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	15	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	16	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	17	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	18	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	19	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	20	8.46	1	20.09	0.12	0.00	4.59	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	1	8.46	1	19.53	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	2	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***** 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/M2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/M2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/M2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/M2D
13	3	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	4	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	5	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	6	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	7	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	8	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	9	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	10	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	11	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	12	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	13	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	14	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	15	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	16	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	17	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	18	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	19	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	20	8.46	1	18.97	0.16	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	1	8.46	1	22.32	0.12	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	2	8.46	1	25.67	0.12	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	3	8.46	1	25.67	0.12	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	4	8.46	1	25.67	0.12	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	5	8.46	1	25.67	0.12	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	6	8.46	1	25.67	0.12	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	7	8.46	1	25.67	0.12	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	8	8.46	1	25.67	0.12	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	9	8.46	1	25.67	0.12	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	10	8.46	1	25.67	0.12	0.00	5.89	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	1	8.46	1	20.09	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	2	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	3	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	4	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	5	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	6	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	7	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	8	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	9	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	10	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00

15	11	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	12	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	13	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	14	8.46	1	14.51	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***** 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/M2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/M2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/M2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/M2D
16	1	8.46	1	20.09	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	2	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	3	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	4	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	5	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	6	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	7	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	8	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	9	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	10	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	11	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	12	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	13	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	14	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	15	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	16	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	17	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	18	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	19	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	20	8.46	1	25.67	0.12	0.00	5.24	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	1	8.46	1	18.42	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	2	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	3	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	4	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	5	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	6	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	7	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	8	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	9	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	10	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	11	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	12	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	13	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	14	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	15	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	16	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	17	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	18	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	19	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	20	8.46	1	11.16	0.12	0.00	3.01	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	1	8.46	1	13.95	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	2	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT	K2 OPT	OXYGN REAIR	BOD DECAY	BOD SETT	SOD RATE	ORGN DECAY	ORGN SETT	NH3 DECAY	NH3 SRCE	NO2 DECAY	ORGP DECAY	ORGP SETT	DISP SRCE	COLI DECAY	ANC DECAY	ANC SETT	ANC SRCE

		MG/L		1/DAY	1/DAY	1/DAY	G/M2D	1/DAY	1/DAY	1/DAY	MG/M2D	1/DAY	1/DAY	1/DAY	MG/M2D	1/DAY	1/DAY	1/DAY	MG/M2D
18	3	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	4	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	5	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	6	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	7	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	8	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	9	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	10	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	11	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	12	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	13	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	14	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	15	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	16	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	17	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	18	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	19	8.46	1	16.74	0.12	0.00	3.27	0.02	0.00	0.58	0.28	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-C	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
1	1	24.55	0.00	0.00	0.00	0.00	2.77	0.10	0.25	0.06	0.06	0.46	0.00	0.00	0.00	0.00	0.00	0.00
1	2	21.63	0.00	0.00	0.00	4.12	31.45	4.98	0.41	0.00	0.17	5.56	0.00	0.00	0.00	0.00	0.00	0.00
1	3	22.15	0.00	0.00	0.00	4.00	30.95	4.97	0.41	0.00	0.17	5.55	0.00	0.00	0.00	0.00	0.00	0.00
1	4	22.58	0.00	0.00	0.00	3.89	30.45	4.96	0.41	0.01	0.17	5.54	0.00	0.00	0.00	0.00	0.00	0.00
1	5	22.93	0.00	0.00	0.00	3.77	29.95	4.95	0.40	0.01	0.17	5.54	0.00	0.00	0.00	0.00	0.00	0.00
1	6	23.23	0.00	0.00	0.00	3.67	29.46	4.94	0.40	0.01	0.17	5.53	0.00	0.00	0.00	0.00	0.00	0.00
1	7	23.47	0.00	0.00	0.00	3.57	28.97	4.93	0.40	0.01	0.17	5.52	0.00	0.00	0.00	0.00	0.00	0.00
1	8	23.67	0.00	0.00	0.00	3.49	28.49	4.93	0.40	0.02	0.17	5.51	0.00	0.00	0.00	0.00	0.00	0.00
2	1	23.85	0.00	0.00	0.00	3.40	28.25	4.92	0.40	0.02	0.17	5.50	0.00	0.00	0.00	0.00	0.00	0.00
2	2	24.01	0.00	0.00	0.00	3.19	27.99	4.91	0.40	0.02	0.17	5.50	0.00	0.00	0.00	0.00	0.00	0.00
2	3	24.13	0.00	0.00	0.00	3.01	27.73	4.90	0.39	0.03	0.17	5.49	0.00	0.00	0.00	0.00	0.00	0.00
2	4	24.23	0.00	0.00	0.00	2.85	27.47	4.88	0.39	0.03	0.17	5.48	0.00	0.00	0.00	0.00	0.00	0.00
2	5	24.30	0.00	0.00	0.00	2.72	27.22	4.87	0.39	0.03	0.17	5.47	0.00	0.00	0.00	0.00	0.00	0.00
2	6	24.36	0.00	0.00	0.00	2.60	26.97	4.86	0.39	0.04	0.17	5.46	0.00	0.00	0.00	0.00	0.00	0.00
2	7	24.41	0.00	0.00	0.00	2.50	26.72	4.85	0.39	0.04	0.17	5.45	0.00	0.00	0.00	0.00	0.00	0.00
2	8	24.45	0.00	0.00	0.00	2.42	26.47	4.84	0.39	0.04	0.17	5.44	0.00	0.00	0.00	0.00	0.00	0.00
2	9	24.48	0.00	0.00	0.00	2.35	26.22	4.83	0.38	0.04	0.17	5.44	0.00	0.00	0.00	0.00	0.00	0.00
2	10	24.50	0.00	0.00	0.00	2.29	25.98	4.82	0.38	0.05	0.17	5.43	0.00	0.00	0.00	0.00	0.00	0.00
2	11	24.52	0.00	0.00	0.00	2.25	25.74	4.81	0.38	0.05	0.17	5.42	0.00	0.00	0.00	0.00	0.00	0.00
2	12	24.53	0.00	0.00	0.00	2.21	25.50	4.80	0.38	0.05	0.18	5.41	0.00	0.00	0.00	0.00	0.00	0.00
2	13	24.54	0.00	0.00	0.00	2.18	25.27	4.79	0.38	0.05	0.18	5.40	0.00	0.00	0.00	0.00	0.00	0.00
2	14	24.55	0.00	0.00	0.00	2.16	25.03	4.78	0.38	0.06	0.18	5.39	0.00	0.00	0.00	0.00	0.00	0.00
2	15	24.56	0.00	0.00	0.00	2.14	24.80	4.77	0.38	0.06	0.18	5.39	0.00	0.00	0.00	0.00	0.00	0.00
3	1	24.59	0.00	0.00	0.00	0.00	2.96	0.10	0.26	0.06	0.06	0.48	0.00	0.00	0.00	0.00	0.00	0.00
3	2	23.90	0.00	0.00	0.00	0.97	19.77	4.78	7.21	0.07	0.27	12.34	0.00	0.00	0.00	0.00	0.00	0.00
3	3	24.46	0.00	0.00	0.00	2.44	19.39	4.70	6.96	0.20	0.28	12.14	0.00	0.00	0.00	0.00	0.00	0.00
3	4	24.57	0.00	0.00	0.00	2.87	19.02	4.62	6.73	0.31	0.29	11.94	0.00	0.00	0.00	0.00	0.00	0.00
3	5	24.59	0.00	0.00	0.00	3.03	18.66	4.54	6.50	0.41	0.30	11.75	0.00	0.00	0.00	0.00	0.00	0.00
3	6	24.60	0.00	0.00	0.00	3.11	18.32	4.47	6.28	0.51	0.31	11.57	0.00	0.00	0.00	0.00	0.00	0.00
3	7	24.60	0.00	0.00	0.00	3.17	17.98	4.39	6.08	0.59	0.33	11.39	0.00	0.00	0.00	0.00	0.00	0.00
3	8	24.60	0.00	0.00	0.00	3.23	17.66	4.32	5.88	0.66	0.36	11.22	0.00	0.00	0.00	0.00	0.00	0.00
3	9	24.60	0.00	0.00	0.00	3.28	17.35	4.25	5.69	0.73	0.38	11.05	0.00	0.00	0.00	0.00	0.00	0.00
3	10	24.60	0.00	0.00	0.00	3.33	17.05	4.19	5.51	0.79	0.41	10.89	0.00	0.00	0.00	0.00	0.00	0.00
3	11	24.60	0.00	0.00	0.00	3.38	16.76	4.12	5.34	0.84	0.43	10.74	0.00	0.00	0.00	0.00	0.00	0.00
3	12	24.60	0.00	0.00	0.00	3.42	16.47	4.06	5.17	0.89	0.46	10.59	0.00	0.00	0.00	0.00	0.00	0.00
3	13	24.60	0.00	0.00	0.00	3.47	16.20	4.00	5.01	0.93	0.49	10.44	0.00	0.00	0.00	0.00	0.00	0.00

RCH NUM	ELE NUM	TEMP DEG-C	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
3	14	24.60	0.00	0.00	0.00	3.51	15.93	3.94	4.86	0.97	0.52	10.29	0.00	0.00	0.00	0.00	0.00	0.00
3	15	24.60	0.00	0.00	0.00	3.56	15.67	3.88	4.71	1.01	0.56	10.16	0.00	0.00	0.00	0.00	0.00	0.00
3	16	24.60	0.00	0.00	0.00	3.60	15.42	3.82	4.57	1.03	0.59	10.02	0.00	0.00	0.00	0.00	0.00	0.00
3	17	24.60	0.00	0.00	0.00	3.64	15.19	3.77	4.43	1.06	0.62	9.89	0.00	0.00	0.00	0.00	0.00	0.00

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-C	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
4	1	24.57	0.00	0.00	0.00	2.13	23.71	4.66	0.82	0.17	0.23	5.87	0.00	0.00	0.00	0.00	0.00	0.00
4	2	24.59	0.00	0.00	0.00	1.83	23.58	4.65	0.81	0.18	0.23	5.87	0.00	0.00	0.00	0.00	0.00	0.00
4	3	24.60	0.00	0.00	0.00	1.63	23.44	4.64	0.80	0.18	0.24	5.86	0.00	0.00	0.00	0.00	0.00	0.00
4	4	24.61	0.00	0.00	0.00	1.48	23.31	4.63	0.79	0.19	0.25	5.85	0.00	0.00	0.00	0.00	0.00	0.00
4	5	24.61	0.00	0.00	0.00	1.38	23.19	4.62	0.78	0.19	0.25	5.84	0.00	0.00	0.00	0.00	0.00	0.00
4	6	24.62	0.00	0.00	0.00	1.31	23.06	4.61	0.77	0.20	0.26	5.83	0.00	0.00	0.00	0.00	0.00	0.00
4	7	24.62	0.00	0.00	0.00	1.27	22.93	4.60	0.76	0.20	0.26	5.83	0.00	0.00	0.00	0.00	0.00	0.00
4	8	24.62	0.00	0.00	0.00	1.24	22.81	4.59	0.75	0.21	0.27	5.82	0.00	0.00	0.00	0.00	0.00	0.00
4	9	24.62	0.00	0.00	0.00	1.22	22.68	4.58	0.75	0.21	0.27	5.81	0.00	0.00	0.00	0.00	0.00	0.00
4	10	24.62	0.00	0.00	0.00	1.21	22.56	4.57	0.74	0.21	0.28	5.80	0.00	0.00	0.00	0.00	0.00	0.00
4	11	24.62	0.00	0.00	0.00	1.20	22.44	4.56	0.73	0.22	0.29	5.80	0.00	0.00	0.00	0.00	0.00	0.00
5	1	24.54	0.00	0.00	0.00	0.00	2.75	0.10	0.25	0.06	0.06	0.46	0.00	0.00	0.00	0.00	0.00	0.00
5	2	24.17	0.00	0.00	0.00	2.21	7.29	4.23	5.17	0.10	0.04	9.55	0.00	0.00	0.00	0.00	0.00	0.00
5	3	24.51	0.00	0.00	0.00	4.30	6.71	3.98	4.74	0.23	0.05	9.01	0.00	0.00	0.00	0.00	0.00	0.00
5	4	24.55	0.00	0.00	0.00	4.79	6.20	3.76	4.37	0.33	0.08	8.53	0.00	0.00	0.00	0.00	0.00	0.00
5	5	24.55	0.00	0.00	0.00	4.97	5.76	3.56	4.03	0.41	0.10	8.10	0.00	0.00	0.00	0.00	0.00	0.00
5	6	24.55	0.00	0.00	0.00	5.10	5.37	3.38	3.74	0.47	0.13	7.72	0.00	0.00	0.00	0.00	0.00	0.00
5	7	24.55	0.00	0.00	0.00	5.20	5.02	3.22	3.48	0.52	0.16	7.37	0.00	0.00	0.00	0.00	0.00	0.00
5	8	24.55	0.00	0.00	0.00	5.30	4.71	3.07	3.24	0.56	0.18	7.06	0.00	0.00	0.00	0.00	0.00	0.00
5	9	24.55	0.00	0.00	0.00	5.38	4.44	2.94	3.03	0.58	0.21	6.77	0.00	0.00	0.00	0.00	0.00	0.00
5	10	24.55	0.00	0.00	0.00	5.46	4.19	2.82	2.84	0.60	0.24	6.51	0.00	0.00	0.00	0.00	0.00	0.00
5	11	24.55	0.00	0.00	0.00	5.54	3.96	2.71	2.67	0.62	0.27	6.26	0.00	0.00	0.00	0.00	0.00	0.00
6	1	24.55	0.00	0.00	0.00	5.81	3.77	2.60	2.52	0.62	0.29	6.04	0.00	0.00	0.00	0.00	0.00	0.00
6	2	24.55	0.00	0.00	0.00	6.03	3.60	2.51	2.39	0.63	0.31	5.83	0.00	0.00	0.00	0.00	0.00	0.00
6	3	24.55	0.00	0.00	0.00	6.12	3.45	2.42	2.26	0.63	0.33	5.64	0.00	0.00	0.00	0.00	0.00	0.00
6	4	24.55	0.00	0.00	0.00	6.17	3.30	2.34	2.15	0.62	0.35	5.46	0.00	0.00	0.00	0.00	0.00	0.00
6	5	24.55	0.00	0.00	0.00	6.22	3.17	2.26	2.05	0.62	0.37	5.30	0.00	0.00	0.00	0.00	0.00	0.00
6	6	24.55	0.00	0.00	0.00	6.26	3.05	2.19	1.95	0.62	0.39	5.14	0.00	0.00	0.00	0.00	0.00	0.00
6	7	24.55	0.00	0.00	0.00	6.31	2.94	2.12	1.86	0.61	0.41	5.00	0.00	0.00	0.00	0.00	0.00	0.00
6	8	24.55	0.00	0.00	0.00	6.35	2.84	2.06	1.78	0.60	0.42	4.86	0.00	0.00	0.00	0.00	0.00	0.00
6	9	24.55	0.00	0.00	0.00	6.38	2.74	2.00	1.70	0.59	0.44	4.73	0.00	0.00	0.00	0.00	0.00	0.00
6	10	24.55	0.00	0.00	0.00	6.42	2.65	1.94	1.63	0.59	0.45	4.61	0.00	0.00	0.00	0.00	0.00	0.00
6	11	24.56	0.00	0.00	0.00	6.45	2.57	1.89	1.56	0.58	0.47	4.49	0.00	0.00	0.00	0.00	0.00	0.00
6	12	24.56	0.00	0.00	0.00	6.49	2.49	1.84	1.50	0.57	0.48	4.39	0.00	0.00	0.00	0.00	0.00	0.00
6	13	24.56	0.00	0.00	0.00	6.52	2.41	1.79	1.44	0.56	0.49	4.28	0.00	0.00	0.00	0.00	0.00	0.00
7	1	24.58	0.00	0.00	0.00	5.95	2.31	1.75	1.37	0.55	0.52	4.20	0.00	0.00	0.00	0.00	0.00	0.00
7	2	24.59	0.00	0.00	0.00	5.34	2.17	1.71	1.29	0.55	0.56	4.11	0.00	0.00	0.00	0.00	0.00	0.00
7	3	24.59	0.00	0.00	0.00	5.23	2.05	1.68	1.22	0.54	0.60	4.04	0.00	0.00	0.00	0.00	0.00	0.00
7	4	24.60	0.00	0.00	0.00	5.24	1.94	1.64	1.15	0.53	0.64	3.96	0.00	0.00	0.00	0.00	0.00	0.00
7	5	24.60	0.00	0.00	0.00	5.27	1.84	1.60	1.09	0.52	0.68	3.89	0.00	0.00	0.00	0.00	0.00	0.00

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP	CM-1	CM-2	CM-3	DO	BOD	ORGN	NH3N	NO2N	NO3N	SUM-N	ORGP	DIS-P	SUM-P	COLI	ANC	CHLA

		DEG-C				MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	#/100ML		UG/L
7	6	24.60	0.00	0.00	0.00	5.31	1.74	1.57	1.03	0.51	0.71	3.82	0.00	0.00	0.00	0.00	0.00	0.00
8	1	24.59	0.00	0.00	0.00	5.90	1.68	1.54	0.98	0.50	0.73	3.75	0.00	0.00	0.00	0.00	0.00	0.00
8	2	24.59	0.00	0.00	0.00	6.02	1.63	1.50	0.95	0.48	0.74	3.68	0.00	0.00	0.00	0.00	0.00	0.00
8	3	24.59	0.00	0.00	0.00	6.06	1.59	1.47	0.91	0.47	0.75	3.61	0.00	0.00	0.00	0.00	0.00	0.00
8	4	24.59	0.00	0.00	0.00	6.10	1.56	1.44	0.88	0.46	0.76	3.55	0.00	0.00	0.00	0.00	0.00	0.00
8	5	24.59	0.00	0.00	0.00	6.13	1.52	1.42	0.85	0.45	0.77	3.49	0.00	0.00	0.00	0.00	0.00	0.00
8	6	24.59	0.00	0.00	0.00	6.16	1.48	1.39	0.82	0.44	0.78	3.43	0.00	0.00	0.00	0.00	0.00	0.00
8	7	24.59	0.00	0.00	0.00	6.18	1.47	1.37	0.79	0.43	0.78	3.37	0.00	0.00	0.00	0.00	0.00	0.00
9	1	24.62	0.00	0.00	0.00	1.38	20.98	4.32	0.73	0.23	0.33	5.61	0.00	0.00	0.00	0.00	0.00	0.00
9	2	24.63	0.00	0.00	0.00	1.26	21.01	4.32	0.72	0.24	0.34	5.61	0.00	0.00	0.00	0.00	0.00	0.00
9	3	24.63	0.00	0.00	0.00	1.19	21.03	4.31	0.71	0.24	0.35	5.60	0.00	0.00	0.00	0.00	0.00	0.00
9	4	24.63	0.00	0.00	0.00	1.15	21.06	4.30	0.70	0.24	0.35	5.59	0.00	0.00	0.00	0.00	0.00	0.00
9	5	24.63	0.00	0.00	0.00	1.14	21.08	4.29	0.69	0.25	0.36	5.59	0.00	0.00	0.00	0.00	0.00	0.00
9	6	24.63	0.00	0.00	0.00	1.13	21.11	4.28	0.68	0.25	0.37	5.58	0.00	0.00	0.00	0.00	0.00	0.00
9	7	24.63	0.00	0.00	0.00	1.13	21.13	4.27	0.67	0.25	0.38	5.57	0.00	0.00	0.00	0.00	0.00	0.00
9	8	24.63	0.00	0.00	0.00	1.13	21.16	4.26	0.66	0.25	0.39	5.57	0.00	0.00	0.00	0.00	0.00	0.00
9	9	24.63	0.00	0.00	0.00	1.13	21.18	4.25	0.65	0.26	0.40	5.56	0.00	0.00	0.00	0.00	0.00	0.00
9	10	24.63	0.00	0.00	0.00	1.13	21.20	4.24	0.64	0.26	0.41	5.55	0.00	0.00	0.00	0.00	0.00	0.00
9	11	24.63	0.00	0.00	0.00	1.14	21.23	4.23	0.63	0.26	0.42	5.55	0.00	0.00	0.00	0.00	0.00	0.00
10	1	24.63	0.00	0.00	0.00	1.14	21.18	4.22	0.63	0.26	0.43	5.54	0.00	0.00	0.00	0.00	0.00	0.00
10	2	24.63	0.00	0.00	0.00	1.15	21.13	4.21	0.62	0.26	0.44	5.53	0.00	0.00	0.00	0.00	0.00	0.00
10	3	24.63	0.00	0.00	0.00	1.15	21.08	4.21	0.61	0.26	0.45	5.53	0.00	0.00	0.00	0.00	0.00	0.00
10	4	24.63	0.00	0.00	0.00	1.16	21.03	4.20	0.60	0.26	0.46	5.52	0.00	0.00	0.00	0.00	0.00	0.00
10	5	24.63	0.00	0.00	0.00	1.16	20.99	4.19	0.59	0.26	0.47	5.51	0.00	0.00	0.00	0.00	0.00	0.00
10	6	24.63	0.00	0.00	0.00	1.17	20.94	4.18	0.58	0.26	0.48	5.51	0.00	0.00	0.00	0.00	0.00	0.00
10	7	24.63	0.00	0.00	0.00	1.17	20.89	4.17	0.58	0.26	0.49	5.50	0.00	0.00	0.00	0.00	0.00	0.00
10	8	24.63	0.00	0.00	0.00	1.18	20.84	4.16	0.57	0.26	0.50	5.49	0.00	0.00	0.00	0.00	0.00	0.00
10	9	24.63	0.00	0.00	0.00	1.19	20.80	4.15	0.56	0.26	0.51	5.49	0.00	0.00	0.00	0.00	0.00	0.00
10	10	24.63	0.00	0.00	0.00	1.19	20.75	4.14	0.55	0.26	0.52	5.48	0.00	0.00	0.00	0.00	0.00	0.00
10	11	24.63	0.00	0.00	0.00	1.20	20.70	4.13	0.55	0.26	0.53	5.47	0.00	0.00	0.00	0.00	0.00	0.00
10	12	24.63	0.00	0.00	0.00	1.21	20.66	4.13	0.54	0.26	0.54	5.47	0.00	0.00	0.00	0.00	0.00	0.00
10	13	24.63	0.00	0.00	0.00	1.21	20.61	4.12	0.53	0.26	0.55	5.46	0.00	0.00	0.00	0.00	0.00	0.00
10	14	24.63	0.00	0.00	0.00	1.22	20.56	4.11	0.52	0.26	0.56	5.46	0.00	0.00	0.00	0.00	0.00	0.00
10	15	24.63	0.00	0.00	0.00	1.23	20.52	4.10	0.52	0.26	0.57	5.45	0.00	0.00	0.00	0.00	0.00	0.00
10	16	24.63	0.00	0.00	0.00	1.23	20.47	4.09	0.51	0.26	0.58	5.44	0.00	0.00	0.00	0.00	0.00	0.00
10	17	24.63	0.00	0.00	0.00	1.24	20.43	4.08	0.50	0.26	0.59	5.44	0.00	0.00	0.00	0.00	0.00	0.00
10	18	24.63	0.00	0.00	0.00	1.25	20.38	4.07	0.50	0.25	0.60	5.43	0.00	0.00	0.00	0.00	0.00	0.00
10	19	24.63	0.00	0.00	0.00	1.25	20.34	4.06	0.49	0.25	0.61	5.42	0.00	0.00	0.00	0.00	0.00	0.00
10	20	24.63	0.00	0.00	0.00	1.26	20.29	4.06	0.49	0.25	0.62	5.42	0.00	0.00	0.00	0.00	0.00	0.00

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-C	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
11	1	24.63	0.00	0.00	0.00	1.80	20.25	4.05	0.48	0.25	0.63	5.41	0.00	0.00	0.00	0.00	0.00	0.00
11	2	24.63	0.00	0.00	0.00	1.95	20.22	4.04	0.47	0.25	0.64	5.40	0.00	0.00	0.00	0.00	0.00	0.00
11	3	24.63	0.00	0.00	0.00	2.05	20.18	4.03	0.47	0.25	0.65	5.40	0.00	0.00	0.00	0.00	0.00	0.00
11	4	24.63	0.00	0.00	0.00	2.11	20.14	4.02	0.46	0.25	0.66	5.39	0.00	0.00	0.00	0.00	0.00	0.00
11	5	24.63	0.00	0.00	0.00	2.15	20.11	4.01	0.46	0.25	0.67	5.39	0.00	0.00	0.00	0.00	0.00	0.00
11	6	24.63	0.00	0.00	0.00	2.18	20.07	4.01	0.45	0.24	0.68	5.38	0.00	0.00	0.00	0.00	0.00	0.00
11	7	24.63	0.00	0.00	0.00	2.20	20.04	4.00	0.45	0.24	0.68	5.37	0.00	0.00	0.00	0.00	0.00	0.00
11	8	24.63	0.00	0.00	0.00	2.21	20.00	3.99	0.44	0.24	0.69	5.37	0.00	0.00	0.00	0.00	0.00	0.00
11	9	24.63	0.00	0.00	0.00	2.22	19.96	3.98	0.44	0.24	0.70	5.36	0.00	0.00	0.00	0.00	0.00	0.00
11	10	24.63	0.00	0.00	0.00	2.23	19.93	3.97	0.44	0.24	0.71	5.35	0.00	0.00	0.00	0.00	0.00	0.00
11	11	24.63	0.00	0.00	0.00	2.24	19.89	3.97	0.43	0.24	0.72	5.35	0.00	0.00	0.00	0.00	0.00	0.00
11	12	24.63	0.00	0.00	0.00	2.24	19.86	3.96	0.43	0.23	0.72	5.34	0.00	0.00	0.00	0.00	0.00	0.00

11	13	24.63	0.00	0.00	0.00	2.25	19.82	3.95	0.42	0.23	0.73	5.34	0.00	0.00	0.00	0.00	0.00	0.00
11	14	24.63	0.00	0.00	0.00	2.26	19.79	3.94	0.42	0.23	0.74	5.33	0.00	0.00	0.00	0.00	0.00	0.00
11	15	24.63	0.00	0.00	0.00	2.26	19.76	3.93	0.41	0.23	0.75	5.32	0.00	0.00	0.00	0.00	0.00	0.00
11	16	24.63	0.00	0.00	0.00	2.27	19.72	3.93	0.41	0.23	0.75	5.32	0.00	0.00	0.00	0.00	0.00	0.00
11	17	24.63	0.00	0.00	0.00	2.27	19.69	3.92	0.40	0.23	0.76	5.31	0.00	0.00	0.00	0.00	0.00	0.00
11	18	24.63	0.00	0.00	0.00	2.28	19.65	3.91	0.40	0.22	0.77	5.31	0.00	0.00	0.00	0.00	0.00	0.00
11	19	24.63	0.00	0.00	0.00	2.28	19.62	3.90	0.40	0.22	0.78	5.30	0.00	0.00	0.00	0.00	0.00	0.00
11	20	24.63	0.00	0.00	0.00	2.29	19.58	3.89	0.39	0.22	0.78	5.29	0.00	0.00	0.00	0.00	0.00	0.00
12	1	24.63	0.00	0.00	0.00	2.14	19.61	3.89	0.39	0.22	0.79	5.29	0.00	0.00	0.00	0.00	0.00	0.00
12	2	24.63	0.00	0.00	0.00	2.27	19.62	3.88	0.38	0.22	0.80	5.28	0.00	0.00	0.00	0.00	0.00	0.00
12	3	24.63	0.00	0.00	0.00	2.34	19.64	3.87	0.38	0.22	0.81	5.28	0.00	0.00	0.00	0.00	0.00	0.00
12	4	24.63	0.00	0.00	0.00	2.39	19.66	3.86	0.38	0.21	0.82	5.27	0.00	0.00	0.00	0.00	0.00	0.00
12	5	24.63	0.00	0.00	0.00	2.42	19.67	3.85	0.37	0.21	0.83	5.26	0.00	0.00	0.00	0.00	0.00	0.00
12	6	24.63	0.00	0.00	0.00	2.44	19.69	3.84	0.37	0.21	0.84	5.26	0.00	0.00	0.00	0.00	0.00	0.00
12	7	24.63	0.00	0.00	0.00	2.45	19.70	3.84	0.36	0.21	0.84	5.25	0.00	0.00	0.00	0.00	0.00	0.00
12	8	24.63	0.00	0.00	0.00	2.46	19.72	3.83	0.36	0.21	0.85	5.25	0.00	0.00	0.00	0.00	0.00	0.00
12	9	24.63	0.00	0.00	0.00	2.46	19.73	3.82	0.36	0.20	0.86	5.24	0.00	0.00	0.00	0.00	0.00	0.00
12	10	24.63	0.00	0.00	0.00	2.47	19.75	3.81	0.35	0.20	0.87	5.23	0.00	0.00	0.00	0.00	0.00	0.00
12	11	24.63	0.00	0.00	0.00	2.48	19.76	3.80	0.35	0.20	0.88	5.23	0.00	0.00	0.00	0.00	0.00	0.00
12	12	24.63	0.00	0.00	0.00	2.48	19.78	3.80	0.34	0.20	0.88	5.22	0.00	0.00	0.00	0.00	0.00	0.00
12	13	24.63	0.00	0.00	0.00	2.49	19.79	3.79	0.34	0.20	0.89	5.22	0.00	0.00	0.00	0.00	0.00	0.00
12	14	24.63	0.00	0.00	0.00	2.49	19.80	3.78	0.34	0.20	0.90	5.21	0.00	0.00	0.00	0.00	0.00	0.00
12	15	24.63	0.00	0.00	0.00	2.50	19.82	3.77	0.33	0.19	0.91	5.20	0.00	0.00	0.00	0.00	0.00	0.00
12	16	24.63	0.00	0.00	0.00	2.50	19.83	3.76	0.33	0.19	0.91	5.20	0.00	0.00	0.00	0.00	0.00	0.00
12	17	24.63	0.00	0.00	0.00	2.51	19.85	3.76	0.33	0.19	0.92	5.19	0.00	0.00	0.00	0.00	0.00	0.00
12	18	24.63	0.00	0.00	0.00	2.51	19.86	3.75	0.32	0.19	0.93	5.19	0.00	0.00	0.00	0.00	0.00	0.00
12	19	24.63	0.00	0.00	0.00	2.52	19.87	3.74	0.32	0.19	0.94	5.18	0.00	0.00	0.00	0.00	0.00	0.00
12	20	24.63	0.00	0.00	0.00	2.52	19.88	3.73	0.32	0.18	0.94	5.18	0.00	0.00	0.00	0.00	0.00	0.00
13	1	24.63	0.00	0.00	0.00	2.89	19.87	3.72	0.31	0.18	0.95	5.17	0.00	0.00	0.00	0.00	0.00	0.00
13	2	24.63	0.00	0.00	0.00	3.01	19.86	3.72	0.31	0.18	0.96	5.16	0.00	0.00	0.00	0.00	0.00	0.00

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-C	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
13	3	24.63	0.00	0.00	0.00	3.08	19.85	3.71	0.31	0.18	0.96	5.16	0.00	0.00	0.00	0.00	0.00	0.00
13	4	24.63	0.00	0.00	0.00	3.13	19.85	3.70	0.31	0.18	0.97	5.15	0.00	0.00	0.00	0.00	0.00	0.00
13	5	24.63	0.00	0.00	0.00	3.16	19.84	3.69	0.30	0.18	0.97	5.15	0.00	0.00	0.00	0.00	0.00	0.00
13	6	24.63	0.00	0.00	0.00	3.18	19.83	3.69	0.30	0.17	0.98	5.14	0.00	0.00	0.00	0.00	0.00	0.00
13	7	24.63	0.00	0.00	0.00	3.19	19.82	3.68	0.30	0.17	0.99	5.14	0.00	0.00	0.00	0.00	0.00	0.00
13	8	24.63	0.00	0.00	0.00	3.20	19.81	3.67	0.29	0.17	0.99	5.13	0.00	0.00	0.00	0.00	0.00	0.00
13	9	24.63	0.00	0.00	0.00	3.21	19.80	3.66	0.29	0.17	1.00	5.12	0.00	0.00	0.00	0.00	0.00	0.00
13	10	24.63	0.00	0.00	0.00	3.21	19.79	3.66	0.29	0.17	1.01	5.12	0.00	0.00	0.00	0.00	0.00	0.00
13	11	24.63	0.00	0.00	0.00	3.22	19.78	3.65	0.29	0.17	1.01	5.11	0.00	0.00	0.00	0.00	0.00	0.00
13	12	24.63	0.00	0.00	0.00	3.22	19.77	3.64	0.28	0.17	1.02	5.11	0.00	0.00	0.00	0.00	0.00	0.00
13	13	24.63	0.00	0.00	0.00	3.23	19.76	3.63	0.28	0.16	1.02	5.10	0.00	0.00	0.00	0.00	0.00	0.00
13	14	24.63	0.00	0.00	0.00	3.23	19.75	3.63	0.28	0.16	1.03	5.10	0.00	0.00	0.00	0.00	0.00	0.00
13	15	24.63	0.00	0.00	0.00	3.24	19.74	3.62	0.28	0.16	1.03	5.09	0.00	0.00	0.00	0.00	0.00	0.00
13	16	24.63	0.00	0.00	0.00	3.24	19.73	3.61	0.28	0.16	1.04	5.09	0.00	0.00	0.00	0.00	0.00	0.00
13	17	24.63	0.00	0.00	0.00	3.24	19.72	3.60	0.27	0.16	1.05	5.08	0.00	0.00	0.00	0.00	0.00	0.00
13	18	24.63	0.00	0.00	0.00	3.25	19.71	3.60	0.27	0.16	1.05	5.07	0.00	0.00	0.00	0.00	0.00	0.00
13	19	24.63	0.00	0.00	0.00	3.25	19.70	3.59	0.27	0.16	1.06	5.07	0.00	0.00	0.00	0.00	0.00	0.00
13	20	24.63	0.00	0.00	0.00	3.26	19.69	3.58	0.27	0.15	1.06	5.06	0.00	0.00	0.00	0.00	0.00	0.00
14	1	24.63	0.00	0.00	0.00	3.18	19.72	3.57	0.26	0.15	1.07	5.06	0.00	0.00	0.00	0.00	0.00	0.00
14	2	24.63	0.00	0.00	0.00	3.21	19.75	3.57	0.26	0.15	1.07	5.05	0.00	0.00	0.00	0.00	0.00	0.00
14	3	24.63	0.00	0.00	0.00	3.23	19.78	3.56	0.26	0.15	1.07	5.05	0.00	0.00	0.00	0.00	0.00	0.00
14	4	24.63	0.00	0.00	0.00	3.25	19.81	3.55	0.26	0.15	1.08	5.04	0.00	0.00	0.00	0.00	0.00	0.00
14	5	24.63	0.00	0.00	0.00	3.26	19.84	3.55	0.26	0.15	1.08	5.04	0.00	0.00	0.00	0.00	0.00	0.00
14	6	24.63	0.00	0.00	0.00	3.26	19.87	3.54	0.26	0.15	1.09	5.03	0.00	0.00	0.00	0.00	0.00	0.00
14	7	24.63	0.00	0.00	0.00	3.27	19.90	3.53	0.26	0.15	1.09	5.03	0.00	0.00	0.00	0.00	0.00	0.00

14	8	24.63	0.00	0.00	0.00	3.27	19.93	3.53	0.25	0.15	1.09	5.02	0.00	0.00	0.00	0.00	0.00	0.00
14	9	24.63	0.00	0.00	0.00	3.28	19.95	3.52	0.25	0.14	1.10	5.01	0.00	0.00	0.00	0.00	0.00	0.00
14	10	24.63	0.00	0.00	0.00	3.28	19.98	3.51	0.25	0.14	1.10	5.01	0.00	0.00	0.00	0.00	0.00	0.00
15	1	24.63	0.00	0.00	0.00	3.64	19.99	3.51	0.25	0.14	1.11	5.00	0.00	0.00	0.00	0.00	0.00	0.00
15	2	24.63	0.00	0.00	0.00	3.60	19.97	3.50	0.25	0.14	1.11	5.00	0.00	0.00	0.00	0.00	0.00	0.00
15	3	24.63	0.00	0.00	0.00	3.58	19.96	3.49	0.24	0.14	1.12	4.99	0.00	0.00	0.00	0.00	0.00	0.00
15	4	24.63	0.00	0.00	0.00	3.57	19.94	3.48	0.24	0.14	1.12	4.99	0.00	0.00	0.00	0.00	0.00	0.00
15	5	24.63	0.00	0.00	0.00	3.56	19.92	3.48	0.24	0.14	1.13	4.98	0.00	0.00	0.00	0.00	0.00	0.00
15	6	24.63	0.00	0.00	0.00	3.56	19.91	3.47	0.24	0.13	1.14	4.98	0.00	0.00	0.00	0.00	0.00	0.00
15	7	24.63	0.00	0.00	0.00	3.56	19.89	3.46	0.24	0.13	1.14	4.97	0.00	0.00	0.00	0.00	0.00	0.00
15	8	24.63	0.00	0.00	0.00	3.56	19.88	3.45	0.23	0.13	1.15	4.97	0.00	0.00	0.00	0.00	0.00	0.00
15	9	24.63	0.00	0.00	0.00	3.56	19.86	3.45	0.23	0.13	1.15	4.96	0.00	0.00	0.00	0.00	0.00	0.00
15	10	24.63	0.00	0.00	0.00	3.56	19.85	3.44	0.23	0.13	1.16	4.96	0.00	0.00	0.00	0.00	0.00	0.00
15	11	24.63	0.00	0.00	0.00	3.57	19.83	3.43	0.23	0.13	1.17	4.95	0.00	0.00	0.00	0.00	0.00	0.00
15	12	24.63	0.00	0.00	0.00	3.57	19.82	3.42	0.23	0.13	1.17	4.95	0.00	0.00	0.00	0.00	0.00	0.00
15	13	24.63	0.00	0.00	0.00	3.57	19.80	3.42	0.22	0.13	1.18	4.94	0.00	0.00	0.00	0.00	0.00	0.00
15	14	24.63	0.00	0.00	0.00	3.58	19.78	3.41	0.22	0.12	1.18	4.94	0.00	0.00	0.00	0.00	0.00	0.00

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-C	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
16	1	24.63	0.00	0.00	0.00	3.73	19.79	3.40	0.22	0.12	1.19	4.93	0.00	0.00	0.00	0.00	0.00	0.00
16	2	24.63	0.00	0.00	0.00	3.89	19.81	3.39	0.22	0.12	1.19	4.93	0.00	0.00	0.00	0.00	0.00	0.00
16	3	24.63	0.00	0.00	0.00	3.99	19.84	3.39	0.22	0.12	1.19	4.92	0.00	0.00	0.00	0.00	0.00	0.00
16	4	24.63	0.00	0.00	0.00	4.04	19.86	3.38	0.22	0.12	1.20	4.92	0.00	0.00	0.00	0.00	0.00	0.00
16	5	24.63	0.00	0.00	0.00	4.07	19.88	3.38	0.22	0.12	1.20	4.91	0.00	0.00	0.00	0.00	0.00	0.00
16	6	24.63	0.00	0.00	0.00	4.09	19.90	3.37	0.22	0.12	1.20	4.91	0.00	0.00	0.00	0.00	0.00	0.00
16	7	24.63	0.00	0.00	0.00	4.10	19.93	3.36	0.22	0.12	1.21	4.90	0.00	0.00	0.00	0.00	0.00	0.00
16	8	24.63	0.00	0.00	0.00	4.11	19.95	3.36	0.21	0.12	1.21	4.90	0.00	0.00	0.00	0.00	0.00	0.00
16	9	24.63	0.00	0.00	0.00	4.12	19.97	3.35	0.21	0.12	1.21	4.89	0.00	0.00	0.00	0.00	0.00	0.00
16	10	24.63	0.00	0.00	0.00	4.12	19.99	3.34	0.21	0.12	1.21	4.89	0.00	0.00	0.00	0.00	0.00	0.00
16	11	24.63	0.00	0.00	0.00	4.13	20.01	3.34	0.21	0.12	1.22	4.88	0.00	0.00	0.00	0.00	0.00	0.00
16	12	24.63	0.00	0.00	0.00	4.13	20.03	3.33	0.21	0.12	1.22	4.88	0.00	0.00	0.00	0.00	0.00	0.00
16	13	24.63	0.00	0.00	0.00	4.13	20.06	3.32	0.21	0.11	1.22	4.87	0.00	0.00	0.00	0.00	0.00	0.00
16	14	24.63	0.00	0.00	0.00	4.14	20.08	3.32	0.21	0.11	1.23	4.87	0.00	0.00	0.00	0.00	0.00	0.00
16	15	24.63	0.00	0.00	0.00	4.14	20.10	3.31	0.21	0.11	1.23	4.86	0.00	0.00	0.00	0.00	0.00	0.00
16	16	24.63	0.00	0.00	0.00	4.14	20.12	3.31	0.21	0.11	1.23	4.86	0.00	0.00	0.00	0.00	0.00	0.00
16	17	24.63	0.00	0.00	0.00	4.14	20.14	3.30	0.21	0.11	1.23	4.85	0.00	0.00	0.00	0.00	0.00	0.00
16	18	24.63	0.00	0.00	0.00	4.15	20.16	3.29	0.20	0.11	1.24	4.85	0.00	0.00	0.00	0.00	0.00	0.00
16	19	24.63	0.00	0.00	0.00	4.15	20.18	3.29	0.20	0.11	1.24	4.84	0.00	0.00	0.00	0.00	0.00	0.00
16	20	24.63	0.00	0.00	0.00	4.15	20.20	3.28	0.20	0.11	1.24	4.84	0.00	0.00	0.00	0.00	0.00	0.00
17	1	24.63	0.00	0.00	0.00	4.61	20.15	3.28	0.20	0.11	1.24	4.83	0.00	0.00	0.00	0.00	0.00	0.00
17	2	24.63	0.00	0.00	0.00	4.35	20.11	3.27	0.20	0.11	1.25	4.83	0.00	0.00	0.00	0.00	0.00	0.00
17	3	24.63	0.00	0.00	0.00	4.17	20.06	3.26	0.20	0.11	1.25	4.82	0.00	0.00	0.00	0.00	0.00	0.00
17	4	24.63	0.00	0.00	0.00	4.04	20.01	3.26	0.20	0.11	1.25	4.82	0.00	0.00	0.00	0.00	0.00	0.00
17	5	24.63	0.00	0.00	0.00	3.94	19.97	3.25	0.20	0.11	1.26	4.81	0.00	0.00	0.00	0.00	0.00	0.00
17	6	24.63	0.00	0.00	0.00	3.87	19.92	3.24	0.20	0.11	1.26	4.81	0.00	0.00	0.00	0.00	0.00	0.00
17	7	24.63	0.00	0.00	0.00	3.82	19.88	3.24	0.20	0.11	1.26	4.80	0.00	0.00	0.00	0.00	0.00	0.00
17	8	24.63	0.00	0.00	0.00	3.79	19.83	3.23	0.20	0.10	1.26	4.80	0.00	0.00	0.00	0.00	0.00	0.00
17	9	24.63	0.00	0.00	0.00	3.76	19.78	3.23	0.19	0.10	1.27	4.79	0.00	0.00	0.00	0.00	0.00	0.00
17	10	24.63	0.00	0.00	0.00	3.75	19.74	3.22	0.19	0.10	1.27	4.79	0.00	0.00	0.00	0.00	0.00	0.00
17	11	24.63	0.00	0.00	0.00	3.74	19.69	3.21	0.19	0.10	1.27	4.78	0.00	0.00	0.00	0.00	0.00	0.00
17	12	24.63	0.00	0.00	0.00	3.73	19.65	3.21	0.19	0.10	1.28	4.78	0.00	0.00	0.00	0.00	0.00	0.00
17	13	24.63	0.00	0.00	0.00	3.73	19.60	3.20	0.19	0.10	1.28	4.77	0.00	0.00	0.00	0.00	0.00	0.00
17	14	24.63	0.00	0.00	0.00	3.72	19.56	3.19	0.19	0.10	1.28	4.77	0.00	0.00	0.00	0.00	0.00	0.00
17	15	24.63	0.00	0.00	0.00	3.72	19.52	3.19	0.19	0.10	1.28	4.76	0.00	0.00	0.00	0.00	0.00	0.00
17	16	24.63	0.00	0.00	0.00	3.72	19.47	3.18	0.19	0.10	1.29	4.76	0.00	0.00	0.00	0.00	0.00	0.00
17	17	24.63	0.00	0.00	0.00	3.72	19.43	3.18	0.19	0.10	1.29	4.75	0.00	0.00	0.00	0.00	0.00	0.00
17	18	24.63	0.00	0.00	0.00	3.73	19.39	3.17	0.19	0.10	1.29	4.75	0.00	0.00	0.00	0.00	0.00	0.00

RCH NUM	ELE NUM	TEMP DEG-C	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
17	19	24.63	0.00	0.00	0.00	3.73	19.34	3.16	0.19	0.10	1.29	4.74	0.00	0.00	0.00	0.00	0.00	0.00
17	20	24.63	0.00	0.00	0.00	3.73	19.30	3.16	0.19	0.10	1.30	4.74	0.00	0.00	0.00	0.00	0.00	0.00
18	1	24.63	0.00	0.00	0.00	3.82	19.26	3.15	0.19	0.10	1.30	4.73	0.00	0.00	0.00	0.00	0.00	0.00
18	2	24.63	0.00	0.00	0.00	4.07	19.22	3.15	0.18	0.10	1.30	4.73	0.00	0.00	0.00	0.00	0.00	0.00

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 21
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-C	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
18	3	24.63	0.00	0.00	0.00	4.24	19.19	3.14	0.18	0.10	1.30	4.73	0.00	0.00	0.00	0.00	0.00	0.00
18	4	24.63	0.00	0.00	0.00	4.35	19.15	3.13	0.18	0.10	1.31	4.72	0.00	0.00	0.00	0.00	0.00	0.00
18	5	24.63	0.00	0.00	0.00	4.43	19.12	3.13	0.18	0.10	1.31	4.72	0.00	0.00	0.00	0.00	0.00	0.00
18	6	24.63	0.00	0.00	0.00	4.48	19.09	3.12	0.18	0.10	1.31	4.71	0.00	0.00	0.00	0.00	0.00	0.00
18	7	24.63	0.00	0.00	0.00	4.52	19.05	3.12	0.18	0.10	1.31	4.71	0.00	0.00	0.00	0.00	0.00	0.00
18	8	24.63	0.00	0.00	0.00	4.54	19.02	3.11	0.18	0.09	1.31	4.70	0.00	0.00	0.00	0.00	0.00	0.00
18	9	24.63	0.00	0.00	0.00	4.56	18.98	3.11	0.18	0.09	1.32	4.70	0.00	0.00	0.00	0.00	0.00	0.00
18	10	24.63	0.00	0.00	0.00	4.58	18.95	3.10	0.18	0.09	1.32	4.69	0.00	0.00	0.00	0.00	0.00	0.00
18	11	24.63	0.00	0.00	0.00	4.58	18.91	3.09	0.18	0.09	1.32	4.69	0.00	0.00	0.00	0.00	0.00	0.00
18	12	24.63	0.00	0.00	0.00	4.59	18.88	3.09	0.18	0.09	1.32	4.68	0.00	0.00	0.00	0.00	0.00	0.00
18	13	24.63	0.00	0.00	0.00	4.60	18.85	3.08	0.18	0.09	1.32	4.68	0.00	0.00	0.00	0.00	0.00	0.00
18	14	24.63	0.00	0.00	0.00	4.60	18.81	3.08	0.18	0.09	1.33	4.67	0.00	0.00	0.00	0.00	0.00	0.00
18	15	24.63	0.00	0.00	0.00	4.61	18.78	3.07	0.18	0.09	1.33	4.67	0.00	0.00	0.00	0.00	0.00	0.00
18	16	24.63	0.00	0.00	0.00	4.61	18.75	3.07	0.18	0.09	1.33	4.66	0.00	0.00	0.00	0.00	0.00	0.00
18	17	24.63	0.00	0.00	0.00	4.61	18.72	3.06	0.18	0.09	1.33	4.66	0.00	0.00	0.00	0.00	0.00	0.00
18	18	24.63	0.00	0.00	0.00	4.62	18.68	3.06	0.18	0.09	1.33	4.66	0.00	0.00	0.00	0.00	0.00	0.00
18	19	24.63	0.00	0.00	0.00	4.62	18.65	3.04	0.17	0.09	1.33	4.64	0.00	0.00	0.00	0.00	0.00	0.00

END OF SYSTEM BOUNDARY CONCENTRATIONS

		TEMP	CM-1	CM-2	CM-3	DO	BOD	ORGN	NH3N	NO2N	NO3N	SUM-N	ORGP	DIS-P	SUM-P	COLI	ANC	CHLA
		25.00	0.00	0.00	0.00	5.00	18.00	0.00	0.16	0.01	0.20	0.37	0.00	0.00	0.00	0.00	0.00	0.00

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 22
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-C	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY) F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
1	1	1	24.55	8.47	0.00	8.47	0.00	1.00	13.82	141.53	-1.70	-2011.00	0.00	-0.49	-0.08
2	1	2	21.63	8.95	4.12	4.83	0.00	1.00	349.63	75.32	-16.95	-45.72	0.00	-0.64	0.00
3	1	3	22.15	8.86	4.00	4.86	0.00	1.00	0.00	76.68	-17.08	-47.08	0.00	-0.66	-0.01
4	1	4	22.58	8.79	3.89	4.90	0.00	1.00	0.00	78.17	-17.14	-48.22	0.00	-0.68	-0.01
5	1	5	22.93	8.73	3.77	4.96	0.00	1.00	0.00	79.70	-17.14	-49.19	0.00	-0.70	-0.01
6	1	6	23.23	8.68	3.67	5.01	0.00	1.00	0.00	81.18	-17.09	-49.99	0.00	-0.72	-0.02
7	1	7	23.47	8.64	3.57	5.07	0.00	1.00	0.00	82.56	-16.99	-50.66	0.00	-0.73	-0.02
8	1	8	23.67	8.61	3.49	5.12	0.00	1.00	0.00	83.82	-16.86	-51.21	0.00	-0.74	-0.02
9	2	1	23.85	8.58	3.40	5.18	0.00	1.00	0.00	70.90	-10.12	-46.03	0.00	-0.74	-0.03
10	2	2	24.01	8.56	3.19	5.36	0.00	1.00	0.00	58.97	-10.10	-46.40	0.00	-0.75	-0.03
11	2	3	24.13	8.54	3.01	5.52	0.00	1.00	0.00	60.94	-10.06	-46.69	0.00	-0.75	-0.04
12	2	4	24.23	8.52	2.85	5.67	0.00	1.00	0.00	62.66	-10.01	-46.90	0.00	-0.76	-0.04
13	2	5	24.30	8.51	2.72	5.79	0.00	1.00	0.00	64.14	-9.95	-47.06	0.00	-0.76	-0.05
14	2	6	24.36	8.50	2.60	5.90	0.00	1.00	0.00	65.42	-9.89	-47.18	0.00	-0.76	-0.05
15	2	7	24.41	8.49	2.50	5.99	0.00	1.00	0.00	66.49	-9.82	-47.26	0.00	-0.76	-0.05
16	2	8	24.45	8.49	2.42	6.07	0.00	1.00	0.00	67.40	-9.74	-47.31	0.00	-0.75	-0.06
17	2	9	24.48	8.48	2.35	6.13	0.00	1.00	0.00	68.17	-9.66	-47.34	0.00	-0.75	-0.06
18	2	10	24.50	8.48	2.29	6.18	0.00	1.00	0.00	68.80	-9.58	-47.35	0.00	-0.75	-0.07

19	2	11	24.52	8.48	2.25	6.23	0.00	1.00	0.00	69.32	-9.50	-47.35	0.00	-0.75	-0.07
20	2	12	24.53	8.47	2.21	6.26	0.00	1.00	0.00	69.74	-9.42	-47.34	0.00	-0.75	-0.07
21	2	13	24.54	8.47	2.18	6.29	0.00	1.00	0.00	70.08	-9.34	-47.32	0.00	-0.74	-0.08
22	2	14	24.55	8.47	2.16	6.31	0.00	1.00	0.00	70.34	-9.26	-47.30	0.00	-0.74	-0.08
23	2	15	24.56	8.47	2.14	6.33	0.00	1.00	0.00	70.54	-9.17	-47.27	0.00	-0.74	-0.08
24	3	1	24.59	8.46	0.00	8.46	0.00	1.00	11.60	622.89	-0.37	-3376.11	0.00	-0.52	-0.08
25	3	2	23.90	8.57	0.97	7.61	0.00	1.00	139.03	550.64	-2.37	-363.28	0.00	-13.50	-0.10
26	3	3	24.46	8.48	2.44	6.04	0.00	1.00	0.00	443.47	-2.38	-371.43	0.00	-13.63	-0.28
27	3	4	24.57	8.47	2.87	5.59	0.00	1.00	0.00	411.55	-2.35	-370.09	0.00	-13.29	-0.44
28	3	5	24.59	8.46	3.03	5.43	0.00	1.00	0.00	399.93	-2.30	-366.89	0.00	-12.86	-0.58
29	3	6	24.60	8.46	3.11	5.35	0.00	1.00	0.00	393.84	-2.26	-363.40	0.00	-12.44	-0.71
30	3	7	24.60	8.46	3.17	5.29	0.00	1.00	0.00	389.34	-2.22	-359.92	0.00	-12.03	-0.83
31	3	8	24.60	8.46	3.23	5.23	0.00	1.00	0.00	385.34	-2.18	-356.51	0.00	-11.64	-0.94
32	3	9	24.60	8.46	3.28	5.18	0.00	1.00	0.00	381.57	-2.14	-353.18	0.00	-11.27	-1.03
33	3	10	24.60	8.46	3.33	5.13	0.00	1.00	0.00	377.91	-2.11	-349.93	0.00	-10.91	-1.11
34	3	11	24.60	8.46	3.38	5.09	0.00	1.00	0.00	374.36	-2.07	-346.76	0.00	-10.57	-1.19
35	3	12	24.60	8.46	3.42	5.04	0.00	1.00	0.00	370.89	-2.03	-343.66	0.00	-10.24	-1.26
36	3	13	24.60	8.46	3.47	4.99	0.00	1.00	0.00	367.50	-2.00	-340.64	0.00	-9.92	-1.32
37	3	14	24.60	8.46	3.51	4.95	0.00	1.00	0.00	364.19	-1.97	-337.68	0.00	-9.62	-1.37
38	3	15	24.60	8.46	3.56	4.90	0.00	1.00	0.00	360.96	-1.94	-334.80	0.00	-9.33	-1.42
39	3	16	24.60	8.46	3.60	4.86	0.00	1.00	0.00	357.80	-1.91	-331.98	0.00	-9.05	-1.46
40	3	17	24.60	8.46	3.64	4.82	0.00	1.00	0.00	354.74	-1.88	-329.22	0.00	-8.78	-1.49

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-C	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY) F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
41	4	1	24.57	8.47	2.13	6.34	0.00	1.00	0.00	187.26	-10.24	-101.52	0.00	-1.61	-0.24
42	4	2	24.59	8.46	1.83	6.63	0.00	1.00	0.00	110.87	-10.19	-101.55	0.00	-1.60	-0.25
43	4	3	24.60	8.46	1.63	6.83	0.00	1.00	0.00	114.33	-10.14	-101.53	0.00	-1.58	-0.26
44	4	4	24.61	8.46	1.48	6.98	0.00	1.00	0.00	116.75	-10.09	-101.48	0.00	-1.56	-0.27
45	4	5	24.61	8.46	1.38	7.08	0.00	1.00	0.00	118.44	-10.03	-101.42	0.00	-1.55	-0.27
46	4	6	24.62	8.46	1.31	7.15	0.00	1.00	0.00	119.60	-9.98	-101.34	0.00	-1.53	-0.28
47	4	7	24.62	8.46	1.27	7.19	0.00	1.00	0.00	120.37	-9.92	-101.27	0.00	-1.51	-0.29
48	4	8	24.62	8.46	1.24	7.22	0.00	1.00	0.00	120.88	-9.87	-101.18	0.00	-1.50	-0.29
49	4	9	24.62	8.46	1.22	7.24	0.00	1.00	0.00	121.19	-9.82	-101.10	0.00	-1.48	-0.30
50	4	10	24.62	8.46	1.21	7.25	0.00	1.00	0.00	121.37	-9.76	-101.02	0.00	-1.46	-0.30
51	4	11	24.62	8.46	1.20	7.26	0.00	1.00	0.00	121.44	-9.71	-100.93	0.00	-1.45	-0.31
52	5	1	24.54	8.47	0.00	8.47	0.00	1.00	11.35	632.13	-2.03	-1032.62	0.00	-0.49	-0.08
53	5	2	24.17	8.53	2.21	6.32	0.00	1.00	28.25	467.85	-5.30	-242.91	0.00	-9.90	-0.14
54	5	3	24.51	8.48	4.30	4.18	0.00	1.00	0.00	311.49	-4.95	-238.76	0.00	-9.32	-0.33
55	5	4	24.55	8.47	4.79	3.68	0.00	1.00	0.00	274.92	-4.59	-231.20	0.00	-8.61	-0.47
56	5	5	24.55	8.47	4.97	3.50	0.00	1.00	0.00	260.89	-4.26	-223.83	0.00	-7.96	-0.58
57	5	6	24.55	8.47	5.10	3.37	0.00	1.00	0.00	251.66	-3.97	-217.00	0.00	-7.38	-0.66
58	5	7	24.55	8.47	5.20	3.27	0.00	1.00	0.00	243.87	-3.71	-210.69	0.00	-6.86	-0.73
59	5	8	24.55	8.47	5.30	3.17	0.00	1.00	0.00	236.82	-3.49	-204.84	0.00	-6.40	-0.78
60	5	9	24.55	8.47	5.38	3.09	0.00	1.00	0.00	230.33	-3.28	-199.41	0.00	-5.98	-0.82
61	5	10	24.55	8.47	5.46	3.00	0.00	1.00	0.00	224.29	-3.10	-194.35	0.00	-5.61	-0.85
62	5	11	24.55	8.47	5.54	2.93	0.00	1.00	0.00	218.66	-2.93	-189.61	0.00	-5.27	-0.87
63	6	1	24.55	8.47	5.81	2.65	0.00	1.00	0.00	232.20	-2.79	-216.19	0.00	-4.97	-0.88
64	6	2	24.55	8.47	6.03	2.44	0.00	1.00	0.00	244.39	-2.66	-211.35	0.00	-4.71	-0.88
65	6	3	24.55	8.47	6.12	2.35	0.00	1.00	0.00	235.94	-2.55	-206.78	0.00	-4.46	-0.88
66	6	4	24.55	8.47	6.17	2.30	0.00	1.00	0.00	230.34	-2.44	-202.47	0.00	-4.24	-0.88
67	6	5	24.55	8.47	6.22	2.25	0.00	1.00	0.00	225.51	-2.35	-198.39	0.00	-4.04	-0.87
68	6	6	24.55	8.47	6.26	2.20	0.00	1.00	0.00	221.05	-2.26	-194.52	0.00	-3.85	-0.86
69	6	7	24.55	8.47	6.31	2.16	0.00	1.00	0.00	216.85	-2.18	-190.85	0.00	-3.67	-0.86
70	6	8	24.55	8.47	6.35	2.12	0.00	1.00	0.00	212.85	-2.10	-187.36	0.00	-3.51	-0.85

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-C	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
71	6	9	24.55	8.47	6.38	2.08	0.00	1.00	0.00	209.04	-2.03	-184.03	0.00	-3.35	-0.84
72	6	10	24.55	8.47	6.42	2.05	0.00	1.00	0.00	205.44	-1.96	-180.85	0.00	-3.21	-0.82
73	6	11	24.56	8.47	6.45	2.01	0.00	1.00	0.00	201.98	-1.90	-177.82	0.00	-3.08	-0.81
74	6	12	24.56	8.47	6.49	1.98	0.00	1.00	0.00	198.70	-1.84	-174.91	0.00	-2.95	-0.80
75	6	13	24.56	8.47	6.52	1.95	0.00	1.00	0.00	195.56	-1.79	-172.14	0.00	-2.84	-0.79
76	7	1	24.58	8.47	5.95	2.52	0.00	1.00	0.00	176.64	-1.71	-120.76	0.00	-2.71	-0.78
77	7	2	24.59	8.46	5.34	3.13	0.00	1.00	0.00	125.51	-1.61	-119.23	0.00	-2.55	-0.77
78	7	3	24.59	8.46	5.23	3.24	0.00	1.00	0.00	129.89	-1.52	-117.68	0.00	-2.41	-0.76
79	7	4	24.60	8.46	5.24	3.23	0.00	1.00	0.00	129.54	-1.44	-116.18	0.00	-2.28	-0.75
80	7	5	24.60	8.46	5.27	3.19	0.00	1.00	0.00	128.14	-1.36	-114.72	0.00	-2.15	-0.73

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

** DISSOLVED OXYGEN DATA **

									COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)						
ELE ORD	RCH NUM	ELE NUM	TEMP DEG-C	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
81	7	6	24.60	8.46	5.31	3.15	0.00	1.00	0.00	126.52	-1.29	-113.31	0.00	-2.04	-0.71
82	8	1	24.59	8.46	5.90	2.57	0.00	1.00	0.00	164.51	-1.24	-200.65	0.00	-1.94	-0.70
83	8	2	24.59	8.46	6.02	2.45	0.00	1.00	0.00	215.65	-1.21	-198.06	0.00	-1.87	-0.68
84	8	3	24.59	8.46	6.06	2.40	0.00	1.00	0.00	211.34	-1.18	-195.57	0.00	-1.81	-0.66
85	8	4	24.59	8.46	6.10	2.37	0.00	1.00	0.00	208.38	-1.15	-193.16	0.00	-1.74	-0.65
86	8	5	24.59	8.46	6.13	2.34	0.00	1.00	0.00	205.78	-1.13	-190.83	0.00	-1.68	-0.63
87	8	6	24.59	8.46	6.16	2.31	0.00	1.00	0.00	203.32	-1.10	-188.57	0.00	-1.63	-0.62
88	8	7	24.59	8.46	6.18	2.28	0.00	1.00	0.00	201.05	-1.09	-186.38	0.00	-1.57	-0.60
89	9	1	24.62	8.46	1.38	7.08	0.00	1.00	0.00	264.65	-2.59	-157.11	0.00	-1.45	-0.33
90	9	2	24.63	8.46	1.26	7.20	0.00	1.00	0.00	160.68	-2.60	-157.04	0.00	-1.43	-0.34
91	9	3	24.63	8.46	1.19	7.27	0.00	1.00	0.00	162.19	-2.60	-156.94	0.00	-1.41	-0.34
92	9	4	24.63	8.46	1.15	7.30	0.00	1.00	0.00	163.01	-2.61	-156.82	0.00	-1.39	-0.35
93	9	5	24.63	8.46	1.14	7.32	0.00	1.00	0.00	163.44	-2.61	-156.69	0.00	-1.37	-0.35
94	9	6	24.63	8.46	1.13	7.33	0.00	1.00	0.00	163.62	-2.61	-156.56	0.00	-1.35	-0.35
95	9	7	24.63	8.46	1.13	7.33	0.00	1.00	0.00	163.67	-2.61	-156.44	0.00	-1.33	-0.36
96	9	8	24.63	8.46	1.13	7.33	0.00	1.00	0.00	163.65	-2.62	-156.31	0.00	-1.31	-0.36
97	9	9	24.63	8.46	1.13	7.33	0.00	1.00	0.00	163.57	-2.62	-156.18	0.00	-1.29	-0.36
98	9	10	24.63	8.46	1.13	7.32	0.00	1.00	0.00	163.47	-2.62	-156.05	0.00	-1.28	-0.36
99	9	11	24.63	8.46	1.14	7.32	0.00	1.00	0.00	163.35	-2.63	-155.92	0.00	-1.26	-0.36
100	10	1	24.63	8.46	1.14	7.31	0.00	1.00	0.00	159.17	-2.62	-147.90	0.00	-1.24	-0.37
101	10	2	24.63	8.46	1.15	7.31	0.00	1.00	0.00	155.04	-2.61	-147.78	0.00	-1.22	-0.37
102	10	3	24.63	8.46	1.15	7.31	0.00	1.00	0.00	154.96	-2.61	-147.66	0.00	-1.21	-0.37
103	10	4	24.63	8.46	1.16	7.30	0.00	1.00	0.00	154.85	-2.60	-147.54	0.00	-1.19	-0.37
104	10	5	24.63	8.46	1.16	7.30	0.00	1.00	0.00	154.72	-2.60	-147.42	0.00	-1.17	-0.37
105	10	6	24.63	8.46	1.17	7.29	0.00	1.00	0.00	154.59	-2.59	-147.30	0.00	-1.16	-0.37
106	10	7	24.63	8.46	1.17	7.28	0.00	1.00	0.00	154.45	-2.58	-147.18	0.00	-1.14	-0.37
107	10	8	24.63	8.46	1.18	7.28	0.00	1.00	0.00	154.31	-2.58	-147.06	0.00	-1.13	-0.37
108	10	9	24.63	8.46	1.19	7.27	0.00	1.00	0.00	154.17	-2.57	-146.94	0.00	-1.11	-0.37
109	10	10	24.63	8.46	1.19	7.26	0.00	1.00	0.00	154.03	-2.57	-146.82	0.00	-1.10	-0.37
110	10	11	24.63	8.46	1.20	7.26	0.00	1.00	0.00	153.89	-2.56	-146.70	0.00	-1.08	-0.37
111	10	12	24.63	8.46	1.21	7.25	0.00	1.00	0.00	153.74	-2.56	-146.59	0.00	-1.07	-0.37
112	10	13	24.63	8.46	1.21	7.24	0.00	1.00	0.00	153.60	-2.55	-146.47	0.00	-1.05	-0.37
113	10	14	24.63	8.46	1.22	7.24	0.00	1.00	0.00	153.46	-2.54	-146.35	0.00	-1.04	-0.36
114	10	15	24.63	8.46	1.23	7.23	0.00	1.00	0.00	153.32	-2.54	-146.23	0.00	-1.03	-0.36
115	10	16	24.63	8.46	1.23	7.22	0.00	1.00	0.00	153.18	-2.53	-146.12	0.00	-1.01	-0.36
116	10	17	24.63	8.46	1.24	7.22	0.00	1.00	0.00	153.04	-2.53	-146.00	0.00	-1.00	-0.36
117	10	18	24.63	8.46	1.25	7.21	0.00	1.00	0.00	152.90	-2.52	-145.88	0.00	-0.99	-0.36
118	10	19	24.63	8.46	1.25	7.20	0.00	1.00	0.00	152.76	-2.52	-145.77	0.00	-0.98	-0.36
119	10	20	24.63	8.46	1.26	7.20	0.00	1.00	0.00	152.61	-2.51	-145.65	0.00	-0.96	-0.36

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-C	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY) F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
120	11	1	24.63	8.46	1.80	6.65	0.00	1.00	0.00	137.38	-2.51	-119.48	0.00	-0.95	-0.35
121	11	2	24.63	8.46	1.95	6.50	0.00	1.00	0.00	130.66	-2.50	-119.38	0.00	-0.94	-0.35
122	11	3	24.63	8.46	2.05	6.41	0.00	1.00	0.00	128.75	-2.50	-119.29	0.00	-0.93	-0.35
123	11	4	24.63	8.46	2.11	6.35	0.00	1.00	0.00	127.52	-2.49	-119.19	0.00	-0.92	-0.35
124	11	5	24.63	8.46	2.15	6.31	0.00	1.00	0.00	126.72	-2.49	-119.10	0.00	-0.91	-0.35
125	11	6	24.63	8.46	2.18	6.28	0.00	1.00	0.00	126.17	-2.48	-119.00	0.00	-0.90	-0.34
126	11	7	24.63	8.46	2.20	6.26	0.00	1.00	0.00	125.80	-2.48	-118.91	0.00	-0.89	-0.34
127	11	8	24.63	8.46	2.21	6.25	0.00	1.00	0.00	125.52	-2.47	-118.82	0.00	-0.88	-0.34
128	11	9	24.63	8.46	2.22	6.24	0.00	1.00	0.00	125.30	-2.47	-118.72	0.00	-0.87	-0.34
129	11	10	24.63	8.46	2.23	6.23	0.00	1.00	0.00	125.13	-2.47	-118.63	0.00	-0.86	-0.34
130	11	11	24.63	8.46	2.24	6.22	0.00	1.00	0.00	124.98	-2.46	-118.54	0.00	-0.85	-0.33
131	11	12	24.63	8.46	2.24	6.21	0.00	1.00	0.00	124.84	-2.46	-118.44	0.00	-0.85	-0.33
132	11	13	24.63	8.46	2.25	6.21	0.00	1.00	0.00	124.72	-2.45	-118.35	0.00	-0.84	-0.33
133	11	14	24.63	8.46	2.26	6.20	0.00	1.00	0.00	124.60	-2.45	-118.26	0.00	-0.83	-0.33
134	11	15	24.63	8.46	2.26	6.20	0.00	1.00	0.00	124.48	-2.44	-118.16	0.00	-0.82	-0.32
135	11	16	24.63	8.46	2.27	6.19	0.00	1.00	0.00	124.37	-2.44	-118.07	0.00	-0.81	-0.32
136	11	17	24.63	8.46	2.27	6.18	0.00	1.00	0.00	124.26	-2.44	-117.98	0.00	-0.80	-0.32
137	11	18	24.63	8.46	2.28	6.18	0.00	1.00	0.00	124.15	-2.43	-117.89	0.00	-0.80	-0.32
138	11	19	24.63	8.46	2.28	6.17	0.00	1.00	0.00	124.04	-2.43	-117.80	0.00	-0.79	-0.32
139	11	20	24.63	8.46	2.29	6.17	0.00	1.00	0.00	123.93	-2.42	-117.71	0.00	-0.78	-0.31
140	12	1	24.63	8.46	2.14	6.32	0.00	1.00	0.00	126.91	-2.43	-114.74	0.00	-0.77	-0.31
141	12	2	24.63	8.46	2.27	6.19	0.00	1.00	0.00	124.36	-2.43	-114.65	0.00	-0.76	-0.31
142	12	3	24.63	8.46	2.34	6.11	0.00	1.00	0.00	122.85	-2.43	-114.56	0.00	-0.75	-0.30
143	12	4	24.63	8.46	2.39	6.07	0.00	1.00	0.00	121.93	-2.43	-114.47	0.00	-0.75	-0.30
144	12	5	24.63	8.46	2.42	6.04	0.00	1.00	0.00	121.36	-2.43	-114.38	0.00	-0.74	-0.30
145	12	6	24.63	8.46	2.44	6.02	0.00	1.00	0.00	120.99	-2.44	-114.29	0.00	-0.73	-0.30
146	12	7	24.63	8.46	2.45	6.01	0.00	1.00	0.00	120.73	-2.44	-114.21	0.00	-0.72	-0.29
147	12	8	24.63	8.46	2.46	6.00	0.00	1.00	0.00	120.54	-2.44	-114.12	0.00	-0.71	-0.29
148	12	9	24.63	8.46	2.46	5.99	0.00	1.00	0.00	120.39	-2.44	-114.03	0.00	-0.71	-0.29
149	12	10	24.63	8.46	2.47	5.99	0.00	1.00	0.00	120.27	-2.44	-113.94	0.00	-0.70	-0.29
150	12	11	24.63	8.46	2.48	5.98	0.00	1.00	0.00	120.15	-2.45	-113.86	0.00	-0.69	-0.28
151	12	12	24.63	8.46	2.48	5.97	0.00	1.00	0.00	120.05	-2.45	-113.77	0.00	-0.68	-0.28
152	12	13	24.63	8.46	2.49	5.97	0.00	1.00	0.00	119.95	-2.45	-113.68	0.00	-0.68	-0.28
153	12	14	24.63	8.46	2.49	5.97	0.00	1.00	0.00	119.85	-2.45	-113.59	0.00	-0.67	-0.28
154	12	15	24.63	8.46	2.50	5.96	0.00	1.00	0.00	119.75	-2.45	-113.51	0.00	-0.66	-0.27
155	12	16	24.63	8.46	2.50	5.96	0.00	1.00	0.00	119.66	-2.45	-113.42	0.00	-0.66	-0.27
156	12	17	24.63	8.46	2.51	5.95	0.00	1.00	0.00	119.57	-2.46	-113.34	0.00	-0.65	-0.27
157	12	18	24.63	8.46	2.51	5.95	0.00	1.00	0.00	119.47	-2.46	-113.25	0.00	-0.64	-0.27
158	12	19	24.63	8.46	2.52	5.94	0.00	1.00	0.00	119.38	-2.46	-113.16	0.00	-0.64	-0.26
159	12	20	24.63	8.46	2.52	5.94	0.00	1.00	0.00	119.28	-2.46	-113.08	0.00	-0.63	-0.26
160	13	1	24.63	8.46	2.89	5.57	0.00	1.00	0.00	108.82	-3.20	-91.99	0.00	-0.62	-0.26
161	13	2	24.63	8.46	3.01	5.45	0.00	1.00	0.00	103.44	-3.19	-91.91	0.00	-0.62	-0.26

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-C	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY) F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
162	13	3	24.63	8.46	3.08	5.38	0.00	1.00	0.00	102.03	-3.19	-91.84	0.00	-0.61	-0.25
163	13	4	24.63	8.46	3.13	5.33	0.00	1.00	0.00	101.15	-3.19	-91.77	0.00	-0.61	-0.25
164	13	5	24.63	8.46	3.16	5.30	0.00	1.00	0.00	100.58	-3.19	-91.70	0.00	-0.60	-0.25

165	13	6	24.63	8.46	3.18	5.28	0.00	1.00	0.00	100.21	-3.19	-91.63	0.00	-0.60	-0.25
166	13	7	24.63	8.46	3.19	5.27	0.00	1.00	0.00	99.95	-3.19	-91.56	0.00	-0.59	-0.24
167	13	8	24.63	8.46	3.20	5.26	0.00	1.00	0.00	99.77	-3.19	-91.49	0.00	-0.59	-0.24
168	13	9	24.63	8.46	3.21	5.25	0.00	1.00	0.00	99.62	-3.18	-91.42	0.00	-0.58	-0.24
169	13	10	24.63	8.46	3.21	5.24	0.00	1.00	0.00	99.50	-3.18	-91.35	0.00	-0.58	-0.24
170	13	11	24.63	8.46	3.22	5.24	0.00	1.00	0.00	99.40	-3.18	-91.29	0.00	-0.57	-0.24
171	13	12	24.63	8.46	3.22	5.23	0.00	1.00	0.00	99.31	-3.18	-91.22	0.00	-0.57	-0.23
172	13	13	24.63	8.46	3.23	5.23	0.00	1.00	0.00	99.23	-3.18	-91.15	0.00	-0.56	-0.23
173	13	14	24.63	8.46	3.23	5.23	0.00	1.00	0.00	99.14	-3.18	-91.08	0.00	-0.56	-0.23
174	13	15	24.63	8.46	3.24	5.22	0.00	1.00	0.00	99.06	-3.17	-91.01	0.00	-0.55	-0.23
175	13	16	24.63	8.46	3.24	5.22	0.00	1.00	0.00	98.98	-3.17	-90.95	0.00	-0.55	-0.22
176	13	17	24.63	8.46	3.24	5.21	0.00	1.00	0.00	98.91	-3.17	-90.88	0.00	-0.54	-0.22
177	13	18	24.63	8.46	3.25	5.21	0.00	1.00	0.00	98.83	-3.17	-90.81	0.00	-0.54	-0.22
178	13	19	24.63	8.46	3.25	5.20	0.00	1.00	0.00	98.75	-3.17	-90.74	0.00	-0.53	-0.22
179	13	20	24.63	8.46	3.26	5.20	0.00	1.00	0.00	98.68	-3.17	-90.68	0.00	-0.53	-0.22
180	14	1	24.63	8.46	3.18	5.28	0.00	1.00	0.00	117.81	-2.44	-126.45	0.00	-0.53	-0.22
181	14	2	24.63	8.46	3.21	5.24	0.00	1.00	0.00	134.62	-2.44	-126.36	0.00	-0.52	-0.21
182	14	3	24.63	8.46	3.23	5.22	0.00	1.00	0.00	134.10	-2.45	-126.27	0.00	-0.52	-0.21
183	14	4	24.63	8.46	3.25	5.21	0.00	1.00	0.00	133.74	-2.45	-126.18	0.00	-0.52	-0.21
184	14	5	24.63	8.46	3.26	5.20	0.00	1.00	0.00	133.50	-2.45	-126.08	0.00	-0.51	-0.21
185	14	6	24.63	8.46	3.26	5.19	0.00	1.00	0.00	133.32	-2.46	-125.99	0.00	-0.51	-0.21
186	14	7	24.63	8.46	3.27	5.19	0.00	1.00	0.00	133.18	-2.46	-125.90	0.00	-0.51	-0.21
187	14	8	24.63	8.46	3.27	5.18	0.00	1.00	0.00	133.06	-2.46	-125.81	0.00	-0.50	-0.20
188	14	9	24.63	8.46	3.28	5.18	0.00	1.00	0.00	132.95	-2.47	-125.71	0.00	-0.50	-0.20
189	14	10	24.63	8.46	3.28	5.17	0.00	1.00	0.00	132.84	-2.47	-125.62	0.00	-0.50	-0.20
190	15	1	24.63	8.46	3.64	4.82	0.00	1.00	0.00	96.81	-2.47	-64.48	0.00	-0.49	-0.20
191	15	2	24.63	8.46	3.60	4.86	0.00	1.00	0.00	70.48	-2.47	-64.43	0.00	-0.49	-0.20
192	15	3	24.63	8.46	3.58	4.88	0.00	1.00	0.00	70.80	-2.47	-64.39	0.00	-0.49	-0.20
193	15	4	24.63	8.46	3.57	4.89	0.00	1.00	0.00	70.98	-2.47	-64.34	0.00	-0.48	-0.19
194	15	5	24.63	8.46	3.56	4.90	0.00	1.00	0.00	71.07	-2.46	-64.30	0.00	-0.48	-0.19
195	15	6	24.63	8.46	3.56	4.90	0.00	1.00	0.00	71.10	-2.46	-64.25	0.00	-0.47	-0.19
196	15	7	24.63	8.46	3.56	4.90	0.00	1.00	0.00	71.09	-2.46	-64.21	0.00	-0.47	-0.19
197	15	8	24.63	8.46	3.56	4.90	0.00	1.00	0.00	71.07	-2.46	-64.16	0.00	-0.46	-0.19
198	15	9	24.63	8.46	3.56	4.90	0.00	1.00	0.00	71.04	-2.46	-64.12	0.00	-0.46	-0.18
199	15	10	24.63	8.46	3.56	4.89	0.00	1.00	0.00	71.00	-2.46	-64.07	0.00	-0.46	-0.18
200	15	11	24.63	8.46	3.57	4.89	0.00	1.00	0.00	70.95	-2.45	-64.03	0.00	-0.45	-0.18
201	15	12	24.63	8.46	3.57	4.89	0.00	1.00	0.00	70.90	-2.45	-63.98	0.00	-0.45	-0.18
202	15	13	24.63	8.46	3.57	4.88	0.00	1.00	0.00	70.85	-2.45	-63.94	0.00	-0.45	-0.18
203	15	14	24.63	8.46	3.58	4.88	0.00	1.00	0.00	70.79	-2.45	-63.90	0.00	-0.44	-0.18

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-C	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY) F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
204	16	1	24.63	8.46	3.73	4.72	0.00	1.00	0.00	94.93	-2.45	-105.13	0.00	-0.44	-0.17
205	16	2	24.63	8.46	3.89	4.56	0.00	1.00	0.00	117.15	-2.45	-105.05	0.00	-0.44	-0.17
206	16	3	24.63	8.46	3.99	4.47	0.00	1.00	0.00	114.77	-2.45	-104.98	0.00	-0.43	-0.17
207	16	4	24.63	8.46	4.04	4.42	0.00	1.00	0.00	113.38	-2.46	-104.91	0.00	-0.43	-0.17
208	16	5	24.63	8.46	4.07	4.38	0.00	1.00	0.00	112.57	-2.46	-104.83	0.00	-0.43	-0.17
209	16	6	24.63	8.46	4.09	4.37	0.00	1.00	0.00	112.07	-2.46	-104.76	0.00	-0.43	-0.17
210	16	7	24.63	8.46	4.10	4.35	0.00	1.00	0.00	111.76	-2.47	-104.68	0.00	-0.43	-0.17
211	16	8	24.63	8.46	4.11	4.35	0.00	1.00	0.00	111.55	-2.47	-104.61	0.00	-0.42	-0.17
212	16	9	24.63	8.46	4.12	4.34	0.00	1.00	0.00	111.40	-2.47	-104.53	0.00	-0.42	-0.17
213	16	10	24.63	8.46	4.12	4.33	0.00	1.00	0.00	111.28	-2.47	-104.46	0.00	-0.42	-0.16
214	16	11	24.63	8.46	4.13	4.33	0.00	1.00	0.00	111.18	-2.48	-104.38	0.00	-0.42	-0.16
215	16	12	24.63	8.46	4.13	4.33	0.00	1.00	0.00	111.09	-2.48	-104.31	0.00	-0.42	-0.16
216	16	13	24.63	8.46	4.13	4.32	0.00	1.00	0.00	111.01	-2.48	-104.24	0.00	-0.42	-0.16
217	16	14	24.63	8.46	4.14	4.32	0.00	1.00	0.00	110.94	-2.48	-104.16	0.00	-0.41	-0.16
218	16	15	24.63	8.46	4.14	4.32	0.00	1.00	0.00	110.86	-2.49	-104.09	0.00	-0.41	-0.16

219	16	16	24.63	8.46	4.14	4.32	0.00	1.00	0.00	110.79	-2.49	-104.02	0.00	-0.41	-0.16
220	16	17	24.63	8.46	4.14	4.31	0.00	1.00	0.00	110.71	-2.49	-103.94	0.00	-0.41	-0.16
221	16	18	24.63	8.46	4.15	4.31	0.00	1.00	0.00	110.64	-2.49	-103.87	0.00	-0.41	-0.16
222	16	19	24.63	8.46	4.15	4.31	0.00	1.00	0.00	110.57	-2.50	-103.80	0.00	-0.40	-0.16
223	16	20	24.63	8.46	4.15	4.30	0.00	1.00	0.00	110.48	-2.50	-103.73	0.00	-0.40	-0.16
224	17	1	24.63	8.46	4.61	3.85	0.00	1.00	0.00	70.93	-2.49	-47.67	0.00	-0.40	-0.15
225	17	2	24.63	8.46	4.35	4.10	0.00	1.00	0.00	45.80	-2.49	-47.64	0.00	-0.40	-0.15
226	17	3	24.63	8.46	4.17	4.29	0.00	1.00	0.00	47.84	-2.48	-47.60	0.00	-0.40	-0.15
227	17	4	24.63	8.46	4.04	4.42	0.00	1.00	0.00	49.32	-2.48	-47.57	0.00	-0.40	-0.15
228	17	5	24.63	8.46	3.94	4.52	0.00	1.00	0.00	50.39	-2.47	-47.54	0.00	-0.39	-0.15
229	17	6	24.63	8.46	3.87	4.58	0.00	1.00	0.00	51.16	-2.46	-47.50	0.00	-0.39	-0.15
230	17	7	24.63	8.46	3.82	4.63	0.00	1.00	0.00	51.71	-2.46	-47.47	0.00	-0.39	-0.15
231	17	8	24.63	8.46	3.79	4.67	0.00	1.00	0.00	52.10	-2.45	-47.44	0.00	-0.39	-0.15
232	17	9	24.63	8.46	3.76	4.69	0.00	1.00	0.00	52.37	-2.45	-47.41	0.00	-0.39	-0.15
233	17	10	24.63	8.46	3.75	4.71	0.00	1.00	0.00	52.56	-2.44	-47.37	0.00	-0.38	-0.15
234	17	11	24.63	8.46	3.74	4.72	0.00	1.00	0.00	52.69	-2.44	-47.34	0.00	-0.38	-0.15
235	17	12	24.63	8.46	3.73	4.73	0.00	1.00	0.00	52.77	-2.43	-47.31	0.00	-0.38	-0.14
236	17	13	24.63	8.46	3.73	4.73	0.00	1.00	0.00	52.82	-2.43	-47.27	0.00	-0.38	-0.14
237	17	14	24.63	8.46	3.72	4.73	0.00	1.00	0.00	52.84	-2.42	-47.24	0.00	-0.38	-0.14
238	17	15	24.63	8.46	3.72	4.73	0.00	1.00	0.00	52.85	-2.41	-47.21	0.00	-0.38	-0.14
239	17	16	24.63	8.46	3.72	4.73	0.00	1.00	0.00	52.84	-2.41	-47.18	0.00	-0.38	-0.14
240	17	17	24.63	8.46	3.72	4.73	0.00	1.00	0.00	52.82	-2.40	-47.14	0.00	-0.37	-0.14
241	17	18	24.63	8.46	3.73	4.73	0.00	1.00	0.00	52.80	-2.40	-47.11	0.00	-0.37	-0.14
242	17	19	24.63	8.46	3.73	4.73	0.00	1.00	0.00	52.77	-2.39	-47.08	0.00	-0.37	-0.14
243	17	20	24.63	8.46	3.73	4.72	0.00	1.00	0.00	52.73	-2.39	-47.05	0.00	-0.37	-0.14
244	18	1	24.63	8.46	3.82	4.64	0.00	1.00	0.00	64.70	-2.38	-59.30	0.00	-0.37	-0.14
245	18	2	24.63	8.46	4.07	4.39	0.00	1.00	0.00	73.43	-2.38	-59.26	0.00	-0.37	-0.14

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

** DISSOLVED OXYGEN DATA **

									COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)						
ELE ORD	RCH NUM	ELE NUM	TEMP DEG-C	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
246	18	3	24.63	8.46	4.24	4.22	0.00	1.00	0.00	70.60	-2.37	-59.22	0.00	-0.37	-0.14
247	18	4	24.63	8.46	4.35	4.10	0.00	1.00	0.00	68.70	-2.37	-59.18	0.00	-0.36	-0.14
248	18	5	24.63	8.46	4.43	4.03	0.00	1.00	0.00	67.41	-2.37	-59.14	0.00	-0.36	-0.14
249	18	6	24.63	8.46	4.48	3.97	0.00	1.00	0.00	66.52	-2.36	-59.10	0.00	-0.36	-0.13
250	18	7	24.63	8.46	4.52	3.94	0.00	1.00	0.00	65.92	-2.36	-59.06	0.00	-0.36	-0.13
251	18	8	24.63	8.46	4.54	3.91	0.00	1.00	0.00	65.50	-2.35	-59.02	0.00	-0.36	-0.13
252	18	9	24.63	8.46	4.56	3.89	0.00	1.00	0.00	65.21	-2.35	-58.98	0.00	-0.36	-0.13
253	18	10	24.63	8.46	4.58	3.88	0.00	1.00	0.00	64.99	-2.34	-58.94	0.00	-0.36	-0.13
254	18	11	24.63	8.46	4.58	3.87	0.00	1.00	0.00	64.83	-2.34	-58.90	0.00	-0.36	-0.13
255	18	12	24.63	8.46	4.59	3.87	0.00	1.00	0.00	64.71	-2.34	-58.86	0.00	-0.35	-0.13
256	18	13	24.63	8.46	4.60	3.86	0.00	1.00	0.00	64.61	-2.33	-58.82	0.00	-0.35	-0.13
257	18	14	24.63	8.46	4.60	3.85	0.00	1.00	0.00	64.53	-2.33	-58.78	0.00	-0.35	-0.13
258	18	15	24.63	8.46	4.61	3.85	0.00	1.00	0.00	64.46	-2.32	-58.74	0.00	-0.35	-0.13
259	18	16	24.63	8.46	4.61	3.85	0.00	1.00	0.00	64.40	-2.32	-58.70	0.00	-0.35	-0.13
260	18	17	24.63	8.46	4.61	3.84	0.00	1.00	0.00	64.34	-2.32	-58.66	0.00	-0.35	-0.13
261	18	18	24.63	8.46	4.62	3.84	0.00	1.00	0.00	64.29	-2.31	-58.62	0.00	-0.35	-0.13
262	18	19	24.63	8.46	4.62	3.84	0.00	1.00	0.00	64.22	-2.31	-58.58	0.00	-0.35	-0.13

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APPENDIX C – RESPONSIVENESS SUMMARY

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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 East 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 East Fork Kaskaskia River watershed, which originates in Fayette county and flows west into Marion and Clinton counties. The watershed encompasses an area of approximately 128.5 square miles. Land use in the watershed is predominately agriculture. East Fork Kaskaskia River segment OK-01 is 17.13 miles in length and is on the *Illinois Integrated Water Quality Report and Section 303(d) List*-2006 as being impaired for low dissolved oxygen, total fecal coliform, and total phosphorus. East Fork Kaskaskia River segment OK-02 is 16.81 miles in length and is on the 2006 Section 303(d) List as being impaired for 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. Baetis Environmental Services, Inc. was subcontracted by Limno-Tech, Inc. to prepare the TMDL report.

Public Meetings

Public meetings were held in the Village of Patoka on March 17, 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 Kinmundy 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.

Illinois
Environmental
Protection Agency

Implementation Plan
TMDLs for Target Watersheds

Project Watershed HUC 0714020205 (East Fork Kaskaskia River)
Stream Segment IL_OK-01

Prepared by

Baetis
ENVIRONMENTAL SERVICES, INC.
Chicago, Illinois

On behalf of Limno-Tech, Inc., Ann Arbor, Michigan
March 2007

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TMDL IMPLEMENTATION PLAN
EAST FORK KASKASKIA RIVER (IL_OK-01)

SUMMARY

In September 2006, a Total Maximum Daily Load (TMDL) was approved for the East Fork Kaskaskia River in Marion, Clinton and Fayette Counties. The TMDL required significant reductions in fecal coliform bacteria loads to stream segment IL_OK-01. This report identifies and evaluates alternative actions for implementing the TMDL.

TMDL IMPLEMENTATION ALTERNATIVES

Alternative	Capital Costs	Comments
Conservation Buffers	$200 - $500/acre	Also recommended in siltation TMDL Implementation Plan. May also aid DO concentrations.
On-Site Sewage Disposal System Inspection and Maintenance Program	Variable	Low cost if existing staff implemented inspection program for older systems; longer-term record keeping encouraged.
Restricting Livestock Access	Fencing: $3,500 to $4,000/mile Pipeline watering: $0.32 - $2.60/ft Watering tanks & troughs: $291 to $1,625 each	Large areas of livestock access to stream have not been documented.
Wetland Restoration	$500 to $1200/acre	Also effective against field erosion and will contribute to siltation TMDL objectives.
Point Source Controls	Moderate capital and annual costs	Seasonal disinfection, possibly limited to low flow periods.

The information is directed to key local stakeholders for their discussion and action. Reductions in pollutant loadings will be based on this non-regulatory incentive-based Implementation Plan.

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1. INTRODUCTION

The State of Illinois assesses its water bodies for compliance with water quality standards established to protect their designated uses. This assessment is required by the federal Clean Water Act. Section 303(d) of the Clean Water Act requires states to identify waters which will not attain applicable water quality standards with technology-based controls alone. Water bodies so identified are placed on a 303(d) list and prioritized to have a Total Maximum Daily Load (TMDL) developed. The TMDL is specific to the water quality constituent(s) that is in violation of the water quality standard. 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 in-stream or in-lake water quality conditions. This allows water quality-based controls to be developed to reduce pollution and to restore and maintain water quality.

The lower segment of the East Fork Kaskaskia River has been identified as being water quality limited and is on Illinois' 303(d) list. Stream segment IL_OK-01 is impaired by siltation, fecal coliform bacteria, and dissolved oxygen (DO) deficits; stream segment IL_OK-02 is impaired by DO deficits. A TMDL for the DO and fecal coliform bacteria impairments was approved by the US EPA in September 2006 (Baetis 2006). The US EPA approval letter accepted the report's conclusion that the DO impairments were attributed to low flow conditions rather than a specific pollutant, and as such, a TMDL was not required for DO for segments IL_OK-01 or IL_OK-02. This report recommends approaches to implementing the fecal coliform bacteria TMDL in segment IL_OK-01. The siltation TMDL and implementation plan was published in 2003 (Harza 2003).

The next step in the TMDL process is to develop an implementation plan for the TMDL that includes both accountability and the potential for adaptive management. Best Management Practices for nonpoint sources will strictly be voluntary. Adaptive management involves 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.

1.1 Stream and Watershed Descriptions

The East Fork Kaskaskia Watershed (Hydrologic Unit Code, or HUC, 0714020205) is 82,254 acres (33,288 ha) in area. The watershed is largely agricultural, with extensive soybean and corn production on its fertile glacial till soils. The watershed is described in detail in the TMDL report (Baetis 2006).

The East Fork Kaskaskia River is part of HUC 0714020205. This HUC also includes the North Fork Kaskaskia River. This targeted watershed was divided for TMDL development and this Implementation Plan addresses the East Fork Kaskaskia River watershed. The East Fork Kaskaskia River includes six subwatersheds: 071402020503, 071402020504, 071402020505, 071402020506, 071402020507, and 071402020508 (Figure 1).

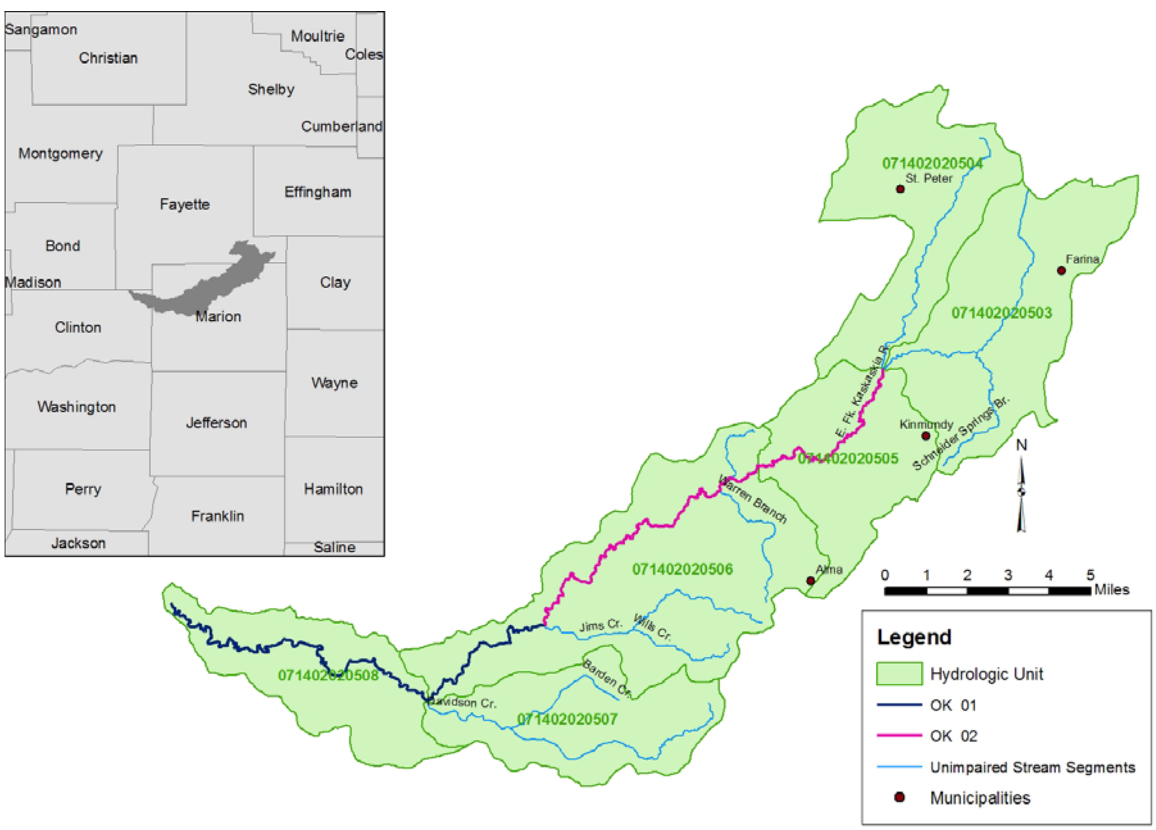

Figure 1. Location Map, Subwatersheds, and Impaired Stream Segments

The watershed is largely used for corn and soybean production, with about 69% of the land overall used for agriculture (Harza 2003). Figure 2 is a map of current land cover / land use in the project watershed. The land cover map also shows point source discharges, impaired waterbody segments, monitoring sites, and other watershed characteristics.

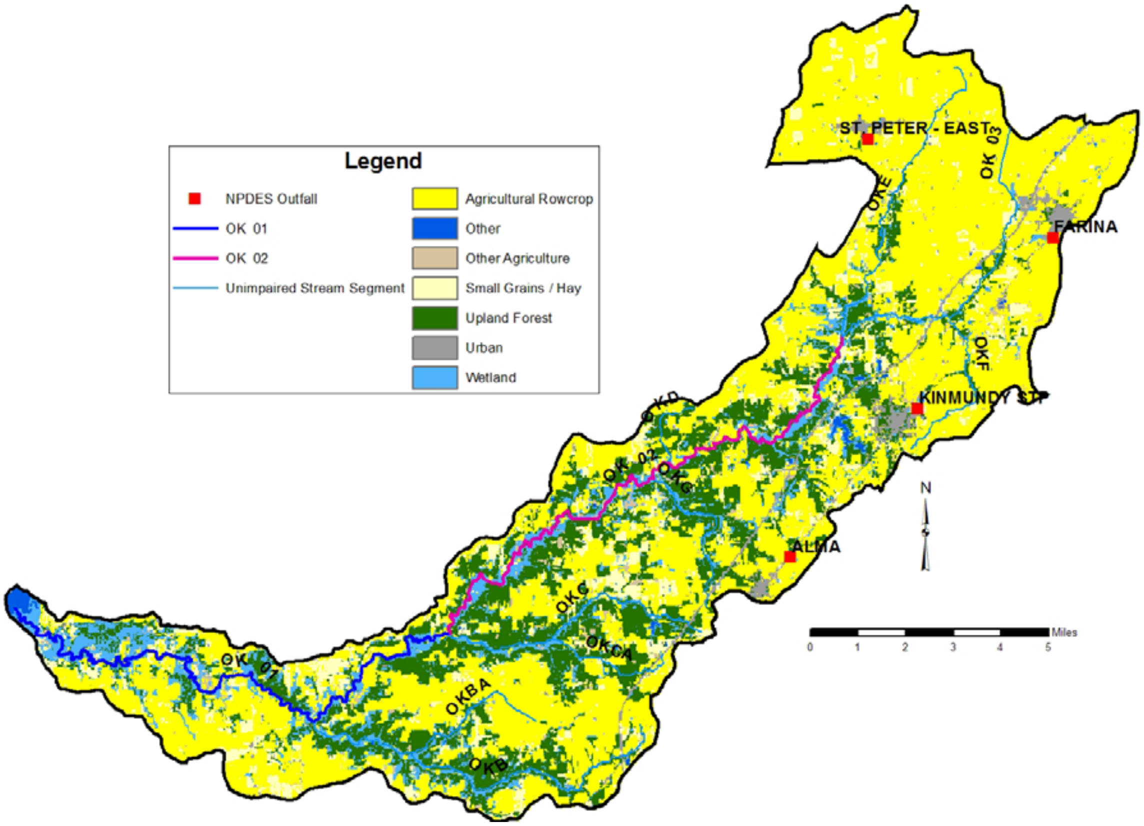

Figure 2. Point Source Discharges, IEPA Monitoring Stations, and Land Use/Land Cover Map

1.2 Water Quality Standard

The impaired designated use for the stream is primary contact. This designated use, as stated in Title 35 of the Illinois Administrative Code, is established to protect waters for swimming and wading where the physical configuration permits these activities. The standard for fecal coliform bacteria is based upon an assumed warm-weather swimming season. During the months May through October, based on a minimum of five samples taken over not more than a 30 day period, fecal coliform are not to exceed a geometric mean of 200 colonies/100 mL, nor shall more than 10% of the samples during any 30-day period exceed 400 colonies/100 mL in protected waters. The water quality target for pathogens is 200 fecal coliform colonies per 100 mL for 100% of the time between May and October.

1.3 TMDL Summary

The fecal coliform bacteria TMDL for the East Fork Kaskaskia River was developed from a load duration analysis (Figure 3). The analysis found that the primary contact use standard is exceeded across the entire range of flows, but principally during wet periods. This implies that both dry weather bacteria sources (such as wastewater treatment plants or instream wildlife) and wet weather bacteria sources such as storm runoff are contributing to the use impairment. The likelihood of water quality impairment is highest under high and mid-range flows. The increased fecal coliform load is therefore likely the result of pollutant delivery associated with rainfall and runoff.

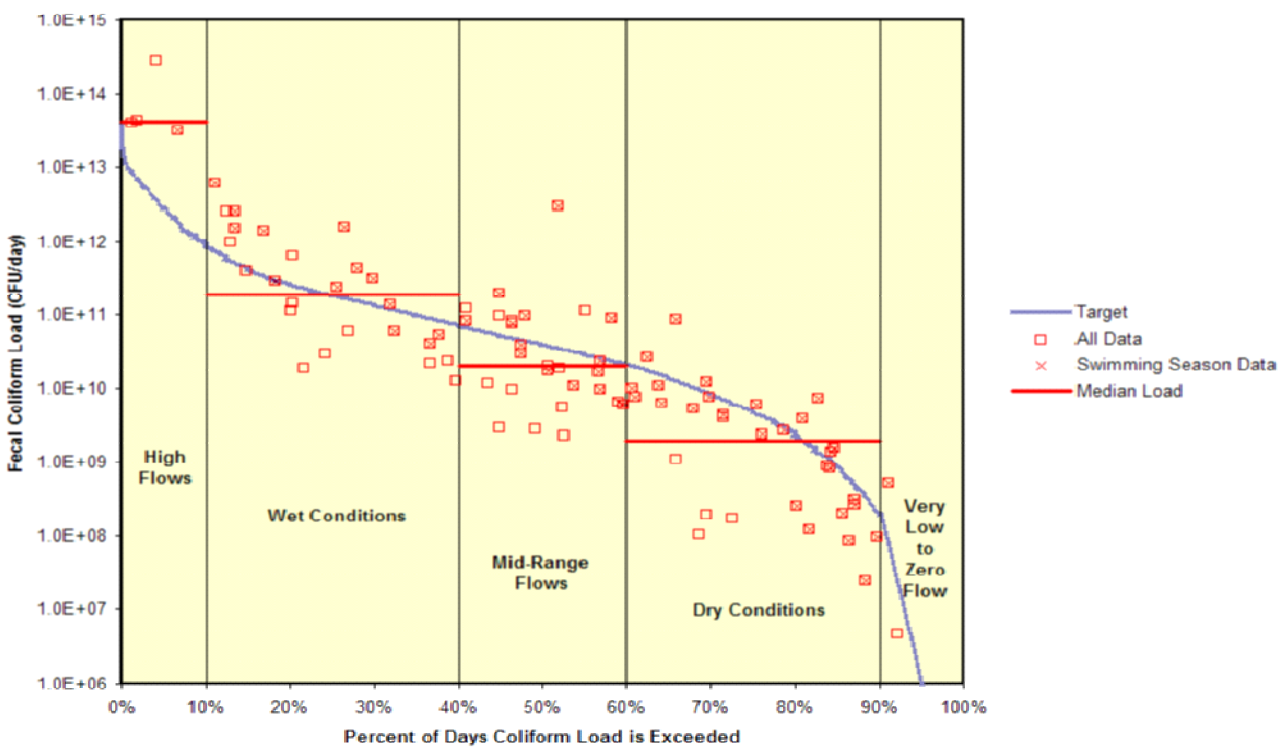

Figure 3. Fecal Coliform Bacteria Load Duration Curve

The four wastewater treatment plants in the watershed define the wasteload allocation (WLA) for the TMDL. The WWTPs have been issued effluent disinfection exemptions by the Illinois EPA. The WLA is based upon each WWTP meeting the water quality target at the downstream end of their disinfection exemption reach.

Table 1 summarizes the TMDL across five flow interval categories. Between 1990 and 2005, the maximum load observed during the swimming season ranged from 5×10^8 to 3×10^{14} CFU/day. The load capacity for the watershed is a product of the water quality target and discharge. The difference between the load capacity and the historic maximum load is defined here as the required pollutant load reductions, which range from 84% to 99%, depending on the flow interval. Also, given that the stream has no flow during most of the lowest flow interval (90th to 100th percentile), no TMDL or load reductions are required for this interval.

Table 1

MAXIMUM LOADS, LOAD CAPACITY, REDUCTIONS AND ALLOCATIONS

	High Flows	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**
Historic Maximum (CFU/day)	300,000 billion	6,000 billion	6,000 billion	80 billion
Load Capacity (CFU/day)	6,000 billion	70,000 billion	40 billion	10 billion
Required Reduction (%)	99%	88%	99%	84%
WLA (CFU/day)	3 billion	3 billion	3 billion	3 billion
LA (CFU/day)	3,000 billion	70,000 billion	40 billion	10 billion

1.4 Implementation Plan Approach

Our approach to TMDL implementation planning is based upon prior discussions with Illinois EPA and its TMDL Scientific Advisory Committee. The approach generally consists of an implementation plan that is based on voluntary actions for nonpoint sources, accountability and, where necessary, the flexibility for adaptive management. 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.

Also, the adaptive management approach recognizes that models used for decision-making are approximations and all TMDLs have uncertainties. 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.

2. EXISTING CONTROLS

2.1 Point Source Controls

The villages of Alma, Farina, Kinmundy and St. Peter have sewage collection, treatment and disposal systems. Homes and businesses outside of these municipalities have on-site systems for wastewater management, typically septic tanks and soil absorption systems. Some newer sites are installing aeration units. The four wastewater treatment plants have NPDES permits specifying effluent limits. Under existing regulatory controls, none of the wastewater treatment plants chlorinate their effluent to disinfect it prior to discharge (Baetis 2006b).

2.2 On-Site Sewage Systems

The health departments in Clinton, Fayette and Marion Counties were contacted for information on existing best management practices for on-site systems. Each county permits new systems, and typically inspects it during construction. Follow-up inspections are not performed in any of the three counties unless a specific complaint is received, or, upon request during a property ownership transfer (e.g. one or two per year in Fayette County). Records of new systems are only kept for a few years in each county.

2.3 Agriculture Programs

USDA/NRCS programs provide incentives to farmers and landowners for implementing conservation practices. These programs include the Conservation Reserve Program, the Conservation Reserve Enhancement Program, the Wetlands Incentive Program, the Wildlife Habitat Incentive Program, the Environmental Quality Incentive Program, and the Wetland Quality Incentive Program. These programs are described later in this plan, but specific information on the extent to which they have been utilized in the East Fork Kaskaskia watershed is not available. 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.

In 2005, the Illinois Department of Agriculture conducted an "aerial assessment" of the East Fork Kaskaskia from Farina downstream to Lake Carlyle (IDOA, 2005). The assessment involved collection of aerial-based digital video of main stream channel conditions to identify stream bed and bank erosion control needs. The report recommended bank stabilization and rock riffle grade control measures throughout the watershed. The rock riffle grade control structures would not only stabilize the streambed and reduce erosion, but increase turbulence to improve dissolved oxygen concentrations. It is not known if any of the recommended work has been completed. Review of the video revealed at least three locations in the upper and middle of the watershed where livestock access to the main stream is uncontrolled; tributaries were not videoed during the survey.

3. ALTERNATIVES FOR TMDL IMPLEMENTATION

Based on the TMDL, information obtained at the public meetings, the scientific literature and case studies from experiences in other watersheds, a number of alternatives have been identified for the implementation of these TMDLs. These alternatives are focused on those sources suspected of contributing fecal coliform bacteria to the stream. Watershed reconnaissance and discussions with local extension agents indicate that numerous agricultural BMPs, including livestock fencing, water and sediment control systems, and manure management have been implemented in this watershed, but there is no detailed, publicly-available inventory of BMPs.

Implementation alternatives are focused on one or more the following suspected source categories:

- Runoff from pastureland and animal feeding operations
- Failing private sewage disposal systems (septic and surface discharge systems)
- Municipal point sources

Alternatives to reduce coliform loads from wildlife sources are not recommended at this time. Watershed alternatives to address these above-bulleted sources are:

- Conservation Buffers
- Private Sewage Disposal System Inspection and Maintenance Program
- Restriction of Livestock Access
- Wetland Restoration
- Point Source Controls

Each of these alternatives is described briefly below, including information about their costs and effectiveness in reducing coliform bacteria loadings to streams.

3.1 Conservation Buffers

Conservation buffers are strips of land in permanent native vegetation that help control pollutants (NRCS 1999). Ancillary benefits include fish and wildlife habitat. Filter strips, riparian buffers, grassed waterways, contour strips are all examples of conservation buffers.

Vegetated filter strips and riparian buffers can reduce bacteria in runoff under wet hydrologic conditions; riparian buffer zones have excellent bacteria removal efficiencies for manure applied to uplands (Tate *et al.* 2006). Buffers have also been recommended as a component in the siltation TMDL Implementation Plan for the East Fork Kaskaskia River Watershed (Harza 2003). All types of conservation buffers are voluntarily implemented.

Lastly, riparian buffers can work to improve instream dissolved oxygen concentrations by promoting increased infiltration and baseflow, and lowering stream temperature.

3.2 Private Sewage Disposal System Inspection and Maintenance Program

Four municipal-owned wastewater treatment plants are in the watershed: Farina, Kinmundy, Alma and St. Peter. Outside of these towns, residences and businesses utilize private on-site systems, typically septic tanks and leach fields. A more proactive program to keep better records, maintain functioning systems, and address nonfunctioning systems could be developed to minimize the potential for releases from private sewage disposal systems. The U.S. EPA has developed guidance for managing private sewage disposal systems (EPA 2005). This guidance includes procedures for assessing existing conditions, assessing public health and environmental risks, selecting a management approach, and implementing a management program (including funding information). This alternative would require the commitment of staff time for county health department personnel; cost depends on whether the additional inspection activities could be accomplished by existing staff or would require additional personnel. Costs for annual maintenance agreements have been estimated at $200/year per household (IEPA 2006).

Operation and maintenance for most on-site systems includes some user awareness of inputs that might impact treatment processes, such as strong cleaners, lye, acids, biocides, paint wastes, oil and grease, etc. Gravity-flow soil-infiltration systems require little maintenance beyond limiting inputs to normal residential wastes, cleaning effluent screens/filters, and periodic (e.g. every three to seven years) tank pumping. Systems employing advanced treatment technologies and electromechanical components require more intensive attention, such as checking switches and pumps, measuring and managing sludge levels, monitoring and adjusting treatment process and system timers, and checking effluent filters. Operators, inspectors, and service technicians should be trained and certified for the types of systems they will be servicing; services should be logged and reported to the county health department so that long-term performance can be tracked.

In January 2007, public hearings were hosted by the Illinois EPA for a proposed general (statewide) NPDES permit for individual surface-discharging private sewage disposal systems. The intent of this new permitting program is to ensure that effluent discharge from private sewage disposal systems to waters of the state comply with water quality standards. If promulgated as originally conceived, the general permit program would improve the performance of on-site wastewater treatment systems that discharge to surface waters and the quality of the receiving waters (under all flow conditions, but most effectively during low flows).

3.3 Restricting Livestock Access

There are livestock operations in Clinton, Fayette, and Marion Counties, but earlier evaluations did not indicate large numbers of livestock in the targeted watershed (Baetis 2006b). Review of the Illinois Department of Agriculture's low-altitude video of the stream (IDOA 2005) revealed three locations along the mainstem where cattle access to the stream is not controlled; there may be additional locations along tributaries, but these areas were not videoed during the survey.

Livestock are a potential source of fecal coliform bacteria and other pollutants of the stream. In addition, livestock can cause or exacerbate streambank erosion and trample riparian buffers. The East Fork Kaskaskia River had a siltation TMDL and implementation plan prepared earlier (Harza 2003). One potential component of TMDL implementation could be to restrict livestock access to the East Fork Kaskaskia River and its tributaries. Restricting livestock access would reduce coliform loads during all flow conditions, but most effectively improve water quality under low flows. This would be voluntary, and involve fencing and installation of alternative systems for livestock watering. The principal direct costs of providing grazing practices vary from relatively low variable costs of dispersed salt blocks to higher capital and maintenance costs of supplementary water supply improvements. Improving the distribution of grazing pressure by developing a planned grazing system or strategically locating water troughs, salt, or feeding areas to draw cattle away from riparian zones can result in improved utilization of existing forage, better water quality, and improved riparian habitat. Fencing costs are estimated as $3,500 to $4,000 per mile (USEPA 2003). Capital costs for pipeline watering range from $0.32 to $2.60 per foot, while watering tanks and troughs range from $291 to $1,625 each (EPA 2003).

3.4 Wetland Restoration

Wetland restoration involves the rehabilitation of a drained or degraded wetland to its natural condition, including its vegetation, soils and hydrology. Wetland restoration can be an effective BMP for reducing loading of bacteria, sediments, nutrients, and oxygen-demanding substances (Johnston *et al*. 1990). Wetlands reduce coliform bacteria concentrations in accordance with first-order decay kinetics (Struck *et al.* 2006).

Currently there are hundreds of acres of hydric soils in the East Fork Kaskaskia River watershed that are not developed, forested or already have wetland hydrology and vegetation. These are potential areas where wetlands could be restored.

A wetland restoration project may be as simple as breaking drain tiles and blocking drain ditches, or it may require more engineering effort to restore hydrology and hydric vegetation communities. In addition to improving water quality, wetland restoration provides additional benefits for flood control, habitat, and recreation.

Costs for wetland restoration vary widely, depending on the acreage, the nature of the work, and land/easement costs. However, a general unit cost of $500 to $1,200 per acre has been suggested (FWS 2006) for simple restoration projects in Illinois.

3.5 Point Source Controls

There are four municipally-owned NPDES permitted point source dischargers in the watershed (Table 2). All have year-round effluent disinfection exemptions, and are not required to remove fecal coliform bacteria from their discharges. The specific stream reaches subject to the disinfection exemptions are shown in Figure 4. IEPA will examine effluent disinfection exemptions as permit renewal periods arise. 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 2

WASTEWATER TREATMENT FACILITY INFORMATION

Facility	Permit No.	Design Average Flow	Design Maximum Flow	Permit Expiration Date
St. Peter	IL0030945	0.042 MGD	0.105 MGD	Dec. 31, 2007
Kinmundy	IL0023124	0.120 MGD	0.300 MGD	Dec. 31, 2007
Farina	IL0028771	0.105 MGD	0.262 MGD	Dec. 31, 2007
Alma	IL0076422	0.050 MGD	0.199 MGD	June 30, 2011

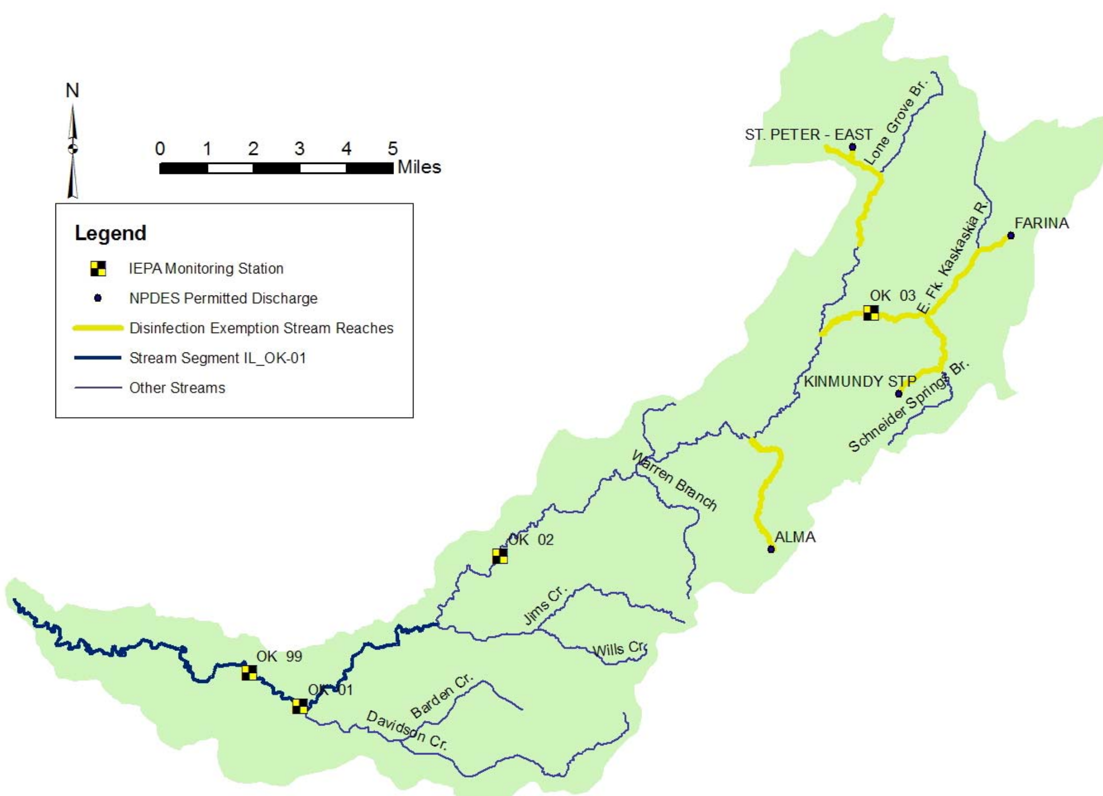

Figure 4. Point Sources and Disinfection Exemption Reaches

3.6 Summary of Alternatives

We identified and evaluated five viable TMDL implementation alternatives (Table 3).

Table 3

SUMMARY OF TMDL IMPLEMENTATION ALTERNATIVES

Alternative	Capital Costs	Comments
Conservation Buffers	$200 - $500/acre	Also recommended in siltation TMDL Implementation Plan
On-Site Sewage Disposal System Inspection and Maintenance Program	Variable	Low cost if existing staff implemented inspection program for older systems; longer-term record keeping encouraged
Restricting Livestock Access	Fencing: $3,500 to $4,000/mile Pipeline watering: $0.32 - $2.60/ft Watering tanks & troughs: $291 to $1,625 each	Large areas of livestock access to stream have not been documented
Wetland Restoration	$500 to $1200/acre	Also effective against field erosion and will contribute to siltation TMDL objectives
Point Source Controls	Moderate capital and annual costs	Seasonal disinfection

4. IDENTIFYING PRIORITY AREAS FOR CONTROLS

Preliminary identification of priority areas for siting 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 and estimate costs. Information reviewed for this preliminary evaluation included the 2003 Siltation TMDL Implementation Plan, tributary water quality data, an aerial video and assessment report, and GIS-based watershed data. Based on this review, it is recommended that alternatives for fecal coliform load reductions be coordinated with the silt load reduction activities for cost effectiveness. This may include streambank stabilization to reduce identified areas of severe bank erosion. Streambank work should 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.

4.1 Tributary Monitoring

Water quality data obtained during Stage 2 of this TMDL development effort were reviewed. Fecal coliform bacteria are regularly measured at the US Hwy 51 bridge (AWQMN station OK 01) by the Agency. A surrogate measure of fecal coliform bacteria, *Escherichia coli*, were measured at numerous locations in the watershed during the 2005 Stage 2 monitoring activities as part of source identification efforts (Table 4, Figure 5). The data in Table 4 were collected during periods of low stream flows. Stage 2 originally included plans for also sampling during wet weather, but the extended drought in central Illinois in 2005 prevented those data from being collected.

Table 4

ESCHERICHIA COLI CONCENTRATIONS MEASURED DURING STAGE 2

TMDL ID	IEPA Station	Name	SEGID	Date / Time	Discharge (cfs)	E coli (/100mL)
B OK 01	OK 01	East Fork Kaskaskia River	OK 01	5/25/05 13:00	0.50	21
B OK 01	OK 01	East Fork Kaskaskia River	OK 01	5/31/05 14:00	0.23	150
B OK 01	OK 01	East Fork Kaskaskia River	OK 01	6/8/05 14:00	0.16	52
B OK 01	OK 01	East Fork Kaskaskia River	OK 01	6/15/05 13:50	0.62	176
B OK 01	OK 01	East Fork Kaskaskia River	OK 01	6/22/05 14:00	1.0	240
B OK 01	OK 01	East Fork Kaskaskia River	OK 01	8/22/05 9:10	0.28	114
B OK 01	OK 01	East Fork Kaskaskia River	OK 01	8/23/05 13:40	0.15	55
B OK 01	OK 01	East Fork Kaskaskia River	OK 01	8/24/05 13:20	0.31	25
B OK 02	OK 02	East Fork Kaskaskia River	OK 02	8/22/05 11:45		70
B OK 13		East Fork Kaskaskia River	OK 02	8/22/05 12:30		55
B OK 03	OK 03	East Fork Kaskaskia River	OK 03	8/22/05 13:15		117
B OKEZ 11		unnamed tributary 5		8/23/05 8:00		263
B OKEZ 11		unnamed tributary 5		8/24/05 11:15	0.01	82
B OKFZ 11		unnamed tributary 6		8/23/05 12:30	0.04	649
B OKF 11		Schneider Springs Branch	OKF	8/23/05 12:00		613
B OK 16		East Fork Kaskaskia River	OK 03	8/24/05 9:30	0.27	131
B OKZ 41		unnamed tributary 8		8/23/05 10:00	0.4	108

These data indicate that, at least when the stream is effluent dominated as it was during the dry weather of 2005, the wastewater treatment plants are important sources of coliform bacteria. Specific data collection recommendations are provided in the Monitoring and Adaptive Management Section later in this Implementation Plan.

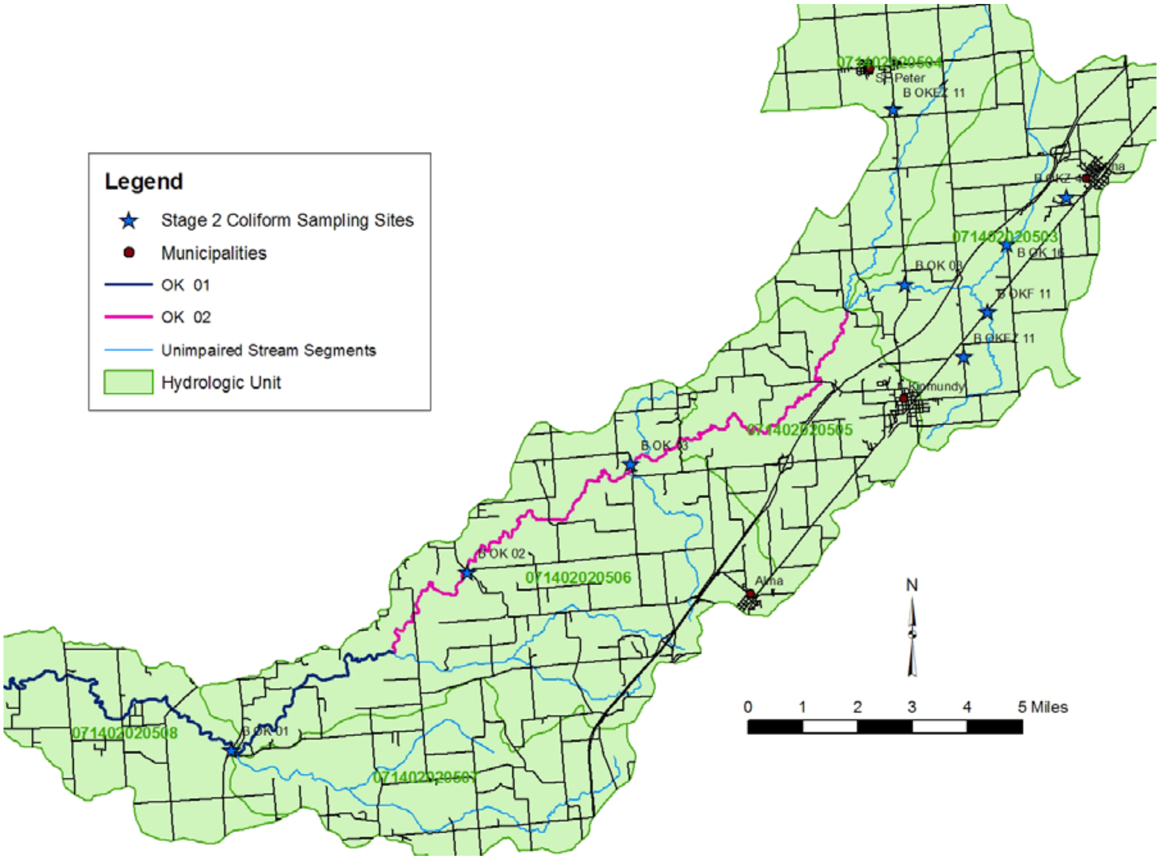

Figure 5. Stage 2 Sample Locations

4.2 Aerial Video and Assessment Report

A 2005 report (IDOA 2005) examined streambank conditions along the mainstem of the East Fork Kaskaskia River and identified locations of severe stream bed and bank erosion. The report did not provide recommendations for coliform load reductions, but the accompanying video documented riparian conditions along the entire length of the mainstem. Three locations of uncontrolled livestock access to the stream in the upper watershed were identified in the video; these were generally areas of barren, well-trodden banks adjacent to pastures. Additional problem areas may exist along tributaries.

4.3 GIS Analysis

GIS soils and land use themes were examined 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. Large areas of the watershed (nearly 14,000 acres) were identified as being potentially suitable for wetland restoration (Figure 6). The analysis was limited to Marion and Clinton Counties, as the requisite hydric soils data were not available for Fayette County. Eligibility of individual fields for funding under the NRCS's Wetland Reserve Program has not been investigated.

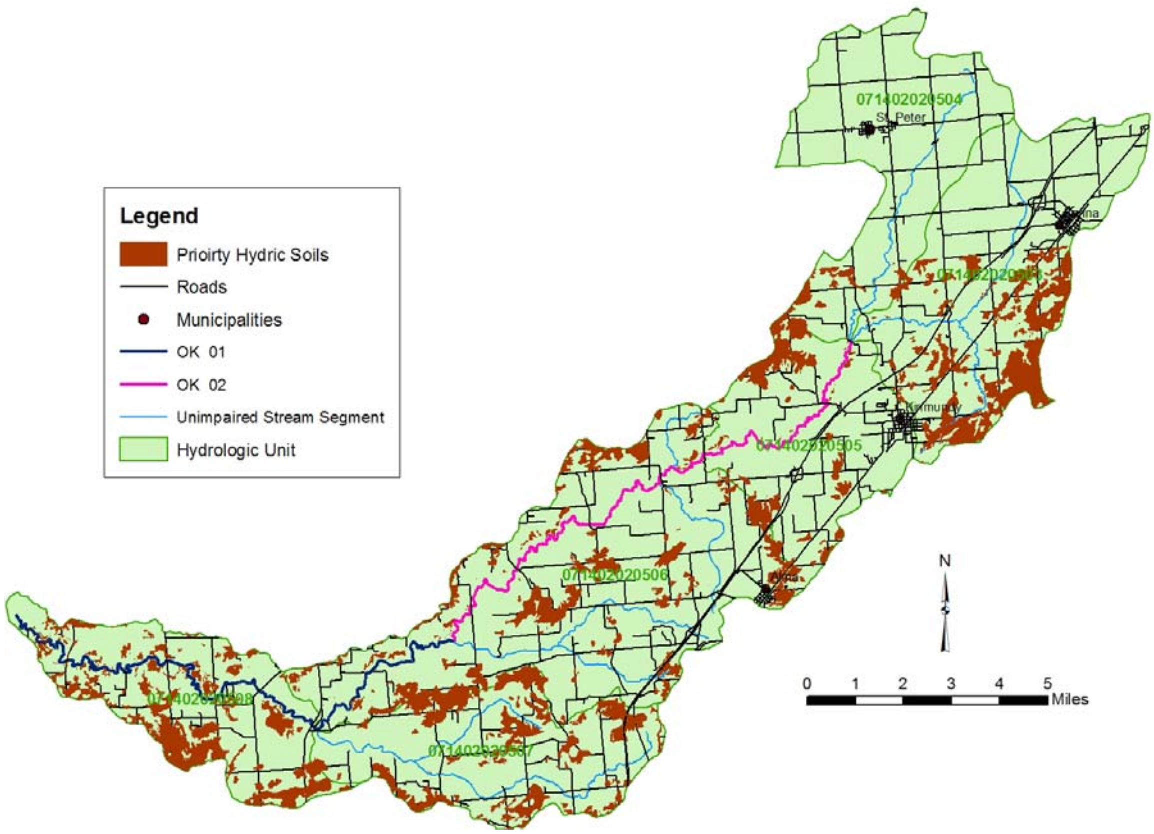

Figure 6. Priority Areas for Wetland Restoration

5. REASONABLE ASSURANCE

Reasonable assurances provide a level of confidence that the waste load allocations and load allocations in TMDLs will be implemented by Federal, State, or local authorities and/or by voluntary action. Reasonable assurance for reductions in nonpoint source loadings may be non-regulatory or incentive-based, and consistent with applicable laws and regulations. Non-enforceable, voluntary nonpoint source control assurances include:

- Demonstration of adequate funding,
- Process by which agreements/arrangements between appropriate parties (e.g. IEPA, NRCS, SWCDs, private landowners) will be reached,
- Using the results of future monitoring to conduct adaptive management,
- Assessment of the future of government programs which contribute to implementation actions, and
- Demonstration of anticipated effectiveness of the actions.

Principal among these assurances are funding and institutional programs. Detailed descriptions are provided below.

5.1 Clean Water Act Section 319 Grants

Section 319 of the Clean Water Act is specific to nonpoint sources of water pollution. Under Section 319, States may reallocate federal funds through grants to public and private entities, including local governments and watershed stakeholder groups. Section 319 funding is being used across the nation to implement TMDLs. Siltation, manganese, and fecal coliform TMDLs approved thus far for the East Fork Kaskaskia River watershed are eligible for Section 319 grant funding. A successful proposal would generally require a 40% local cost share. Further information is available at http://www.epa.state.il.us/water/financial-assistance/non-point.html.

Illinois' 319 Program funds a Watershed Liaison through the Illinois Association of Soil and Water Conservation Districts. The Watershed Liaison assists the Illinois EPA in implementing Illinois' Nonpoint Source Management Program. The Liaison provides educational, informational and technical assistance to Soil and Water Conservation Districts (SWCDs), agricultural producers and other interested parties to help them better understand programs implemented under Sections 319(h), 305(b) and 303(d) of the Clean

Water Act. The Liaison also encourages SWCDs and producers to participate in watershed planning and nutrient management planning where appropriate. The results of this activity include a watershed-based plan that meets USEPA's nine minimum elements. The liaison acts as a coordinating mechanism for the delivery of federal/state water quality related programs (i.e. EQIP, CPP, SSRP, CREP, 319 and ICLP). The liaison advertises programs, gives talks, meets with landowners and acts as a tool to spread the word about how each of these programs can benefit water quality. The liaison acts as an overall facilitator for water quality coordination between SWCDs, Illinois EPA and other state/federal agencies.

5.2 Conservation 2000

Conservation 2000 is a state program (http://www.epa.state.il.us/water/conservation-2000/). It is a multi-million dollar initiative designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water resources. It currently expires in 2009. C2000 funds nine programs across three state agencies, and includes the IDOA Conservation Practices Cost-Share Programs. C2000 is 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.

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.

5.3 Agricultural Watershed Programs

There are several federally-funded programs for soil and water conservation in agricultural watersheds, including the Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), Wildlife Habitat Incentives Program (WHIP), and Environmental Quality Incentive Program (EQIP). These programs can assist in implementing the TMDL in the watershed. It should be noted that these programs 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.

CRP is a voluntary program encouraging landowners for long-term conservation of soils, water, and wildlife resources. CRP is the USDA's single largest environmental improvement program. It is administered through the Farm Service Agency (FSA) and involves 10 to 15 year contracts. Further information is available online at http://www.agr.state.il.us/Environment/conserv/index.html.

The WRP is also a voluntary program (http://www.nrcs.usda.gov/programs/wrp/). WRP also provides technical and financial assistance to eligible landowners to restore, enhance, and protect wetlands. At least 70 percent of each project area will be restored to the original natural condition, to the extent practicable. Landowners enroll eligible lands through permanent easements, 30-year easements, or restoration cost-share agreements. The program is offered on a continuous sign-up basis and is available nationwide. It is administered through the NRCS.

The Environmental Quality Incentive Program (EQIP) is another voluntary USDA conservation program for farmers faced with serious threats to soil, water, and related natural resources (general information at http://www.nrcs.usda.gov/PROGRAMS/EQIP/; Illinois information and materials at http://www.il.nrcs.usda.gov/programs/eqip/). EQIP provides technical, financial, and educational assistance primarily in designated "priority areas", including TMDL watersheds. Landowners, in consultation with a local NRCS representative or technical service provider, are responsible for development of a site-specific conservation plan, including nutrient management planning.

The Wildlife Habitat Incentives Program (WHIP) (materials available online at http://www.il.nrcs.usda.gov/programs/whip/index.html), 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.

5.4 Legal Authority

Because neither Illinois EPA, county SWCDs, nor other governmental entities have direct authority over the identified nonpoint sources, it will be important to coordinate activities with entities that have programs in place to implement the nonpoint source actions.

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6. MONITORING AND ADAPTIVE IMPLEMENTATION

Continued watershed monitoring is needed to assess the effectiveness of implementing all TMDLs in the East Fork Kaskaskia River watershed, and to adjust implementation strategies through 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 East Fork Kaskaskia River, Station OK 01 (US 51 Bridge) is an AWQMN site. The Lakes Program also has monitoring stations in the four water supply reservoirs with approved TMDLs in the watershed. Beyond the 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 impaired waterbodies.

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 tributary sites, to better understand where wet weather loads are being generated in the watershed. This monitoring is described in more detail below.

Preliminary recommended monitoring activities in the East Fork Kaskaskia River watershed include fecal coliform measurements in the East Fork Kaskaskia River and its major tributaries. Sampling should occur during all flows, but particularly 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 Schneider Springs, Lone Grove Branch, Jims Creek and Davidson Creek, as well as several locations along the mainstem of the East Fork Kaskaskia River. The supplemental sampling sites used for Stage 2 are shown in Figure 5.

Periodic low flow is a cause of low dissolved oxygen in segments IL_OK-01 and IL_OK-02 of the East Fork Kaskaskia River. Watershed stakeholders are encouraged to consider this as pollution control projects are implemented, and consider alternatives that serve to moderate streamflows during hydrologic extremes (such as wetland restoration).

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