RAYSE CREEK (ILNK01) TMDL AND IMPLEMENTATION PLAN

Prepared for

Illinois Environmental Protection Agency

By

MWH

September 2003

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

REPLY TO THE ATTENTION OF WW-16J

04 SEP 2003

Ms. Marcia T. Willhite
Bureau of Water
IEPA
1021 North Grand Avenue East
Springfield, IL 62794-9276

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Load (TMDL) for Rayse Creek, including supporting documentation and follow up information. IEPA's submitted TMDL addresses a phosphorus and a Total Suspended Solids (TSS) load that partially impairs the Aquatic Life Use Support (ALUS) in approximately 13 miles of the river (ILNK01). Based on this review, U.S. EPA has determined that Illinois' TMDL for phosphorus and TSS meets the requirements of Section 303(d) of the Clean Water Act (CWA) and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves Illinois' TMDL for this partially impaired reach of Rayse Creek. The statutory and regulatory requirements, and U.S. EPA's review of Illinois' compliance with each requirement, are described in the enclosed decision document.

We wish to acknowledge Illinois' effort in 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

EXECUTIVE SUMMARY

Total Maximum Daily Loads (TMDL) for phosphorus and siltation are required for stream segment NK 01 in the Rayse Creek watershed, ILNK01 (Exhibit 2). This report presents an appraisal of water quality in the target watershed, and pollutant TMDLs accounting for critical periods, seasonal variability and uncertainty, and an implementation plan.

A TMDL is required for ILNK01 because of a determination that aquatic life use support (ALUS) is impaired in waterbody segment NK 01. In its 1998 development of a list of waters requiring TMDLs, the IEPA identified nutrients and siltation as causes of impairment in NK 01 and nutrients, dissolved oxygen, and suspended solids as causes of impairment in NK 02. Since that time, the Illinois EPA has updated its guidelines for determining use impairment (IEPA 2000). Upon applying the new guidelines (IEPA 2000) to stream segments NK 01 and NK 02, we found that a TMDL was required for siltation for NK 01, but not for NK02. We also found that a TMDL was required for phosphorus for NK 01, but not for NK02.

Since initiating the development of this report, new data have been collected through our ambient and intensive river basin survey monitoring programs. Based on the assessment of the new data, segment NK 02 is considered fully supporting its designated uses, and therefore no longer requires a TMDL. Illinois EPA is recommending in its Draft Illinois 2002 Section 303(d) List that Segment NK 02 be delisted. This request to delist was submitted to USEPA on December 10, 2002. Approval of this request by USEPA is pending.

The text and data for the DO TMDL on NK02 will remain in the report. While it will not be used for official TMDL purposes, the information can be used for watershed planning by stakeholders and watershed committees to ensure improved water quality conditions in the future.

The ALUS stream assessment guidelines for siltation involve both a water column indicator (total suspended solids concentration) and a substrate indicator (>34 percent silt). If total suspended solids concentration (TSS) exceeds 116 mg/L in more than one sample in three years, or, if physical habitat transect data shows the substrate to be predominately silt in over 34 percent of the surveyed area, ALUS is considered to be impaired by siltation. In NK 01, no substrate data are available. However, TSS concentrations exceeded the target concentrations of 116 mg/L five times from 1991 to

1995, indicating it is a cause of ALUS impairment in the 1996 305(b) report (IEPA 1996). More recently, TSS concentrations exceeded the water quality target five times from 1996 through 1998. Given that there are no substrate data available, we have taken TSS concentration as a surrogate indicator of siltation in stream segment NK 01, and developed a TMDL on that basis.

Sediment sources in the watershed were identified and a model developed to link those sources to loadings in the Rayse Creek watershed. The model examined loadings for 12 different storm events. For this watershed, sediment eroded from agricultural fields and transported by storm runoff is the source of TSS causing water quality impairments. The model results indicate that TSS concentrations need to be reduced 71 to 89 percent, depending on design storm and duration, to comply with the TSS TMDL endpoint of 116 mg/L.

In addition to sheet and rill erosion from fields, probable sources of suspended solids include gully erosion, and stream bed and bank erosion; no data are currently available to assess the significance of these sources. This report recommends that the Illinois EPA obtain data sufficient to estimate gully, bank, and stream bed erosion.

Sediment load from the subwatersheds discharging directly into NK 01 increases stream TSS concentration by approximately 15 percent. Therefore, the TMDL and implementation plan should include upstream subwatersheds.

The ALUS stream assessment guideline for phosphorus rated a stream impaired if total phosphorus concentration exceeds 0.61 mg/L in more than one sample in three years. In NK 01, total phosphorus concentrations exceeded the target concentration three times from 1991 to 1995, and four additional times from 1996 to 1998. Under the updated assessment guidelines (IEPA 2000), these exceedances indicate phosphorus is a cause of ALUS impairment. Phosphorus sources in the watershed were identified and a model developed to link those sources to loadings in the Rayse Creek watershed. The model examined loadings for 12 different storm events. For this target watershed, ILNK01, sediment eroded from agricultural fields and transported by storm runoff and cattle manure are the sources of phosphorus causing water quality impairments (IEPA 1998). The model results indicate that phosphorus concentrations need to be reduced up to 40 percent, depending on design storm and duration, to comply with the phosphorus TMDL endpoint of 0.61 mg/L.

Phosphorus load from the subwatersheds discharging directly into NK 01 increases stream phosphorus concentration by approximately 12 percent. Therefore, the TMDL and the implementation plan should include upstream subwatersheds.

Six options to control suspended solids and phosphorus loadings were examined to determine their feasibility for meeting the TSS and phosphorus endpoint concentrations of <116 mg/L and <0.61 mg/L, respectively for a three-year storm. These control options included:

- Changing agricultural land use in all subwatersheds (Option 1),
- Changing agricultural land use in subwatersheds discharging into NK 01 (Option 2),
- Selectively changing land use based on soil type (Option 3),
- Increasing conservation tillage (Option 4),
- Installing conservation buffers along Rayse Creek and tributary streams in its watershed (Option 5), and
- Contour stripcropping to reduce the slope length of farmed fields (Option 6).

All six options were evaluated to determine their feasibility for meeting the TMDL. Option 1, if implemented alone, would meet the TSS TMDL goal. Options 1, 3, 4, 5, and 6, if implemented alone, would meet the phosphorus TMDL goal. The Implementation Plan recommends integrated application of Options 3, 4, 5, and 6 to meet the water quality targets and to provide for reasonable assurance of its implementability. Individual farm conservation plans will need to be prepared, or may need to be revised, to finance and implement the controls. These farm conservation plans will provide for a higher resolution than this TMDL development. Implementing the TMDL in this manner will have average initial costs of $2.0 million and recurring costs of $2.2 million annually, depending upon the mix of BMPs selected by landowners for implementation.

Phase II Storm Water Regulations were not addressed in this TMDL because municipal separate storm sewer systems (MS4s) were not identified as a contributor to the pollutant for which this TMDL was developed.

This TMDL has accounted for several Concentrated Animal Feeding Operations (CAFOs) in the watershed. However, no specific data were readily available concerning these operations at the time of TMDL development. Potential problems concerning these operations will be addressed when Illinois CAFO rules are finalized. Should permits be issued for CAFOs in the watershed, the permit limitations and best management practices will be re-evaluated and adjusted as needed to maintain water quality standards.

DEVELOPMENT OF TMDLS AND IMPLEMENTATION PLANS FOR THE RAYSE CREEK WATERSHED

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LIST OF ACRONYMS

ALUS	AQUATIC LIFE USE SUPPORT
AWQMN	AMBIENT WATER QUALITY MONITORING NETWORK
BMP	BEST MANAGEMENT PRACTICE
BOD	BIOCHEMICAL OXYGEN DEMAND
CCC	COMMODITY CREDIT CORPORATION
CREP	CONSERVATION RESERVE ENHANCEMENT PROGRAM
CRP	CONSERVATION RESERVE PROGRAM
DO	DISSOLVED OXYGEN
DOA	ILLINOIS DEPARTMENT OF AGRICULTURE
DNR	ILLINOIS DEPARTMENT OF NATURAL RESOURCES
EQIP	ENVIRONMENTAL QUALITY INCENTIVE PROGRAM
FSA	FARM SERVICE AGENCY
IEPA	ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
MOS	MARGIN OF SAFETY
NPDES	NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
NRCS	NATURAL RESOURCES CONSERVATION SERVICE
RUSLE	REVISED UNIVERSAL SOIL LOSS EQUATION
STORET	STORAGE AND RETRIEVAL DATABASE

SWCD	SOIL AND WATER CONSERVATION DISTRICT
TMDL	TOTAL MAXIMUM DAILY LOAD
TSS	TOTAL SUSPENDED SOLIDS
WHIP	WILDLIFE HABITAT INCENTIVES PROGRAM
USDA	UNITED STATES DEPARTMENT OF AGRICULTURE
USEPA	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
USLE	UNIVERSAL SOIL LOSS EQUATION

UNITS OF MEASUREMENT

AC	ACRE
CM	CENTIMETER
D	DAY
FT	FOOT
HA	HECTARE
HR	HOUR
IN	INCH
KG	KILOGRAM
L	LITER
LB	POUND
M	METER
MG	MILLIGRAM
MGD	MILLION GALLONS PER DAY
YR	YEAR

FOREWORD

Authorization

The development of the TMDL for the Rayse Creek watershed was authorized under Agency contract number FWD-0302, between MWH (formerly Harza Engineering Company, Inc.) and Illinois Environmental Protection Agency.

Scope

The scope of work for this contract included meeting the following objectives:

- Identifying water quality targets for the target watershed, ILNK01, Rayse Creek
- Estimating wasteloads, loads, seasonal variation, and a margin of safety for pollutants impairing the waterbody segments
- Preparation of a TMDL implementation plan to bring the target waterbody into compliance with the water quality target

Acknowledgments

Harza acknowledges the valuable contributions of the Illinois EPA staff to this study, including Mr. Gary Eicken, Mr. Lalit Sinha, Mr. Bruce Yurdin, Mr. David Muir, Mr. Bob Hite, Mr. Jeff White and many others. Mr. Douglas Mulvey and Ms. Beth Padera performed the study. Mr. David Pott was MWH's Project Manager.

1. 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 water bodies that are not meeting applicable water quality standards/guidelines 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 total load of a specific pollutant that can be assimilated, 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/guidelines and designated uses in waterbody segments NK 01 and NK 02, Rayse Creek. Pollutant load reductions will be allocated among sources and provide a scientific basis for restoring surface water quality in this waterbody. In this way, the TMDL process links the development and implementation of control actions to attain and maintain water quality standards and designated uses.

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 1998b). 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/guidelines and support designated uses.

1.2 APPROACH TO TMDL DEVELOPMENT

MWH is following a technical approach to developing this TMDL that is consistent with the 1998 Report of the Federal Advisory Committee on the TMDL Program and USEPA's protocol for developing sediment TMDLs (USEPA 1998b, 1999). The general components of this approach include:

- Problem Identification

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

Exhibit 1 illustrates the interrelationships between these and other activities that MWH and the Illinois Environmental Protection Agency (Illinois EPA) have undertaken, or will be undertaking, to develop and implement the TMDL and to restore the targeted waterbody to meet water quality criteria and designated uses.

1.3 SOURCES OF INFORMATION

Table 1 lists data, by source, that were obtained and reviewed in preparation of this TMDL. These and other references have complete citations at the end of this report. No original data were collected as part of this assignment.

1.4 ORGANIZATION OF THE REPORT

This report documents the TMDL and implementation plan to restore use support in Rayse Creek. Chapter 1 is an introduction. Chapter 2 summarizes the targeted watershed condition and identifies the water quality problem. Chapter 3 identifies water quality indicators and TMDL target values. Chapter 4 is a source assessment and Chapter 5 links sources and the water quality target. Chapter 6 presents the TMDL calculation and allocation scenarios. Chapter 7 is the implementation plan. Data and model results are printed out as appendices.

Table 1

DATA SOURCES, RAYSE CREEK WATERSHED (ILNK01)

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.
Soils	Soil Geographic (STATSGO) Database, U.S. Department of Agriculture, Natural Resources Conservation Service, 1994.
NPDES Permit Conditions and Excursion Data, PCS Query	IEPA NPDES permit electronic files, Envirofacts Data Warehouse, Water Discharge Permits available at http://www.epa.gov/enviro/html/pcs/pcs_query_java.html
STORET data	Hardcopy 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
Biotic Integrity and Habitat Survey results	BIOS database, from IEPA headquarters
General watershed information	Jefferson and Washington County Soil Surveys, NRCS, and *An Intensive Survey of the Big Muddy River Basin* (IEPA, 1997).
USDA programs and data	http://www.usda.gov
Climate data	Illinois State Water Survey's *Rainfall Frequency Atlas of the Midwest*, Bulletin 71 (Huff and Angel 1992)
Population forecast data	South Central Illinois Regional Planning & Development Commission
Conservation tillage data	Transect data provided by the Illinois Department of Agriculture

2. PROBLEM IDENTIFICATION

The objective of this chapter of the report is to document the nature of water quality in the targeted waterbodies using available data, and to assess the watershed with respect to land use, soil characteristics, and topography.

2.1 DESCRIPTION OF THE WATERSHED

The watershed targeted for TMDL development is Rayse Creek (ILNK01). Rayse Creek is located in Jefferson County in a headwater reach of the Big Muddy River Basin. Exhibit 2 is a location map. There are two waterbody segments in the 63,581-acre watershed being targeted for TMDL and implementation plan development, NK 01 and NK 02. This watershed includes 29.74 miles of river in the TMDL development area (IEPA 1998). The boundaries of the two segments are described in Table 2. We have divided ILNK01 into 12 subwatersheds for this TMDL analysis (Exhibit 3).

Table 2

RAYSE CREEK (ILNK01) SEGMENTS FOR TMDL AND IMPLEMENTATION PLAN DEVELOPMENT (Source: Illinois EPA files)

Segment	Description
NK 02	From its point of origin extending approximately 16.69 miles downstream to the confluence with Novak Creek
NK 01	From the confluence with Novak Creek downstream approximately 13.05 miles to the Big Muddy River

The soils and topography of Rayse Creek are typical of the Big Muddy River basin and the Southern Till Plain Division. The topography of this Division (including the targeted watershed) is typically gently rolling hills, originally vegetated with post oak flatwood forests and mesic tallgrass prairies. Upland soils tend to be derived from loess, whereas alluvium soils occupy the lowlands (Miles 1996). In general, the pre-settlement watershed was gently rolling hills with post oak hardwood forests and mesic tallgrass prairies (IEPA 1997). Today the watershed remains rural, but is largely devoted to the cultivation of corn and soybeans.

2.1.1 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 water quality standards for any specified use, in addition to meeting the general standards of Part 302. There are no specially designated uses for Rayse Creek, and therefore, the stream must meet the water quality standards in Part 302. Uses of the ILNK01 river segments include aquatic life use support (ALUS) (Table 3).

Table 3

STREAM USE DESIGNATION AND USE SUPPORT STATUS
(Source: IEPA 1998)

Segment	Designated Uses	Use Support Status
NK 02	Overall Use	Partial Support/Minor Impairment
	Fish Consumption	Unknown
	Aquatic Life	Partial Support/Minor Impairment
	Swimming	Unknown
NK 01	Overall Use	Partial Support/Minor Impairment
	Fish Consumption	Unknown
	Aquatic Life	Partial Support/Minor Impairment
	Swimming	Partial Support/Moderate Impairment

2.1.2 Water Quality Standards

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. Narrative water quality standards describe conditions necessary for the water body to attain its designated use. Often expressed as “free from” certain characteristics, narrative criteria can be the basis for controlling nuisance conditions such as floating debris, objectionable deposits or offensive odors. Narrative standards are often used to supplement numeric standards.

Numeric water quality standards are concentrations, toxicity units, or other numbers deemed necessary to protect designated uses. Numeric standards define the relationship between pollutant concentrations and environmental and human health effects. 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 can also be the water quality endpoints used for TMDLs.

Applicable water quality standards for Rayse Creek are found in Title 35 of the Illinois Administrative Code. Subtitle C, Subpart B contains the General Use Water Quality Standards which must be met in waters of the state for which there is no specific designation. The General Use Standards are written to protect aquatic life, wildlife, agricultural use, secondary contact use, most industrial uses, and aesthetics. Primary contact uses are protected for all general use waters whose physical configuration (*i.e.* depth) permits such use.

The General Use Standard for dissolved oxygen (DO) is defined in Subpart B Section 302.206. DO shall not be less than 6.0 mg/l during at least 16 hours of any 24-hour period, nor less than 5.0 mg/l at any time.

Subpart B does not contain General Use Standards, numeric or narrative, applicable to ILNK 01 for nutrients, siltation, or total suspended solids. The basis for the 303(d) listing is taken from the narrative standard, Section 302.203, which states that waters are to be free from sludge or bottom deposits, plant or algal growth, color or turbidity of other than natural origin.

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 10-year return frequency (7Q10) (Title 35 Illinois Administrative Code Section 302.103).

2.1.3 305(b)-Identified Causes of Non-Attainment

Illinois' 1998 submittal of its Section 303(d) list catalogs the causes of water use impairment of Rayse Creek as moderate nutrient and suspended solids loadings, and moderate organic enrichment/DO deficit in the upper segment, (Exhibits 4, 5 and 6), and moderate nutrient loadings and siltation, in the lower segment (Exhibits 4, 5 and 7). The 1998 303(d) listing of impaired waters was based upon information in the 1996 305(b) water quality assessment report. Formal criteria for listing and identification of the causes of non-attainment were not available at that time. 305(b) assessment criteria for ensuring consistency are now available and are currently being utilized by the IEPA Bureau of Water (IEPA 2000). Section 2.2.4 reviews available water quality data and compares it with the updated assessment criteria (IEPA 2000).

NK 02. Phosphorus, BOD and sediment loadings impair the designated uses (*i.e.* aquatic life support) of NK 02 to a moderate degree. According to the Agency's 303(d) report, the sources of these loadings are generally agriculture, non-irrigated crop production and animal holding/management areas (IEPA 1998) (Table 4). As indicated earlier, current listing criteria differ for those used in compiling the 1998 303(d) List and, as detailed in Chapter 3, new listing criteria require no TMDLs be developed for NK02.

NK 01. Phosphorus loadings and siltation impair the designated uses (*i.e.* aquatic life support and swimming) of NK 01 to a moderate degree. The source of these pollutants is generally agriculture and non-irrigated crop production (IEPA 1998) (Table 4). As indicated earlier, current listing criteria differ for those used in compiling the 1998 303(d) List and, as detailed in Chapter 3, new listing criteria require TMDLs for siltation and phosphorus be developed for NK01.

Table 4

CAUSES AND SOURCES OF WATER USE IMPAIRMENTS IN NK 01 AND NK 02 (Source: IEPA 1996, 1998)

Segment	Use/Impairment Status	Cause and Severity	Sources and Significance
NK 01	Overall/Minor Fish Consumption/Unknown Aquatic Life/Minor Swimming/Moderate Public Water Supply/None	Nutrients – Moderate Siltation - Moderate	Agriculture – Moderate Non-irrigated Crop Production - Moderate
NK 02	Overall/Minor Fish Consumption/Unknown Aquatic Life/Minor Swimming/Unknown Public Water Supply/None	Nutrients – Moderate Dissolved Oxygen – Moderate Suspended Solids – Moderate	Agriculture – Moderate Non-irrigated Crop Production – Moderate Animal holding/Management Areas – Moderate

2.1.4 Institutions

Within the Big Muddy River basin, USGS Hydrologic Cataloging Unit 07140106, we have attempted to identify watershed stakeholder groups. The Big Muddy River Task Force exists, but is not specifically associated with Rayse Creek or its watershed. The city of Richview is the only permitted point source discharger in the Rayse Creek watershed. Their cooperation will be important to successful implementation of the TMDL and the restoration of use support in the waterbody. Approximately 28 livestock facilities are also located in the watershed (IEPA 1997). The cooperation of their owners and operators will also be important.

Other institutions identified to date that are, or potentially are, involved in watershed management in the target watershed include:

- Natural Resources Conservation Service, USDA
- Washington County Soil and Water Conservation District
- Jefferson County Soil and Water Conservation District
- Illinois EPA
- Illinois Department of Agriculture

2.2 DATA-BASED CHARACTERIZATION OF THE WATERSHED

MWH reviewed the available data to characterize the spatial and temporal extent of the watershed's water quality problems that prevent attainment of designated uses. Data sources reviewed and discussed below include hydrology, soils, land use, water quality, and stream habitat and aquatic life data.

2.2.1 Hydrology

Streamflow data for watershed ILNK01 are available from a gage on Rayse Creek near Waltonville, Ill. (05595730). The gage is located at County Road 9, 2.4 miles downstream from Novak Creek, reported in the USGS records to be at river mile 6.7. The drainage area of this gage is reported by the USGS to be 88.0 square miles (56,320 acres). There are daily discharge records from October 1979 to September 1998 (Exhibit 8). The daily records were reviewed to find the maximum yearly flows (Table 5).

Table 5

MAXIMUM DISCHARGES, RAYSE CREEK NEAR WALTONVILLE, IL
(Source: USGS Gage 05595730 Data)

Year	Flow (cfs)	Year	Flow (cfs)	Year	Flow (cfs)
1979	600	1986	4,190	1993	10,700
1980	1,210	1987	18,20	1994	4,810
1981	1,720	1988	4,580	1995	10,800
1982	4,990	1988	5,920	1996	11,200
1983	6,470	1990	6,870	1997	2,020
1984	2,780	1991	1,220	1998	1,720
1985	8,260	1992	3,380		

Using the maximum daily discharge values in Table 5, return periods for given floods were calculated using the Weibull formula (Chow *et al*. 1988). From these data, selected return periods and corresponding discharges are presented in Table 6. Exhibit 9 is a flow duration curve, indicating median flows around 5 ft^3/s (cfs). State water quality standards are based on the minimum mean seven consecutive day drought flow with a 10-year return frequency (7Q10). For all reaches of Rayse Creek, 7Q10 is zero.

Table 6

ESTIMATED DISCHARGES FOR SELECT RETURN PERIODS
IN RAYSE CREEK, NEAR WALTONVILLE, IL

Return Period (years)	Flow (cfs)
1	1,100
2	3,500
3	5,400
5	7,800
10	11,800

2.2.2 Soils

The Southern Till Plain is entirely covered by fertile Illinoian glacial till, originally vegetated by mesic tallgrass prairie and post oak flatwood forest. Exhibit 10 presents the three major soil associations found in the watershed. The GIS files for Exhibit 10 have been obtained from the national STATSGO database. Soil associations in NK 01 include the Bluford-Ava-Hickory Association (IL038), the Cisne-Hoyleton-Darmstadt Association (IL006), and the Hurst-Reesville-Patton Association (IL051). Table 7 presents a summary of soil association type and abundance in the watershed in each of twelve defined subwatersheds. Each soil type of the association is discussed below.

Table 7

SOILS IN THE RAYSE CREEK WATERSHED (ACRES)
(Source: STATSGO)

Subwatershed	Cisne-Hoyleton-Darmstadt (IL006)	Bluford-Ava-Hickory (IL038)	Hurst-Reesville-Patton (IL051)
RC-1	0	2,446	1,143
RC-2	1,251	4,131	575
RC-3	0	881	3,650
RC-4	3,595	3,877	177
RC-5	1,527	4,470	0
RC-6	0	5,626	0
RC-7	0	3,202	0
RC-8	9,541	4,396	0
RC-9	1,266	4,449	0
RC-10	1,286	1,363	0
RC-11	2,222	49	0
RC-12	2,194	267	0
Total	**22,882**	**35,157**	**5,546**

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 1 to 45 percent.

The Cisne-Hoyleton-Darmstadt Association is found in nearly level to gently sloping, poorly drained areas. These are the upland prairie soils; they are found on broad till plains, with slopes up to 7percent (Miles 1996).

The Hurst-Reesville-Patton Association is nearly level to steep, generally poorly drained soils on till plains, terraces or moraines. Slopes generally range from 0 to 7 percent, but may be up to 15 percent in the Hurst series.

These three soil associations are well suited or moderately well suited to cultivated crops. The following soil descriptions have been taken from the USDA-NRCS Soil Survey Division, Official Soil Series Description Data Access website.

Ava Series. The Ava series consists of moderately well drained soils on convex ridges and side slopes of drainage ways on till plains. They formed in loess and the underlying silty or loamy deposits that overlie a strongly developed paleosol. They have a bisequal profile that is moderately deep to a fragipan and very deep to bedrock. Ava soils are moderately permeable in the upper part of the solum, and very slowly permeable in the fragipan horizon. Slope ranges from 0 to 18 percent.

Bluford Series. The Bluford series consists of very deep, somewhat poorly drained soils on hill slopes and knolls. They formed in loess and the underlying silty or loamy sediments. Permeability is low. Slopes range from 0 to 7 percent.

Cisne Series. The Cisne series consists of very deep, poorly drained, very slowly permeable soils on till plains. They formed in loess and the underlying gritty loess or pedisediment. Slopes range from 0 to 2 percent.

Darmstadt Series. The Darmstadt series consists of very deep, somewhat poorly drained, very slowly permeable soils formed in loess, or in loess and the underlying silty pedisediment on till plains. These soils contain a concentration of exchangeable sodium in the subsoil. Slopes range from 0 to 10 percent.

Hickory Series. The Hickory series consists of very deep, well-drained, moderately permeable soils on dissected till plains. They formed in till that can be capped with up to 20 inches of loess. Slope ranges from 5 to 70 percent.

Hoyleton Series. The Hoyleton series consists of deep, somewhat poorly drained, slowly permeable soils on low convex ridges on uplands. They formed in loess and the underlying silty or loamy deposits which overlie a strongly weathered paleosol in the Illinoian till. Slopes range from 0 to 7 percent.

Hurst Series. The Hurst series consists of very deep, somewhat poorly drained, very slowly permeable soils on lacustrine terraces and lake plains, mainly along major tributaries of the Mississippi River. They formed dominantly in clayey lacustrine sediments and typically have a thin mantle of loess or other silty material. Slopes range from 0 to 15 percent.

Patton Series. The Patton series consists of deep, poorly drained and very poorly drained soils formed in lacustrine sediments on stream terraces and glacial lake plains. Permeability is moderate in the solum and moderate or moderately slow in the underlying material. Slope gradient range from 0 to 2 percent.

Reesville Series. The Reesville series consists of very deep, somewhat poorly drained soils on till plains or moraines. They formed in 40 to 60 inches of loess and are underlain by loamy till. Permeability is moderate in the solum and moderately slow or slow in the underlying till. Slopes range from 9 to 7 percent.

2.3 Land Use and Cover

The Southern Till Plain is entirely covered by fertile Illinoian glacial till, originally covered by mesic tallgrass prairie and post oak flatwood forest. Today it is largely used for crop production (Table 8). Exhibit 11 is a map of land use in the watershed and Exhibit 12 contains detailed acreage figures of each land use type in each soil association.

Table 8

RAYSE CREEK WATERSHED LAND USE
(Source: Illinois Natural History Survey, *et al*. 1996)

Land Use Type	Area (ac)	Proportion
Urban	101	0.2%
Agriculture	29,718	46.7%
Grassland	20,404	32.1%
Forest	9,885	15.5%
Water	33	0.1%
Wetland	3,444	5.4%
Total	**63,584**	**100%**

2.3.1 Water Quality

All water quality data were provided by the Agency from STORET, the USEPA's STOrage and RETrieval database. The Agency monitors water quality data in each stream segment of Rayse Creek. These stations are:

- NK 02 – Rayse Creek, approximately 6.0 miles upstream of Novak Creek confluence
- NK 01 – Rayse Creek, approximately 1.7 miles downstream of Novak Creek confluence

There are substantial data available to characterize water quality in the downstream segment of Rayse Creek, NK 01, as it is an ambient water quality monitoring network (AWQMN) station. Conversely, few data are available for NK 02, the upstream segment of Rayse Creek.

Exhibits 13 through 17 provide the most recent water quality data available. Table 9 lists dates on which water quality at NK 01 or NK 02 exceeded water quality standards or current 305(b) assessment guidelines (IEPA 2000), so identified causes of impairment (shown in Table 9) may differ from the 1998 303(d) report. The water quality standards are found in Title 35, Illinois Administrative Code Part 302.

NK 02. Water quality data for NK 02 are limited to four sampling events: July 27, 1995, February 27, 1996, July 18, 2000, and September 25, 2000 (Exhibit 13). The July 27, 1995, sample had relatively high total suspended solids (TSS), nutrients, organic carbon, and, low dissolved oxygen (DO). Secchi disk visibility was limited to two inches. The July 27, 1995, and July 18, 2000, summer DO measurements were out of compliance with the General Use Water Quality Standard for DO. Further, the July 27, 1995, ammonia-N measurement exceeded the IEPA's current 305(b) assessment guideline. Neither phosphorus nor suspended solids at NK 02 exceeded the 305(b) assessment guideline.

NK 01. In comparison to NK 02, there are substantially more data available to characterize NK 01. IEPA provided us with monthly data for the site from STORET, for the period February 1991 through December 1998. This period includes the years 1991 through 1995, which were used as the basis for the 1998 303(d) listing. These data are summarized in Exhibit 14 and illustrated in Exhibits 15 through 17.

While there were DO excursions from the standard in NK 01 (Table 9, Exhibit 15) DO was not listed as a cause of impairment in the 1998 303(d) report and a TMDL is not being prepared as part of this effort. TMDL listings are required to go through a public notice process, which has not been done for this cause for listing NK 01. It is likely that implementing the DO TMDL in the upstream segment NK 02 will remedy DO deficits in NK 01.

Monthly data for total phosphorus concentrations at NK 01 were also obtained from STORET (Exhibit 16). The mean for total phosphorus at NK 01 was 0.27 mg/L (N=70 samples) (Exhibit 14). The maximum concentration during this monitoring period was 2.50 mg/L. High concentrations are not significantly correlated with discharge (Exhibit 17). However, peaks in phosphorus concentrations are generally noted with peaks in turbidity and total suspended solids, particularly in winter months.

Table 9

INCIDENCES OF NON-COMPLIANCE WITH WATER QUALITY TARGETS

(Source: STORET, IEPA 2000)

	Flow[1]	DO	Suspended Solids	Phosphorus
Standard/Guideline		<5[2]	>116[3]	>0.61[3]
NK 01				
2/6/91	569		578	
8/22/91	0	3.4		
11/18/91	16	4		2.5
1/2/92	188		844	0.85
7/20/92	0.3	3.6	120	
8/19/92	0	2.1		
3/8/93	62			
4/21/93	145		168	
9/21/93	0.22	4.3		
6/27/94	69		146	
7/27/94	1	3.9		
9/22/94	0	3.5		
11/10/94	7.5	1		1.46
7/20/95	0.22	4.1		
9/6/95	0	2.8		
11/15/95	0	2.6		
1/23/96	225			0.74
3/7/96	51			
4/1/96	860		198	0.63
7/25/96	0.4	3.6		
9/12/96	0	3		
10/1/96	0.51		128	
11/26/96	300		268	0.75
6/23/97	49		130	
7/24/97	3.5	4.1		
10/7/97	0	3.9		
11/19/97	0.03	2.2		
5/7/98	824		464	
8/5/98	0.32	3.4		
9/9/98	0	3.6		
10/21/98	NA	4.9		
12/2/98	NA			0.68
NK 02				
7/27/95	14	3.5		
7/18/00	0.54	3.4		

[1] Flow at the Waltonville gage, in cfs
[2] General Use Water Quality Standard, in mg/L
[3] 2000 305(b) Assessment Guideline, in mg/L
NA – Flow Not Available

Illinois' general use phosphorus standard of 0.05 mg/L applies to any stream at the point it enters a reservoir or lake with a surface area of 8.1 hectares (20 acres) or more. This standard does not apply to NK 01, as this station is considerably upstream of Rend Lake. During the 1991 to 1995 period used as the basis for the state's 1998 303(d) list, three total phosphorus measurements exceeded the current 305(b) assessment full ALUS guideline of 0.61 mg/L. Four measurements exceeded the current 305(b) assessment ALUS guideline during the most recent three years (1996 – 1998) for which we have data (Table 9).

Dissolved phosphorus measurements, which averaged 0.12 mg/L, are illustrated in Exhibit 16. The maximum concentration of dissolved phosphorus was 2.2 mg/L. Dissolved phosphorus is not significantly correlated with discharge.

Monthly data for TSS concentrations at NK 01 indicate routinely high solids levels in Rayse Creek (Exhibit 16). The mean for TSS at NK 01 over the period 1991 through 1998 was 72 mg/L (N=71 samples), and ranged from 4 to 844 mg/L. Correlation of TSS and discharge is statistically significant ($P<0.001$, Exhibit 17). The current 305(b) assessment guideline for TSS causing aquatic life support impairment is >116 mg/L in one sample in three years (IEPA 2000). During the most recent three years for which we have data available, there were five measurements which TSS exceeded 116 mg/L (Table 9).

2.3.2 Other Data Describing Use Attainment

The 1998 303(d) listing of NK 01 and NK 02 was based, at least in part, upon bioassessment surveys conducted in summer 1995 by IEPA staff. Fish community, benthic community and physical habitat sampling was performed at NK 02. No ecological sampling was performed in NK 01. The NK 02 bioassessment sampling site is located at County Road 1400 North, 3.7 miles west of Woodlawn. Summary descriptions and tables extracted from the IEPA's BIOS database are presented below.

Substrate in the NK 02 bioassessment reach (Table 10) was primarily sand (43 percent) and coarse gravel (21 percent). NK 02 is largely run-type habitat (57 percent) and pools (26 percent). Aquatic vegetation, which includes filamentous algae on the streambed, was 3.4 percent of the study reach. Average width of the stream was 28 feet; average depth was 1.4 feet and average velocity was 0.7 ft/s. Field notes from the bioassessment survey indicate Secchi disk visibility was limited to two inches, and indicted hog waste as impacting the stream.

Table 10

SUBSTRATE (%) IN NK 02
(Source IEPA BIOS Database)

Date Sampled	July 26, 1995
Mud	5.4
Sand	42.6
Fine Gravel	1.4
Medium Gravel	1.4
Coarse Gravel	20.9
Small Cobble	4.7
Large Cobble	2.0
Boulder	3.4
Bedrock	0
Claypan	2.7
Detritus	6.8
Vegetation	3.4
Logs	3.4

Fish community data allowed estimation of the Index of the Biotic Integrity (IBI). The IBI at NK 02 from the 1995 survey data was 38 (Table 11). For perspective, the current Agency 305(b) guideline used to indicate full aquatic life support is an IBI 41; IBI 20 indicates non-support and values between 20 and 41 generally indicate partial support. Therefore, if the current 305(b) assessment guidelines were applied, the 1995 IBI score would indicate partial aquatic life support conditions at NK 02.

The most common fish collected by the Agency at NK 02 was bluegill. This fish is adaptable to a variety of lake and stream habitats (Becker 1983). Two other fishes caught at NK 02 contradict their relative high abundance. Creek chubsucker is sensitive to siltation and turbidity, strongly preferring clear headwater streams with abundant vegetation and organic debris. Green sunfish is more tolerant of turbidity and siltation than other sunfishes, and will tend to be the most abundant species in streams with poor water quality (Becker 1983).

Benthic macroinvertebrates found during the bioassessment survey are listed in Table 12, together with their abundance and pollution tolerance values. Most of the macroinvertebrate taxa are sowbugs. The Macroinvertebrate Biotic Index (MBI) is computed from abundance and pollution tolerance values, and for NK 02, is 5.7. MBI and pollution tolerance values are inversely related to water quality conditions. That is, MBI increases as water quality is degraded. The MBI is used to make judgments on the biological effects of pollutant discharges. For perspective, the current Agency guideline for full aquatic life support is MBI < 5.9. An MBI > 8.9 indicates nonsupport and values between 5.9 and 8.9 generally indicate partial support. Therefore, if the current 305(b) assessment guidelines were used, the 1995 MBI score would indicate full support conditions at NK 02.

Table 11

FISHES COLLECTED FROM RAYSE CREEK SEGMENT NK 02
(Sampled July 26, 1995)

Scientific name	Common name	Abundance
Esox americanus	Grass pickerel	2
Cyprinus carpio	Carp	1
Notropis umbratilis	Redfin shiner	8
Notemigonus crysoleucas	Golden shiner	4
Pimephales notatus	Bluntnose minnow	2
Semotilus atromaculatus	Creek chub	20
Catostomus commersoni	White sucker	4
Erimyzon oblongus	Creek chubsucker	29
Ictalurus natalis	Yellow bullhead	9
Noturus gyrinus	Tadpole madtom	2
Aphredoderus sayanus	Pirate perch	16
Fundulus notatus	Blackstripe topminnow	2
Lepomis cyanellus	Green sunfish	28
Lepomis macrochirus	Bluegill	39
Lepomis megalotis	Longear sunfish	2
Lepomis microlophus	Redear sunfish	1
Micropterus salmoides	Largemouth bass	4
Pomoxis annularis	White crappie	1
Etheostoma gracile	Slough darter	1
Etheostoma nigrum	Johnny darter	1
Aplodinotus grunniens	Freshwater drum	4
Lepomis lepomis	Hybrid bluegill	11
Index of Biotic Integrity		38

Table 12

MACROINVERTEBRATES COLLECTED IN RAYSE CREEK SEGMENT NK 02
(Sampled on July 26, 1995)

Scientific Name	Common Name	Abundance	Tolerance
Annelida		1	
Caecidotea	Sowbugs	68	6.0
Hyalella azteca	Tiny olive scud	11	5.0
Orconectes virilis		8	5.0
Baetis	Small minnow mayfly	4	4.0
Cloeon	Small minnow mayfly	4	3.0
Stenacron	Flatheaded mayfly	14	4.0
Caenis	Small squaregill mayfly	4	6.0
Nasiaeschna	Dragonflies	1	2.0
Perithemis		1	4.0
Sialis	Alderflies	3	4.0
Helichus		1	4.0
Dubiraphia		3	5.0
Tipulidae	Crane flies	1	4.0
Chaoboridae	Phanton midges	4	8.0
Anopheles	Mosquitoes	1	6.0
Culex	Mosquitoes	1	8.0
Procladius	Midges	4	8.0
Dicrotendipes		3	6.0
Polypedilum scalaenum		3	6.0
Hydrobiidae		2	6.0
Physella	Snails	6	9.0
Ferrissia		3	7.0
Sphaerium	Clams	3	5.0
Macroinvertebrate Biotic Index			5.7

3. IDENTIFICATION OF WATER QUALITY TARGETS

Water quality target values, or endpoints, are used as the basis for TMDL development. Often the target will be the numeric water quality standard for the pollutant of concern. In Illinois, many TMDLs must be developed for parameters that do not have numeric standards, including TMDLs for the Rayse Creek watershed. The narrative standard must be interpreted to develop a quantifiable target value on which to base the TMDL.

The state's current approach to developing TMDLs in the absence of numerical water quality standards utilizes the Illinois EPA's 305(b) assessment guidelines (IEPA 2000). These guidelines are the basis for identifying impaired segments and impairment causes. For certain parameters, narrative expressions of the assessment guidelines are required. Others are a combination of metrics developed by the state or USEPA in the overall monitoring strategy for the assessment of ALUS in lakes and streams. ALUS is one of several use support categories against which data are assessed to determine attainment of a particular use (fish consumption, shellfish, swimming, secondary contact and drinking water are the other categories). As indicated in the 1998 303(d) report (IEPA 1998) and summarized in Table 3, ALUS is impaired in both NK 01 and NK 02. Nutrients (phosphorus) and siltation have been identified in that report as causes of impairment in segment NK 01. Nutrients (phosphorus), dissolved oxygen deficits, and suspended solids have been identified as the causes of impairment in segment NK 02 (IEPA 1998). The identification of these causes was based upon Illinois EPA's 305(b) guidelines preceding those adopted for 2000. In this chapter, we apply the 2000 305(b) guidelines to confirm waterbody designated use support, causes of impairment, and to develop TMDL endpoints, or target values. In some cases, use of the 2000 guidelines to identify impairment causes will produce results differing from the 1998 303(b) report.

For parameters such as nutrients, suspended solids and siltation that have no numeric water quality standards, a statistical value equivalent to the 85th percentile (statewide mean plus one standard deviation) is used as the threshold for determining full ALUS under the 305(b) assessment program (IEPA 2000). This statistical value is calculated from all available AWQMN data statewide. At AWQMN sites, like NK 01, one exceedence of this statistic over the most current three years of monitoring triggers the identification of that water quality constituent as a cause of use impairment. At non-AWQMN monitored sites, like NK 02, biological and physical habitat data are used in combination with available chemical data to assess use support and identify causes of impairment.

3.1 Nutrients

At NK 01, an AWQMN site, there are four exceedences of the 305(b) assessment criterion of 0.61 mg/L phosphorus during the three most recent years for which we have data. During the period 1991 to 1995 used to derive the 1998 303(d) list, there were three exceedances of the 0.61 mg/L criterion. Our analysis indicates that, under the more recent water quality assessment guidelines, a TMDL is required in NK 01 for phosphorus (Table 13).

There are only two measurements of phosphorus in NK 02 available. The maximum total phosphorus concentration was 0.46 mg/L. Under the 2000 305(b) guidelines, phosphorus cannot be listed as a cause of impairment if concentrations are less than 0.61 mg/L.

Table 13

NUTRIENT TMDL DEVELOPMENT RECOMMENDATIONS FOR RAYSE CREEK, ILNK01

Waterbody	Basis	Recommendation
NK 01	Four exceedances of guideline	Develop phosphorus TMDL
NK 02	No exceedances of guideline	Delist NK 02 for phosphorus

3.2 Siltation/Suspended Solids

The 2000 305(b) assessment guidelines for siltation involve both a water column indicator (total suspended solids concentration) and a substrate indicator (>34 percent silt). If total suspended solids concentration (TSS) exceeds 116 mg/L in more than one sample in three years, or if physical habitat transect data shows the substrate to be predominately silt in over 34 percent of the surveyed area, ALUS is considered to be impaired by siltation and the waterbody is placed on the 303(d) list. The 1998 303(d) report listed NK 01 as being impaired by siltation, and NK 02 as being impaired by TSS.

At NK 01, an AWQMN site, there are five exceedences of the 305(b) assessment criterion of 116 mg/L TSS during the three most recent years for which we have data. During the monitoring period used to derive the 1998 303(d) list, 1991 to 1995, there were five exceedances of the criterion. No substrate data are available for NK 01.

Therefore, under the more recent water quality assessment guidelines, a TMDL is required in NK 01 for siltation (Table 14).

There are only two measurements of TSS in NK 02 available, but substrate data exist. The maximum TSS concentration was 50 mg/L. Substrate was found to be 5.4 percent silt/mud (Table 10). Therefore under the latest 305(b) guidelines, suspended solids or siltation cannot be listed as a cause of impairment.

Table 14

SILTATION/TSS TMDL DEVELOPMENT RECOMMENDATIONS FOR RAYSE CREEK, ILNK01

Waterbody	Impairment Cause	Basis	Recommendation
NK 01	Siltation – TSS	Five exceedances of TSS criterion	Prepare TSS TMDL
NK 01	Siltation – silt/mud substrate	No data available	Address water column indicator only
NK 02	TSS	No exceedance of TSS guideline	Delist NK 02 for TSS

3.3 Dissolved Oxygen

NK 02 is listed in the 303(d) report as being impaired, with DO deficits being an identified cause. There are four measurements of DO from NK 02, two of which are less than the 5 mg/L standard. Therefore, this segment is considered impaired for ALUS by DO deficits, and a TMDL should be prepared.

4. 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 watershed, ILNK01, there are currently no permitted point source discharges. An NPDES permit has been issued for the construction of the Richview Sewage Treatment Plant (STP). The location of this facility is shown on Exhibit 18. The initial reporting date was June 2001; no data have yet been submitted in fulfillment of NPDES reporting requirements. Parameters that the STP will need to monitor include flow, BOD_5, residual chlorine, pH, and TSS. Note that nutrient data are not required to be monitored. Table 15 presents the permitted TSS waste load for this facility when it is operational. When compared with nonpoint source loads from a 24-hour, 3-year storm, the Richview facility TSS wasteload will be approximately 0.0004 percent of the total TSS load, and the P wasteload will be approximately 0.007 percent of the total P loading in the watershed[1]. Therefore, this point source is negligible compared with nonpoint source loads.

Table 15

WASTEWATER TREATMENT FACILITY EFFLUENT LOADINGS
(Source: USEPA Permit Compliance System)

Monitoring Location	Parameter	Monthly Average Limit (lb/d)	Weekly Average Maximum Limit (lb/d)	Monthly Average Concentration Limit (mg/L)	Weekly Average Maximum (mg/L)
Effluent	BOD_5	35	56	25	40
Effluent	TSS	52	63	37	45
Effluent	pH range between 6 and 9				

[1] No phosphorus discharge standard is available for the aerated lagoon. Discharge from the lagoon was estimated to be 130 gallons per capita per day for 300 individuals with an average phosphorus concentration of 2.8 mg/L.

4.2 Watershed Loads

Pollutant loads to surface water can originate from several sources. The primary mechanism for transport of suspended solids and phosphorus to local streams is surface runoff. Illinois EPA (1998) identified nonpoint sources of pollutants impairing one or more stream segments in ILNK01 to include animal holding areas and non-irrigated rowcrop production (Exhibit 19). In addition to sheet and rill erosion from fields, probable sources of suspended solids include gully erosion, and stream bed and bank erosion; no data are currently available to assess the significance of these sources. We recommend that the Agency obtain data sufficient to estimate gully, bank, and stream bed erosion.

Land use data from the Illinois DNR indicates 47 percent of the watershed is used for agriculture (Illinois Natural History Survey, *et al.* 1996). In this area of Illinois, rowcrop production is primarily corn and soybeans, although some small grains are farmed. Another 32 percent of the land area is grassland, a large measure of which is pasture, another possible source of nonpoint source pollution.

IEPA (1997) indicated 28 livestock management facilities were in the Rayse Creek watershed; three of these were described as having moderate to high pollution potential. The Marion office of IEPA provided GIS files showing the locations of these facilities (Exhibits 18 and 19). All but one facility is on the west side of the stream. According to IEPA records, these sources include 13 feedlots, 14 livestock facilities and one pasture (Exhibit 19). While IEPA GIS files contain data on the location of the facilities within the Rayse Creek tributaries, there are no data on numbers and types of livestock, or farm waste management practices.

4.2.1 Model Selection

Quantitative assessment of nonpoint loads will be performed using predictive models. Application of a watershed and/or water quality model is typically required as part of TMDL development, in order to define allowable loads that will lead to attainment of water quality standards and designated uses. For this TMDL, the modeling objectives include:

- Consistency with Other Applications
- Acceptability to Stakeholders

- Model Constituents. TMDL development in this targeted watershed is limited to total suspended solids (an indictor of siltation), total phosphorus and BOD/DO.
- Spatial Scale
- Time Scale. Seasonal variability is important for TMDLs.
- Forecasting Capability. The watershed/water quality model must be suitable for forecasting the effects of different levels of treatment processes and watershed management practices on water quality.
- Model Reliability

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

- Simple methods (*e.g.,* EPA Simple Method)
- Mid-range models (*e.g*., Generalized Watershed Loading Functions)
- 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:

- Site specific characteristics
- Management objectives
- Available resources

Site-specific features of relevance for selecting a watershed model include the constituents of interest (solids, nutrients, BOD) and the nature of land use (mixture of urban, agriculture, grassland, and forest). Additional objectives relevant to model selection include predicting loads during specific events, such as the 1-in-10-year storm. Available resources include field data for the waterbody and the time available to devote to the assessments. Limited watershed data exist.

The effort to appropriately apply a rigorous watershed model would require several years of data collection and analysis. Because of the desire to have a management tool developed in a short time frame and with relatively limited data, it was recognized that a high level of complexity for the watershed model would not be suitable for this study. Simple and mid-range methods were considered for the TMDLs. The available watershed models are summarized in Exhibit 20.

The EPA screening procedures (Mills *et al*. 1985) are recommended as an appropriate simple modeling approach for simulating TSS and phosphorus loads in ILNK01. This approach predicts pollutant concentrations using the Universal Soil Loss Equation (USLE) and runoff curve number procedure. The AGNPS model was also considered, but would require the additional use of screening procedures for the urban loads. Other models that were considered are listed below, with the reason(s) they were discounted:

Model	**Reason for Rejection**
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. Could be modified for events.
FHWA	Designed for highways; no sediment capability
WMM	Annual loads only, no erosion/sediment capability
SITEMAP	Designed for retention basins/wetlands; no sediment capability
GWLF	Continuous simulation only, no single event capability.
P8-UCM	Urban only
Auto-QI	Continuous simulation only; no rural capabilities
AGNPS	Agricultural/rural only (no urban).
SLAMM	Continuous simulation only; no rural capabilities

U.S. EPA's (1997) *Compendium of Tools for Watershed Assessment and TMDL Development* recognizes limitations of the EPA screening procedures and other models. The simplicity of the EPA screening procedures approach offers advantages over more complex computational procedures in cases where data and resources are limiting. 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 (Freedman 2002).

The set of water quality models considered were those described in USEPA (1997). This document lists 20 receiving water models, divided into hydrodynamic, steady-state, and dynamic categories. Based on the desire for event-based evaluations identified in the management objectives, as well as resource constraints, candidate models were limited to the steady-state water quality models. Complex dynamic models provide much finer temporal and spatial resolution and simulate more parameters than required by the management objectives. The cost for this resolution is more complicated model set-up and more detailed model inputs, and may not manifest itself in reduced uncertainty (Freedman 2002). For these reasons, the dynamic models were not considered suitable for this project. The basic features of the steady-state models are summarized in Exhibit 21.

Limiting the steady-state models under consideration to those suitable for the site-specific characteristics (nutrients and solids in rivers and streams) results in the following list of models:

- EPA Screening Procedures
- QUAL2E

The EPA Screening Procedures are simplified methodologies that allow preliminary assessment of conventional and toxic pollutants in rivers, impoundments, and estuaries. 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. We have selected the Screening Procedures for modeling of instream siltation and phosphorus. The Screening Procedures could be modified to simulate DO, but we have opted to predict DO using the EPA's QUAL2E model.

4.2.2 Selection of Critical Periods

The traditional procedure for water quality modeling on a watershed basis consists of either a continuous simulation or "critical condition" approach. Continuous simulation provides rigorous results, but is often too data and resource intensive to apply on a watershed basis. Statistically selected critical environmental conditions (e.g. drought stream flows, design storms) are more easily applied. In this method, water quality evaluations are targeted to protect water quality during some critical period (typically low flow for point sources and high rainfall for nonpoint sources), under the assumption that these controls will be sufficient for most other periods.

For this TMDL, data are too sparse to set up continuous model simulations. We therefore relied on modeling a set of critical conditions. Two high flow events will be analyzed. A storm with a recurrence interval of one-in-three years will be the basis for the total suspended solids and phosphorus TMDL due to its relationship to the 305(b) assessment guideline used as the endpoint. The 305(b) assessment guidelines reflect a time scale of once in three years for exceedences at AWQMN stations.

Phosphorus binds very tightly to soil particles (Bohn *et al*. 1979). Small particles, such as clays, have proportionally greater binding capacity for phosphorus and are more erodible than larger soil particles (Bohn *et al*. 1979, Hill and Mannering 1995). Hence, TSS and total phosphorus are eroded and transported together under wet weather conditions, and can be modeled similarly.

As part of our uncertainty analysis, we have also opted to evaluate a storm with a recurrence interval of 10 years. Further to uncertainty analysis, three different storm durations are being evaluated: 12-hour duration, 24-hour duration and 72-hour duration. TSS and phosphorus loadings under low flow conditions will not be modeled because the point source is not expected to contribute significantly to impairment of segment NK 01.

The critical period for the DO TMDL is during low flow events (< 5 cfs) when water temperature is high (generally summer). Therefore, DO was modeled under these low flow conditions and not for higher flow conditions.

4.2.3 Watershed Model Development

Sediment, phosphorus and BOD loadings to Rayse Creek were computed for the study area using the EPA's Simple Method for Watershed Sediment Yield. This technique uses data for rainfall, land uses, and soil types in the subwatersheds to estimate soil erosion (Mills *et al.* 1985). The subwatershed sediment yield, Y, due to surface erosion is estimated as:

$$Y = s_d \sum_k X_k A_k \qquad \text{Equation (1)}$$

where

Y = sediment yield (tons)

X_k = erosion from subwatershed k (tons/ha)

A_k = area of subwatershed k (ha)

s_d = subwatershed sediment delivery ratio

The s_d factor accounts for the attenuation of sediment through deposition and filtering as it travels from source areas to the watershed outlet. Erosion, X, from each subwatershed was estimated using the Universal Soil Loss Equation (USLE), an empirical equation designed to predict average soil loss from source areas (Equation 2).

$$X = 1.29(E)(K)(ls)(C)(P) \qquad \text{Equation (2)}$$

where

X = soil loss (tons/ha)

E = rainfall/runoff erosivity index (100 m-ton-cm/ha-hr), also identified as R in some publications

K = soil erodibility (tons/ha per unit of E)

ls = topographic factor

C = cover/management factor

P = supporting practice factor

The USLE is widely used in the United States and abroad for soil conservation planning (Nearing *et al*. 2001). The USLE approach is the basis for many other watershed models, such as AGNPS, WATERSHED and SWMM (USEPA 1997). The Revised USLE, or RUSLE, is a similar tool used to estimate soil loss. We contacted the developers of RUSLE and were advised that it should not be used to estimate erosion for individual storms. They also stated that soil loss estimates from USLE are consistent with those calculated by the Revised Universal Soil Loss Equation (RUSLE) when comparing 206 natural runoff plots representing a broad range of conditions (Rapp *et al.* 2001).

The erosivity index, E, reflects rainfall intensity, among other factors. Expected magnitudes of single-storm erosivity indices are presented in Wischmeier and Smith (1978). Erosivity values for the Rayse Creek watershed were linearly interpolated between two stations in Illinois (Cairo and Springfield). For a 1-year storm, the erosivity is 65 (10^2 m-ton-cm/ha-hr). For the 3-year storm, the erosivity is 118 (10^2 m-ton-cm/ha-hr). For the 10-year storm, the erosivity is 199 (10^2 m-ton-cm/ha-hr).

We consulted with the Jefferson County Soil and Water Conservation District for selection of K, ls, and C values. Soil erodibility, or K, values are a function of soil texture and organic content. The topographic factor, ls, is related to slope angle and slope length. Soil type was identified for each subwatershed using the STATSGO database.

Corresponding K and ls values are tabulated in Table 16, derived from information provided by the Jefferson County SWCD. No information on K or ls values is available at the soil association level. Therefore, K and ls values for each soil type in a soil association are calculated based on a weighting formula that accounts for the relative amount of each soil type in Jefferson County.

Table 16

SOIL ERODIBILITY "K" AND TOPOGRAPHIC FACTOR "LS"
(Sources: STATSGO Database and Jefferson Co. SWCD)

Soil Type	Soil ID	K Value	ls Value
Cisne-Hoyleton-Darmstadt	IL006	0.34	0.18
Bluford-Ava-Hickory	IL038	0.42	0.64
Hurst-Reesville-Patton	IL051	0.43	0.17

The cover/management, or C, factor is the ratio of soil loss under the conditions being evaluated to that which would occur under continuously bare soil. C reflects the protection of the soil surface by plant canopy, crops, and mulches. A C value of 1.0 corresponds to no protection, while a value of 0.0 corresponds to total protection. Published C values were selected from Wischmeier and Smith (1978) based on the land use type. No published values for urban lands are available. Urban areas tend to be hardened and stabilized; the practice in the industry is to set the C value equal to zero (Wischmeier and Smith 1978). Since the watershed is less than 0.2 percent urban, this does not significantly contribute to uncertainty. The Jefferson County SWCD provided C factors for agricultural lands (Table 17). These row-crop agriculture C factors reflect a corn-soybean crop rotation, which predominates in this watershed.

Table 17

AGRICULTURAL C FACTORS
(Source: Jefferson Co. NRCS)

Land Cover	C Factor
Row Crop Agriculture (Conventional Tillage)	0.17-0.22
Row Crop Agriculture (Conservation Tillage)	0.06-0.08
Rural Grassland/Conservation Reserve Set-Aside	0.001

Data on conventional or reduced tillage (0-30 percent residue) versus conservation tillage (>30 percent residue) is not available on a watershed basis. It is available at the county level from the Statewide Soil Conservation Transect Survey that was conducted in the spring and early summer of 2000. The Transect Survey indicates the status of soil conservation efforts. Survey teams in each county collect information on tillage systems and crop residue amounts at over 50,000 points across the state. The Rayse Creek watershed includes 63,584 acres in Jefferson and Washington counties (Table 18).

Table 18

WATERSHED AREA BY COUNTY
(Source: Watershed Delineation GIS files, IEPA)

County	Area (ac)	% of Watershed
Jefferson	52,307	82.3
Washington	11,277	17.7
Total	63,584	100

Tables 19 and 20 show the distribution tillage systems and crop residues for Jefferson and Washington counties for 1995 and 2000. We opted to utilize the 1995 data from these tables to develop the watershed loadings model so that crop residue information was consistent with the dates for the land use/land cover and water quality data.

Table 19

JEFFERSON COUNTY TILLAGE AND RESIDUE INFORMATION (ACRES)
(Source: Transect Data, Illinois Department of Agriculture)

Tillage System	Corn	Soybeans	Small Grains	Residue Level	Corn	Soybeans	Small Grains
1995 Tillage				**1995 Crop Residues**			
Conventional	17,080	32,918	311	0-15%	16,148	24,533	311
Reduce-till	1,242	4,658	1,863	16-30%	2,795	15,527	1,863
Mulch-till	1,863	5,590	1,553	>30%	12,111	30,744	10,559
No-till	10,559	27,639	621	NA	0	0	3,105
N/A	311	0	11,490	Unknown	0	0	0
Unknown	0	0	0				
Total	31,055	70,804	15,838	Total	31,055	70,804	15,838
2000 Tillage				**2000 Crop Residues**			
Conventional	17,990	22,079	2,453	0-15%	17,581	21,670	1,635
Reduce-till	3,271	7,360	1,227	16-30%	4,498	7,360	2,044
Mulch-till	6,133	5,315	1,635	>30%	26,985	51,108	18,399
No-till	21,261	45,384	16,763	NA	0	0	0
N/A	0	0	0	Unknown	0	0	0
Unknown	409	0	0				
Total	49,064	80,137	22,079	Total	49,064	80,137	22,079

Table 20

WASHINGTON COUNTY TILLAGE AND RESIDUE INFORMATION (ACRES)
(Source: Transect Data, Illinois Department of Agriculture)

Tillage System	Corn	Soybeans	Small Grains	Residue Level	Corn	Soybeans	Small Grains
1995 Tillage				**1995 Crop Residues**			
Conventional	35,162	27,348	25,069	0-15%	35,488	27,348	24,744
Reduce-till	5,860	15,628	19,534	16-30%	7,814	16,604	20,186
Mulch-till	1,628	10,093	21,162	>30%	31,906	41,348	31,906
No-till	32,557	32,232	11,070	NA	0	0	0
N/A	0	0	0	Unknown	0	0	0
Unknown	0	0	0				
Total	75,208	85,300	76,835	Total	75,208	85,300	76,835
2000 Tillage				**2000 Crop Residues**			
Conventional	30,940	10,743	9,024	0-15%	30,940	10,743	9,024
Reduce-till	33,518	16,329	44,691	16-30%	33,518	16,329	44,691
Mulch-till	8,594	24,494	19,767	>30%	51,567	91,531	31,370
No-till	42,972	67,037	11,603	NA	0	0	0
N/A	0	0	0	Unknown	0	0	0
Unknown	0	0	0				
Total	116,025	118,604	85,085	Total	116,025	118,604	85,085

Table 21 summarizes tillage systems and crop residue on the fields for the years 1995 and 2000.

Table 21

SUMMARY OF CONVENTIONAL AND CONSERVATION TILLAGE
(Source: Transect Data, IDOA)

County	2000		1995	
	Conventional Tillage (%)	Conservation Tillage (%)	Conventional Tillage (%)	Conservation Tillage (%)
Jefferson	36.2	63.8	52.0	48.0
Washington	45.4	54.6	55.7	44.3

We calculated an overall watershed weighted C factor for agricultural row crop land from these estimates of cover factors for conventional and conservation tillage (Table 17), the area of watershed in each county (Table 18), and the number of acres of conventional and conservation tillage in each county (Tables 19 and 20). We used 1995 crop residue and land use conditions. Table 22 presents the cover factors for all land use/land cover types in the watershed. Table 23 provides the weighted average C factors for each subwatershed during the fall season. The Jefferson County SWCD provided average C factors for the fall season, but had no spring values. We obtained spring C factors from the Marion County SWCD. As acres in the spring are subsequently planted, and fall acres are not, C factors are higher in fall. The area-weighted average C factor for agricultural row cropland in the watershed is 0.14 for the fall season.

Table 22

C VALUES FOR THE TARGET WATERSHED – FALL SEASON
(Source: Wischmeier and Smith, 1978, except as noted in text)

Land Use	C Value
Urban – High Density	0
Urban – Medium Density	0
Agriculture – Rowcrop	0.14
Agriculture – Small Grains	0.055
Agriculture – Orchards/Nurseries	0.055
Urban Grassland	0.055
Rural Grassland	0.001
Forested – Deciduous: Closed Canopy	0.004
Forested – Deciduous: Open Canopy	0.004
Water	0
Shallow Marsh/ Wet Meadow	0.055
Deep Marsh	0.055
Forested Wetland	0.004
Shallow Water Wetland	0.055

Table 23

AVERAGE SUBWATERSHED C FACTORS – FALL SEASON

Subwatershed	Average C Factor
RC-1	0.070
RC-2	0.080
RC-3	0.068
RC-4	0.062
RC-5	0.049
RC-6	0.049
RC-7	0.032
RC-8	0.056
RC-9	0.044
RC-10	0.069
RC-11	0.084
RC-12	0.078

The supporting practice factor P is a measure of the effect of traditional soil conservation practices on erosion from agricultural fields. Watershed-wide information on conservation practices has been difficult to obtain. The data we have been able to collect on conservation practices have been incorporated into the cover factor, as discussed above. Our approach is to set P equal to 1.0, corresponding to no conservation practices, and serving as a "worst case" scenario.

Soil loss estimates for one, three and 10-year storms using the above described techniques are presented in Table 24. Details on subwatershed soil loss computations can be found in Appendix B. These data reflect the fall season, which is the season with the highest relative soil loss. Table 25 provides estimates of areal soil loss. Subwatershed RC-1 has the highest areal soil loss followed by subwatersheds RC-2 and RC-6.

Table 24

SUBWATERSHED SOIL LOSS – FALL SEASON
(tons)

Subwatershed	Area (acres)	1-Year Storm	3-Year Storm	10-Year Storm
RC-1	3,590	1,891	3,432	5,788
RC-2	5,956	2,890	5,247	8,848
RC-3	4,531	1,379	2,504	4,222
RC-4	7,649	2,415	4,384	7,393
RC-5	5,997	1,972	3,580	6,037
RC-6	5,626	2,740	4,975	8,390
RC-7	3,202	1,022	1,855	3,128
RC-8	13,937	2,634	4,781	8,063
RC-9	5,715	1,593	2,893	4,878
RC-10	2,649	874	1,586	2,675
RC-11	2,271	436	792	1,336
RC-12	2,461	479	869	1,466
Total	**63,584**	**20,325**	**36,898**	**62,226**

Table 25

SUBWATERSHED AREAL SOIL LOSS – FALL SEASON
(tons/acre)

Subwatershed	Area (acres)	1-Year Storm	3-Year Storm	10-Year Storm
RC-1	3,590	0.53	0.96	1.61
RC-2	5,956	0.49	0.88	1.49
RC-3	4,531	0.30	0.55	0.93
RC-4	7,649	0.32	0.57	0.97
RC-5	5,997	0.33	0.60	1.01
RC-6	5,626	0.49	0.88	1.49
RC-7	3,202	0.32	0.58	0.98
RC-8	13,937	0.19	0.34	0.58
RC-9	5,715	0.28	0.51	0.85
RC-10	2,649	0.33	0.60	1.01
RC-11	2,271	0.19	0.35	0.59
RC-12	2,461	0.19	0.35	0.60

Phosphorus loadings to Rayse Creek were also computed for each of the 12 subwatersheds. Loadings calculations are based upon two nonpoint agricultural sources: soil erosion and livestock facilities. The soil erosion source estimate is calculated from the sediment yield, phosphorus concentration in the soil, and the nutrient enrichment ratio (Mills *et al.* 1985). The watershed phosphorus yield due to surface erosion is:

$$Wp = 0.001 s_d \sum_k Cs_k \; X_k \; A_k \qquad \text{Equation (3)}$$

where:

W_p = solid-phase phosphorus load in runoff (kg/ha)

Cs_k = concentration of chemical in eroded soil in source area k (mg/kg)

X_k = soil loss in source area k (tons/ha)

A_k = area of subwatershed k (ha)

The concentration of chemical in eroded soil, Cs_k, is computed as the product of nutrient enrichment ratio, en, and the nutrient concentration in soil. Phosphorus concentrations in *in situ* soil were not available from the STATSGO database for the study area. Therefore, we estimated phosphorus concentration from a general soil nutrient map provided by Mills *et al.* (1985). Southern Illinois has a soil P_2O_5 concentration as phosphorus of between 0.05 and 0.09 percent. A value of 0.078 was taken to calibrate the model. Since 44 percent of P_2O_5 is phosphorus, and 1 percent = 10,000 mg/kg, Ci = 0.04 (0.078% P_2O_5) x 10^4, or 343 mg/kg.

The sediment nutrient concentration can be related to the comparable concentration in soil by an enrichment ratio, $C_s = enC_i$

A nutrient enrichment ratio is a measure of the degree of erosion that occurs during a specific storm event, and is defined by the following relationship for single events (Mills *et al.* 1985):

$$en = \frac{7.39}{1000 X^{0.2}} \qquad \text{Equation (4)}$$

where X = soil loss (tons/ha).

We estimated phosphorus and BOD_5 loadings from livestock operations as a product of the number of animals and the expected contribution per animal. The Illinois EPA identified 28 livestock farms in the Rayse Creek watershed (IEPA 1997). No site-specific information is available on the number of animals in the watershed, however county-wide data are available. The 1997 Census of Agriculture for Jefferson County was used to estimate that the average farm has 21 cows and 13 hogs. Because no large hog operations are noted in the watershed, the census data for small operations (fewer than 100 hogs) were used for this estimation. Tunney (1980) reported that dairy and beef cows produce 8.2 percent and 6 percent, respectively, of their body weight in fresh manure every day. Our analysis used an average value of 7.1 percent of the body weight to account for both dairy and beef cows. Tunney (1980) also stated the range of values from the literature for phosphorus content of cow manure to be between 4 to 18 kilograms per 10 tons of fresh manure. For this analysis, the average value in this range, 11 kilograms per 10 tons of fresh manure, was used. For hogs, Tunney (1980) estimated they produce 6.5 percent of their body weight in fresh manure each day and the range of values from the literature for phosphorus content of hog manure to be between 6 to 21 kilograms per 10 tons of fresh manure. Our analysis used the average value in this range, 13.5 kilograms per 10 tons of fresh manure. Table 26 estimates average daily phosphorus production from a livestock facility in Jefferson County, serving as the basis for our Rayse Creek watershed phosphorus source assessment. Values presented by Tunney are comparable with those presented by the MidWest Plan Service (Lorimor *et al.,* 2000).

Table 26

AVERAGE PHOSPHORUS (P) PRODUCTION FROM A LIVESTOCK OPERATION

Animal	No./Farm	Animal Weight (lbs)	Manure Production (lbs/animal/d)	Total Manure (lbs/d)	P Production (kg/d)
Cows	21	500	35.5	745.5	0.373
Hogs	13	190	12.4	161.2	0.099

Extending this average daily phosphorus production at a livestock facility to all facilities inventoried in the 12 subwatersheds allows us to estimate that 2,647 kg of phosphorus are produced by livestock in the study area each year (Table 27).

Table 27

PHOSPHORUS PRODUCTION BY ALL LIVESTOCK OPERATIONS

Subwatershed	No. Cow Facilities	No. Swine Facilities	P from Cow (kg/yr)	P from Swine (kg/yr)	Livestock P Production (kg/yr)
RC-1	3	3	408	108	516
RC-2	4	3	545	108	653
RC-3	0	0	0	0	0
RC-4	3	2	408	72	480
RC-5	1	1	136	36	172
RC-6	1	0	136	0	136
RC-7	0	0	0	0	0
RC-8	4	4	545	145	690
RC-9	0	0	0	0	0
RC-10	0	0	0	0	0
RC-11	0	0	0	0	0
RC-12	0	0	0	0	0
Total	**16**	**13**	**2,178**	**469**	**2,647**

BOD_5 is the measurement of the DO used by microorganisms in the biochemical oxidation of organic matter over a period of five days. BOD_5 loads will consume DO in the water. The MidWest Plan Service (Lorimor *et al.,* 2000) provides estimates of BOD_5 production for cows and hogs. For a 500-pound dairy cow, the BOD_5 production is approximately 0.65 pounds per day. For a 500-pound beef cow, the BOD_5 production is approximately 0.70 pounds per day. We opted to use 0.68 lb/d (0.31 kg/d) as a bovine average. For a 190-pound hog, the BOD_5 production is approximately 0.28 lb/d (0.13 kg/d). Table 28 estimates average daily BOD_5 production from livestock in Jefferson County and serves as the basis for our Rayse Creek watershed BOD source assessment.

Table 28

AVERAGE BOD_5 PRODUCTION FROM A LIVESTOCK OPERATION

Animal	No./Farm	Production Rate (lb/d)	BOD_5 Production (lb/d)
Cows	21	0.68	14.28
Hogs	13	0.28	3.64

Extending this average daily BOD_5 production at a livestock facility to all facilities inventoried in the 12 subwatersheds allows us to estimate that 100,668 lbs of BOD_5 are produced by livestock in the study area each year (Table 29).

Table 29

BOD_5 PRODUCTION BY ALL LIVESTOCK OPERATIONS

Subwatershed	No. Cow Facilities	No. Swine Facilities	BOD_5 from Cow (lb/yr)	BOD_5 from Swine (lb/yr)	Livestock BOD_5 Production (lb/yr)
RC-1	3	3	15,637	3,986	19,623
RC-2	4	3	20,849	3,986	24,835
RC-3	0	0	0	0	0
RC-4	3	2	15,637	2,657	18,294
RC-5	1	1	5,212	1,329	6,541
RC-6	1	0	5,212	0	5,212
RC-7	0	0	0	0	0
RC-8	4	4	20,849	5,314	26,163
RC-9	0	0	0	0	0
RC-10	0	0	0	0	0
RC-11	0	0	0	0	0
RC-12	0	0	0	0	0
Total	**16**	**13**	**83,396**	**17,272**	**100,668**

Table 30 compares the BOD_5 concentrations of livestock and municipal waste. Undiluted, lagooned animal wastes have very large oxygen demands. Additionally, runoff from animal lots also has large oxygen demands. Animal holding facilities can contribute very large concentrations of BOD_5 to the stream. Data for the Rayse Creek watershed are not available to identify the impact from these sources, and we recommend that the next intensive basin survey include collection of data on numbers/type of livestock and management of manure at the 28 livestock facilities.

IEPA's monitoring of ALUS in waterbody segment NK 02 occurs in Rayse Creek between subwatersheds RC-5 and RC-7. Because many livestock facilities are downstream of NK 02, the sources of BOD loads and DO deficits are either in subwatersheds RC-8 or RC-5. IEPA's intensive basin survey indicates a swine facility in RC-5 and a cattle feedlot in RC-8 to be "high risk" for adversely impacting stream ALUS (IEPA 1997).

An additional future source of BOD_5 in the watershed will be the Richview WWTP when it becomes active. For comparison with Tables 29 and 30, the Richview WWTP is permitted to discharge BOD_5 with a monthly average load limit of 35 lb/d and a weekly average maximum limit of 56 lb/d (as well as a monthly average concentration limit of 25 mg/L and a weekly average maximum concentration limit of 40 mg/L).

Table 30

POLLUTION STRENGTH OF TYPICAL LIVESTOCK AND MUNICIPAL WASTES (Source: IEPA, 1991)

Type of Waste	BOD_5 (mg/L)
Undiluted Livestock Waste	40,000
Manure Lagoon Effluent	14,400
Runoff from a Feedlot (Concrete)	1,000
Runoff from a Feedlot (Earthen)	500
Raw Municipal Sewage	250
Treated Municipal Sewage	30

Aside from animal production and the point source, BOD_5 loads also arise from land runoff. Estimates of BOD_5 production rates based on land type were taken from the literature as neither site specific data nor measurements are available (Table 31).

Table 31

LAND USE BASED BOD_5 (Source: Northwest Florida Water Management District, 1994)

Land Use	Average Rate (lbs/ac/yr)
Urban	18
Agriculture	10
Grassland	20
Forested	5
Wetland	12

These rates were used to calculate the BOD_5 load associated with land use for each subwatershed (Table 32).

Table 32

BOD_5 PRODUCTION (LBS/YR) BASED ON LAND USE

Source	Urban	Agriculture	Grassland	Forested	Wetland	Total
RC1	176	19,263	23,036	591	3,506	46,572
RC2	40	31,949	42,623	1,429	2,231	78,273
RC3	0	23,134	20,018	887	11,026	55,065
RC4	56	37,621	54,278	3,466	3,091	98,513
RC5	0	23,222	35,281	6,813	3,856	69,172
RC6	532	20,838	46,236	3,910	3,080	74,597
RC7	0	7,703	28,962	3,160	3,070	42,895
RC8	976	63,630	91,975	10,577	4,156	171,315
RC9	17	17,659	33,370	8,315	4,582	63,942
RC10	0	13,243	10,525	2,950	1,182	27,900
RC11	2	13,996	9,534	1,244	801	25,576
RC12	0	13,823	11,831	1,758	569	27,981
Total	**1,801**	**286,082**	**407,669**	**45,101**	**41,151**	**781,803**

A summary of total estimated BOD_5 production from land runoff and animal production is estimated in Table 33. Richview STP, not yet operational, is not included.

Table 33

TOTAL ESTIMATED BOD_5 PRODUCTION (LBS/YR)

Source	Land	Animal	Total	Source	Land	Animal	Total
RC1	46,572	19,623	66,195	**RC7**	42,895	0	42,895
RC2	78,273	24,835	103,108	**RC8**	171,315	26,136	197,451
RC3	55,065	0	55,065	**RC9**	63,942	0	63,942
RC4	98,513	18,294	116,807	**RC10**	27,900	0	27,900
RC5	69,172	6,541	75,713	**RC11**	25,576	0	25,576
RC6	74,597	5,212	79,809	**RC12**	27,981	0	27,981
				Total	**781,803**	**100,641**	**882,444**

These estimates suggest that livestock are responsible for approximately 11 percent of the total BOD_5 produced in the watershed. In individual subwatersheds, livestock are responsible for as much as 30 percent of the BOD_5 production.

No data are available on the management of livestock wastes in the watershed. Phosphorus and BOD_5 enter Rayse Creek from feedlots or field runoff, and manure may be lagooned or land applied. According to our interviews with agricultural officials, manure is generally spread on fields during early spring and late fall. Some is also applied during dry times in the spring and in July on wheat stubble. Our load estimates are based on the annual manure load being transported to Rayse Creek during the large (greater than or equal to one year) storm events in the same proportion as sediment (i.e., if $s_d = 0.20$, 20 percent of the manure phosphorus is also transported to the stream). We believe this to be a generally conservative approach because:

- Phosphorus from field-applied manure will mineralize and bind to soil particles. BOD will rapidly oxidize on the soil surface.
- Not all manure is applied to fields.
- Some of the manure nutrients will be assimilated by vegetation and soil microbes before erosion and transport can take place.
- Not all manure applied to the fields is transported to streams.

5. WATER QUALITY ANALYSIS

Chapter 5 discusses the development and calibration of a water quality model for the target waterbody, a prerequisite for developing the TMDL. Total suspended solids and total phosphorus concentrations during wet weather events are predicted using the EPA screening procedures, essentially a runoff-dilution model. Dissolved oxygen is modeled using QUAL2E. Details of the EPA screening procedures, essentially the water quality analyses, are in Appendix C.

5.1 Hydrology

For each subwatershed, total runoff volume was calculated using the Soil Conservation Service[2] (SCS) Rainfall-Runoff Method (SCS 1972). The volume of runoff (Q) depends on the volume of precipitation (P) and the volume of storage (S) that is available for retention. A certain volume of precipitation at the beginning of a storm, the initial abstraction (I_a), will not appear as runoff. The SCS Method involves the following equation to calculate runoff:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}$$ Equation (5)

Initial abstraction (I_a) is a function of land use, management, and condition; interception; infiltration; depression storage; and antecedent soil moisture (SCS 1972). An empirical equation was developed by the SCS for estimating I_a:

$$I_a = 0.2S$$ Equation (6)

where:

$$S = \frac{1000}{CN} - 10$$ Equation (7)

Runoff curve numbers (CN) are provided by the SCS Method for different land uses and cover types; separate values are provided for four hydrologic soil groups. Published curve number values were selected from McCuen (1982) based on land use type, antecedent soil moisture condition II (average soil moisture conditions), and hydrologic soil group

[2] Now known as the Natural Resources Conservation Service

classification C (indicative of the watershed). Table 34 presents the CN values chosen to represent the target watershed, ILNK01.

Table 34

SUMMARY OF CURVE NUMBERS BASED ON LAND USE TYPE
(Source: McCuen 1982)

Land Use	Curve Number	Basis of Estimate
Urban-High Density	83	¼ acre residential lot
Urban-Medium Density	80	½ acre residential lot
Agriculture-Row Crop	85	Cultivated land without conservation treatment
Agriculture-Small Grains	83	Small grain, straight row, good condition
Agriculture-Orchards/Nurseries	71	Meadow
Urban Grassland	74	Open spaces, good condition
Rural Grassland	79	Open spaces, fair condition
Forested-Deciduous: Closed Canopy	70	Woods, good condition
Forested-Deciduous: Open Canopy	73	Woods, fair condition
Water	0	
Shallow Marsh/ Wet Meadow	86	Pasture, poor condition
Deep Marsh	0	
Forested Wetland	77	Woods, poor condition
Shallow Water Wetland	0	

Combining Equations 5 and 6 results in the following equation used to calculate runoff:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$ Equation (8)

Depths of rainfall for one, three and 10-year storms of several durations are presented in Table 35. These data, for Zone 9 in Illinois, are applicable for the Rayse Creek watershed.

Table 35

RAINFALL (INCHES) FOR MULTIPLE RETURN PERIODS AND DURATIONS
(Source: Huff and Angel, 1992)

Duration	1 yr	2 yr	3 yr[1]	5 yr	10 yr	25 yr	50 yr	100 yr
10 days	4.75	5.74	6.18	7.09	8.07	9.54	10.68	11.79
5 days	3.75	4.48	4.89	5.57	6.5	7.91	9.16	10.57
3 days	3.27	3.92	4.3	4.92	5.75	7.05	8.23	9.4
2 days	3	3.6	3.95	4.52	5.28	6.48	7.58	8.62
24 hours	2.62	3.16	3.47	4	4.62	5.79	6.71	7.73
18 hours	2.41	2.91	3.19	3.68	4.25	5.33	6.17	7.11
12 hours	2.28	2.75	3.02	3.48	4.02	5.04	5.84	6.72
6 hours	1.97	2.37	2.6	3	3.47	4.34	5.03	5.8
3 hours	1.68	2.02	2.22	2.56	2.96	3.71	4.29	4.95
2 hours	1.55	1.85	1.92	2.36	2.72	3.41	3.96	4.56
1 hours	1.23	1.49	1.63	1.88	2.2	2.72	3.15	3.63
30 min.	0.97	1.17	1.28	1.47	1.73	2.14	2.48	2.86
15 min.	0.71	0.85	0.94	1.08	1.25	1.56	1.81	2.09
10 min.	0.58	0.7	0.77	0.88	1.02	1.27	1.48	1.7
5 min.	0.32	0.38	0.42	0.48	0.55	0.69	0.81	0.93

[1] Note: Data for the three-year return period were interpolated.

Runoff varies not only with the amount of precipitation but with the duration of the storm, antecedent moisture conditions, vegetation, and other factors. Our water quality model includes an analysis of the effect of storm duration on pollutant loads and concentrations. To aid selection of storm duration for this TMDL, we examined the work of Huff (1967). This researcher investigated time distributions for 261 storms over the 12-year period 1955-1966 from a 400-square-mile network of 49 recording rain gages in east-central Illinois. Among the 261 storms, 42 percent had durations less than or equal to 12 hours, 33 percent lasted from 12.1 to 24 hours, and 25 percent had durations exceeding 24 hours. Our sensitivity analysis included the effect on water quality of storm durations of 12 hours, 24 hours, and 72 hours. Hence, we are examining the water quality conditions of 12 hydrologic events (Table 36).

Table 36

RAINFALL (INCHES) FOR SELECT RETURN PERIODS

(Source: Huff and Angel, 1992)

Return Period (yr)	Precipitation (inches)			
	6-hr duration	12-hr duration	24-hr duration	72-hr duration
1	1.97	2.28	2.62	3.27
3	2.60	3.02	3.47	4.30
10	3.47	4.02	4.62	5.75

Given the precipitation shown in Table 36, we used Equation 8 to derive runoff volumes for these 12 storms for each subwatershed (Table 37). Details on the curve numbers and precipitation and runoff calculations for each subwatershed can be reviewed in Appendix C.

Table 37

SUMMARY OF RUNOFF VOLUMES (AC-FT)

Subwatershed	1-Year Return Period				3-Year Return Period				10-Year Return Period			
	6 hr	12 hr	24 hr	72 hr	6 hr	12 hr	24 hr	72 hr	6 hr	12 hr	24 hr	72 hr
RC-1	182	244	317	467	313	408	515	724	515	653	807	1,110
RC-2	295	397	517	764	510	667	844	1,188	844	1,070	1,326	1,826
RC-3	223	300	390	578	385	504	638	900	638	810	1,004	1,384
RC-4	366	494	646	826	637	836	1,061	1,500	1,061	1,349	1,675	2,313
RC-5	245	337	448	681	442	589	757	1,087	757	973	1,220	1,707
RC-6	245	335	442	665	436	577	738	1,053	738	945	1,180	1,642
RC-7	125	174	232	354	228	306	394	569	394	509	639	897
RC-8	610	834	1,100	1,654	1,084	1,435	1,834	2,617	1,834	2,347	2,930	4,076
RC-9	216	300	403	618	396	533	689	998	689	891	1,123	1,580
RC-10	115	157	207	312	204	271	346	494	346	443	554	771
RC-11	115	155	201	296	198	258	326	459	326	413	511	703
RC-12	118	159	208	309	205	269	342	483	342	434	539	745

5.2 Suspended Solids Yield

TSS concentration in the EPA screening procedures is computed as the quotient of sediment yield (mass) and runoff volume. Sediment yield is computed using an empirical model specific for Rayse Creek (Equation 1). We selected a 24-hour, 1-year event for calibration of the water quality model because the available USGS streamflow dataset had a maximum measured flow of 860 cfs, significantly lower than that estimated for the 3-year event. Return periods of various storm events, and their corresponding discharges, were presented in Table 6. In analyzing water quality data, we found a statistically significant correlation ($P<0.001$) between TSS concentrations and discharge (Q) at NK 01. The standard error of estimate for the regression is 105 mg/L. The regression equation (Equation 9) allows TSS concentration, C, to be estimated.

$$C = 0.51Q + 38.1 \qquad \text{Equation (9)}$$

Using Equation 9, TSS concentration during a 24-hr, 1-year storm flow (1,100 cfs) is 599 ±105 mg/L.

EPA screening procedures very closely predicted actual values in the uncalibrated (initial condition). Calibration of the EPA screening procedures was limited to varying the topographic factor (ls) to match the 24-hr, 1-year storm flow event (1,100 cfs) that is associated with a TSS concentration of 600 mg/L (Table 38). The calibrated model was then used to estimate TSS concentrations for the 24-hour three- and 10-year events.

Table 38

LENGTH SLOPE (ls) CALIBRATION VALUES

Soil Type	Soil ID	ls Range	Weighted ls	Calibrated ls
Cisne-Hoyleton-Darmstadt	IL006	0.04-0.49	0.18	0.198
Bluford-Ava-Hickory	IL038	0.17-3.73	0.64	0.704
Hurst-Reesville-Patton	IL051	0.17-0.19	0.17	0.187

Table 39

SEDIMENT DELIVERY RATIO
(Source: Wischemeir and Smith 1978)

Subwatershed	Value
RC-1	0.19
RC-2	0.19
RC-3	0.19
RC-4	0.18
RC-5	0.19
RC-6	0.19
RC-7	0.20
RC-8	0.15
RC-9	0.19
RC-10	0.20
RC-11	0.21
RC-12	0.20

The product of subwatershed soil loss (Table 24) and sediment delivery ratio provides (Table 39) an estimate of subwatershed sediment yield, that is, the quantity of sediment delivered to the stream (Table 40).

Table 40

SUBWATERSHED SEDIMENT YIELD (TONS) – FALL SEASON

Subwatershed	Area (acres)	1-Year Storm	3-Year Storm	10-Year Storm
RC-1	3,590	359	652	1,100
RC-2	5,956	549	997	1,681
RC-3	4,531	262	476	802
RC-4	7,649	435	789	1,331
RC-5	5,997	375	680	1,147
RC-6	5,626	521	945	1,594
RC-7	3,202	204	371	626
RC-8	13,937	395	717	1,209
RC-9	5,715	303	550	927
RC-10	2,649	175	317	535
RC-11	2,271	92	166	281
RC-12	2,461	96	174	293
Total	**63,584**	**3,765**	**6,834**	**11,526**

Estimates of areal sediment yield are presented in Table 41. The highest areal sediment yield is predicted for RC-1, closely followed by RC-2 and RC-6. This is largely due to significant portions of the Bluford-Ava-Hickory (IL038) soil association being used for row crop production in those subwatersheds. Computational details are in Appendices B and C.

Table 41

SUBWATERSHED AREAL SEDIMENT YIELDS (TONS/AC) – FALL SEASON

Subwatershed	Area (acres)	1-Year Storm	3-Year Storm	10-Year Storm
RC-1	3,590	0.10	0.18	0.31
RC-2	5,956	0.09	0.17	0.28
RC-3	4,531	0.06	0.10	0.18
RC-4	7,649	0.06	0.10	0.17
RC-5	5,997	0.06	0.11	0.19
RC-6	5,626	0.09	0.17	0.28
RC-7	3,202	0.06	0.12	0.20
RC-8	13,937	0.03	0.05	0.09
RC-9	5,715	0.05	0.10	0.16
RC-10	2,649	0.07	0.12	0.20
RC-11	2,271	0.04	0.07	0.12
RC-12	2,461	0.04	0.07	0.12

5.3 Phosphorus Yield

Application of the phosphorus loading equation (Equation 3) to the above predictions of sediment yield provide estimates of phosphorus yield associated with soil erosion. Subwatershed phosphorus enrichment ratios (Table 42) were calculated using Equation 4.

Table 42

PHOSPHORUS ENRICHMENT RATIOS

Subwatershed	1-Year	3-Year	10-Year
RC-1	2.45	2.18	2.02
RC-2	2.50	2.21	1.99
RC-3	2.74	2.43	2.19
RC-4	2.75	2.44	2.20
RC-5	2.70	2.39	2.16
RC-6	2.49	2.21	1.99
RC-7	2.69	2.38	2.15
RC-8	3.16	2.80	2.53
RC-9	2.79	2.47	2.23
RC-10	2.67	2.37	2.13
RC-11	2.94	2.61	2.35
RC-12	2.97	2.63	1.99

A 24-hour, one-year event was selected for calibration of the EPA screening procedures because the available dataset had a maximum flow of 860 cfs, significantly lower than that estimated for the 3-year event. Return periods of various storm events, and their corresponding discharges, were presented in Table 6. In analyzing water quality data, we did not find a statistically significant correlation between total phosphorus concentrations and discharge (Q) at NK 01.

Phosphorus concentrations that exceed the target water quality concentration of 0.61 mg/L are presented in Table 43.

Table 43

WATER QUALITY MEASUREMENTS AT NK 01 EXCEEDING THE TARGET PHOSPHORUS CONCENTRATION

Flow (cfs)	Total Phosphorus (mg/L)	Date
860	0.63	4/1/96
300	0.75	11/26/96
225	0.75	1/23/96
188	0.85	1/2/96
16	2.5	11/18/91
7.5	1.46	11/10/94
0.22 (estimated)	0.68	12/2/98

As mentioned above, 860 cfs is the highest measured flow in the NK 01 dataset. The target phosphorus concentration was not only exceeded at the highest flows in the dataset, but also at flows much lower than these.

Three additional high flows were in the dataset that did not exceed the target water quality concentration (Table 44).

Table 44

HIGH FLOW MEASUREMENTS NOT EXCEEDING THE TARGET PHOSPHORUS CONCENTRATION

Flow (cfs)	Total Phosphorus (mg/L)	Date
824	0.48	5/7/98
569	0.47	2/6/91
284	0.25	5/10/95

The measured phosphorus concentration of 0.63 mg/L at a flow of 860 cfs was used for calibration purposes (i.e., it was assumed that the 1-year, 24-hour flow has a phosphorus concentration of 0.63 mg/L). This calibration datum was selected because it was the highest flow in the data set and is closest to the wet weather conditions for which the TMDL is being developed. The calibrated TSS model, as input to the total phosphorus model, predicted phosphorus to be 0.63 mg/L. Therefore additional calibration was not required for the EPA screening procedures.

Subwatershed phosphorus yields associated with soil erosion are shown below (Tables 45 and 46). Phosphorus yield from manure, estimated as the product of subwatershed sediment delivery ratio and manure production, is similar for all major storms (Table 47). The sum of phosphorus from soil erosion and from manure represents total phosphorus yield, or loadings, to Rayse Creek (Tables 48 and 49). The total phosphorus load for these specific hydrologic events is the basis for predicting instream phosphorus concentrations (Section 5.6).

Table 45

SUBWATERSHED PHOSPHORUS YIELD (KG)

Subwatershed	Area (acres)	1-Year Storm	3-Year Storm	10-Year Storm
RC-1	3,590	303	488	741
RC-2	5,956	470	758	1,151
RC-3	4,531	246	397	603
RC-4	7,649	410	661	1,004
RC-5	5,997	347	559	849
RC-6	5,626	446	718	1,091
RC-7	3,202	188	303	461
RC-8	13,937	428	690	1,048
RC-9	5,715	290	467	709
RC-10	2,649	160	258	392
RC-11	2,271	93	149	227
RC-12	2,461	97	157	239
Total	63,584	3,478	5,604	8,513

Table 46

AREAL PHOSPHORUS YIELD (KG/AC) FROM SOIL EROSION – FALL

Subwatershed	Area (acres)	1-Year Storm	3-Year Storm	10-Year Storm
RC-1	3,590	0.084	0.136	0.206
RC-2	5,956	0.079	0.127	0.193
RC-3	4,531	0.054	0.088	0.133
RC-4	7,649	0.054	0.086	0.131
RC-5	5,997	0.058	0.093	0.142
RC-6	5,626	0.079	0.128	0.194
RC-7	3,202	0.059	0.095	0.144
RC-8	13,937	0.031	0.050	0.075
RC-9	5,715	0.051	0.082	0.124
RC-10	2,649	0.060	0.097	0.148
RC-11	2,271	0.041	0.066	0.100
RC-12	2,461	0.040	0.064	0.097

Table 47

PHOSPHOROUS YIELD (KG/YR) FROM MANURE DURING MAJOR STORMS

Subwatershed	Area (ac)	Yield (kg/yr)	Areal Yield (kg/ac/yr)
RC-1	3,590	98	0.027
RC-2	5,956	124	0.021
RC-3	4,531	0	0
RC-4	7,649	91	0.012
RC-5	5,997	33	0.005
RC-6	5,626	26	0.005
RC-7	3,202	0	0
RC-8	13,937	131	0.009
RC-9	5,715	0	0
RC-10	2,649	0	0
RC-11	2,271	0	0
RC-12	2,461	0	0
Total	63,584	503	

Table 48

TOTAL PHOSPHORUS YIELD (KG)

Subwatershed	Area (acres)	1-Year Storm	3-Year Storm	10-Year Storm
RC-1	3,590	401	586	839
RC-2	5,956	594	882	1,275
RC-3	4,531	246	397	603
RC-4	7,649	496	747	1,090
RC-5	5,997	380	592	882
RC-6	5,626	471	744	1,116
RC-7	3,202	188	303	461
RC-8	13,937	532	794	1,152
RC-9	5,715	290	467	709
RC-10	2,649	160	258	392
RC-11	2,271	93	149	227
RC-12	2,461	97	157	239
Total	63,584	3,948	6,075	8,984

Table 49

TOTAL AREAL PHOSPHORUS YIELD (KG/AC) – FALL SEASON

Subwatershed	Area (acres)	1-Year Storm	3-Year Storm	10-Year Storm
RC-1	3,590	0.122	0.163	0.234
RC-2	5,956	0.100	0.148	0.214
RC-3	4,531	0.054	0.088	0.133
RC-4	7,649	0.065	0.098	0.143
RC-5	5,997	0.063	0.099	0.147
RC-6	5,626	0.084	0.132	0.198
RC-7	3,202	0.059	0.095	0.144
RC-8	13,937	0.038	0.057	0.083
RC-9	5,715	0.051	0.082	0.124
RC-10	2,649	0.060	0.097	0.148
RC-11	2,271	0.041	0.066	0.100
RC-12	2,461	0.040	0.064	0.097

5.4 BOD Yield

Estimates of BOD_5 produced from land use and manure sources were presented in Section 4 and calculated in Appendix D. BOD_5 delivered to the stream is estimated here using the same delivery ratio computational method as described above for sediment and phosphorus yields. Table 50 presents an estimate of BOD_5 delivered to Rayse Creek. Table 51 presents a summary of areal BOD_5 yield for each subwatershed. These values are used in the prediction of dissolved oxygen (DO) in the stream.

Table 50

BOD_5 YIELD (LB)

Subwatershed	BOD_5	Subwatershed	BOD_5	Subwatershed	BOD_5
RC-1	12,577	**RC-5**	14,385	**RC-9**	12,149
RC-2	19,591	**RC-6**	15,164	**RC-10**	5,580
RC-3	10,462	**RC-7**	8,579	**RC-11**	5,371
RC-4	21,025	**RC-8**	29,622	**RC-12**	5,596
				Total	160,102

Table 51

AREAL BOD_5 YIELD (KG/AC)

Subwatershed	BOD_5	Subwatershed	BOD_5	Subwatershed	BOD_5
RC1	1.6	**RC5**	1.1	**RC9**	1.0
RC2	1.5	**RC6**	1.2	**RC10**	1.0
RC3	1.0	**RC7**	1.2	**RC11**	1.1
RC4	1.2	**RC8**	1.0	**RC12**	1.0
				Total	1.1

5.5 DO Model

DO concentrations in Rayse Creek can be predicted using the USEPA's steady-state program QUAL2E (Brown and Barnwell 1987). In QUAL2E, the stream is simulated as a string of completely mixed reactors that are linked sequentially by advective transport and dispersion. Sequential groups of these reactors are defined as reaches. Each stream reach is divided into computational elements with identical length, hydrogeometric properties, and rate constants.

Table 52 presents a summary of the major QUAL2E model coefficients, rates and boundary conditions that we have selected for this initial model of DO in Rayse Creek. Many of these rates and variables require verification for more accurate simulation of DO dynamics in the stream. The complete input file is reprinted in Appendix C.

Table 52

SUMMARY OF MAJOR QUAL2E RATES, COEFFICIENTS AND VARIABLES

Model Parameters and Rates	Value	Comments
Number of headwaters	3	Novak Creek (RC-4), Richview (RC-8), and Suburban Heights (RC-12)
Number of reaches	27	
Total distance modeled (miles)	30.5	
Length of computational element (mi)	0.25	
Number of tributary loads	47	Treated as point sources by QUAL2E
Reaeration Rate	1.024	Default rate, O'Connor-Dobbins
BOD Decay (1/day)	1	Default rate
Water Quality Data	**Value**	**Comments**
Temperature	79°F	Boundary condition estimate
Headwater DO (mg/L)	5.5	Boundary condition estimate
Headwater BOD (mg/L)	2.9	Boundary condition estimate
Tributary BOD (mg/L)	10-500	Values provided in Table 56
Sediment Oxygen Demand (g/ft^2/d)	0.5	Estimated (0.5 default value)

Many model parameters are based upon best professional judgement because of the limited data set. SOD and/or BOD are the two main variables that impact the DO concentration. Neither of these have been measured for this watershed. Subwatershed 8, which drains into NK 02, has a number of animal facilities located in it. In order to calibrate the DO model to the measured concentration, we found it necessary to set BOD in headwater of subwatershed 8 (Richview) to 500 mg/L. A BOD of 500 mg/L is indicative of runoff from an earthen animal feedlot (Table 30). This calibration is supported by Agency field observations of a "high risk" cattle feedlot in RC-8 (IEPA 1997).

5.6 Model Results

The reader is referred to Appendices B and C for computational details on runoff, pollutant yield, and concentrations for each subwatershed for various storm return periods. Table 53 presents TSS concentrations calculated for each subwatershed. TSS concentrations, that is, mass of solids per volume of stream water, were computed using the EPA screening procedures as the quotient of subwatershed sediment yield (mass) and runoff volume. These values reflect a specific subwatershed (*i.e.* TSS concentrations in Table 53 are not cumulative). The concentration of TSS at any point must be estimated as the flow-weighted mean of the concentrations of contributing areas.

Table 53

MODELED SUBWATERSHED TSS CONCENTRATIONS (MG/L)

	1-Year Return Period				3-Year Return Period				10-Year Return Period			
Subwatershed	**6 hr**	**12 hr**	**24 hr**	**72 hr**	**6 hr**	**12 hr**	**24 hr**	**72 hr**	**6 hr**	**12 hr**	**24 hr**	**72 hr**
RC-1	1,599	1193	918	623	1,690	1,295	1,025	729	1,728	1,365	1,103	803
RC-2	1,506	1121	861	582	1,585	1,211	957	679	1,614	1,273	1,027	746
RC-3	954	708	544	367	1,001	764	604	428	1,018	802	647	469
RC-4	962	712	545	367	1,004	765	602	426	1,016	799	644	466
RC-5	1,241	900	677	446	1,248	936	728	507	1,228	955	761	544
RC-6	1,722	1,259	954	634	1,758	1,327	1,038	727	1,750	1,367	1,094	786
RC-7	1,322	953	714	467	1,316	983	762	528	1,286	996	793	565
RC-8	524	384	291	193	536	405	317	222	534	417	334	240
RC-9	1,138	816	609	397	1,123	836	646	446	1,090	842	669	475
RC-10	1,235	903	683	454	1,259	950	742	520	1,252	978	783	562
RC-11	644	480	370	251	681	522	413	294	696	550	445	324
RC-12	658	487	373	251	687	523	412	292	695	547	440	319

The concentration of TSS at NK 01 is the flow-weighted mean of the concentrations of the upstream subwatersheds (Table 54). The average TSS concentration for a 3-year, 24-hour storm at NK 01 is 652±105 mg/L. Additional model results are presented for 11 other storms in Table 54.

Table 54

ESTIMATED AVERAGE TSS CONCENTRATIONS (MG/L) AT NK 01

Event Durations	1-Yr Return Period	3-Yr Return Period	10-Yr Return Period
6-hr	1,068	1,099	1,100
12-hr	785	832	861
24-hr	597	652	691
72-hr	399	459	498

Because stream velocities are much higher during large flow events than during base flow periods, the wet weather TSS model is based on all eroded material being transported down the river, with no significant deposition. This is generally valid for estimating suspended solids concentrations during high flow events. During high flows, sediment is kept in suspension by the higher current velocities, only settling after flows and velocities recede. Deposition occurs after flood flows ebb with reduced current velocities and reduced turbulence; in the Rayse Creek system, the majority of deposition likely occurs in downstream reaches that are influenced by Rend Lake backwater effects.

The concentration of total phosphorus at NK 01 was also calculated as the flow-weighted mean of the concentrations of the upstream subwatersheds. The average phosphorus concentration for a 3-year, 24-hour storm at NK 01 is approximately 0.58 mg/L. Additional data are presented for 11 other storms in Table 55.

Table 55

ESTIMATED AVERAGE TOTAL PHOSPHORUS CONCENTRATIONS (MG/L) AT NK 01

Event Durations	1-Yr Return Period	3-Yr Return Period	10-Yr Return Period
6-hr	1.01	0.98	0.86
12-hr	0.82	0.74	0.67
24-hr	0.63	0.58	0.54
72-hr	0.42	0.41	0.39

Because of its relationship to the 305(b) assessment criteria (total phosphorus greater than 0.61 mg/L once in three years), we selected the 24-hour storm that recurs once in three years as the phosphorus TMDL endpoint statistic. The EPA screening procedure results indicate that NK01 is in compliance for the 24-hour storm, but will exceed the endpoint during more intense wet weather events. Therefore, bringing this watershed into compliance for TSS will likely resolve nutrient impairments as well.

At present, there are no known point sources of solids, phosphorus or BOD in the watershed. The Richview STP will begin operation soon; a NPDES permit regulates its discharges. Maximum TSS waste load permitted for this facility is reprinted in Table 15. When compared with sediment loads from a 1-year storm, the point sources contribute less than 0.004 percent of the total TSS load in the watershed and these point sources are negligible when compared with agricultural runoff. Phosphorus loads from the Richview treatment plant will also be very small (0.007 percent).

BOD loads and yields have been converted to concentrations using the method used to compute sediment and phosphorus concentrations. Table 56 presents an estimate of BOD_5 concentrations for tributaries draining the 12 Rayse Creek subwatersheds. These values were used in the QUAL2E model to reflect BOD in drainage ditches and tributary streams (modeled as point sources) in the watershed.

Table 56

TRIBUTARY BOD_5 CONCENTRATIONS (MG/L)

Subwatershed	BOD	Subwatershed	BOD	Subwatershed	BOD
RC1	15	**RC5**	12	**RC9**	11
RC2	14	**RC6**	13	**RC10**	10
RC3	10	**RC7**	14	**RC11**	10
RC4	12	**RC8**	500	**RC12**	10

Recall the paucity of data used to identify ALUS impairment by DO deficits and to develop this DO TMDL. In such cases a sensitivity analysis is useful to identify parameters in the system most influencing DO concentrations. This analysis can guide further data collection and TMDL refinement. We varied sediment oxygen demand (SOD) and BOD in the QUAL2E DO model to examine model sensitivity to these parameters. Table 57 presents DO concentrations for different sediment oxygen demand (SOD) and BOD concentrations.

Table 57

SENSITIVITY OF DO TO CHANGES IN SOD AND BOD

SOD (g/ft^2/d)	BOD (mg/L)	DO (mg/L)
0.5	500	3.53
0.5	250	4.15
0.5	100	4.53
0.5	50	4.65
0.5	10	4.75
0.4	500	3.93
0.4	10	5.15
0.3	500	4.34
0.3	10	5.56
0.2	500	4.91
0.2	10	5.96
0.1	500	5.15
0.1	10	6.37

DO concentrations are quite sensitive to changes in both BOD and SOD. For DO to be above 6.0 mg/L in summer low flow periods, SOD and BOD must remain rather low. As shown in Table 57, BOD must be below 10 mg/L and SOD must be less than 0.2 mg/L. Current projections indicate BOD ranges from 10 to 15 mg/L in most subwatersheds (Table 56). Calibration required a high BOD in RC-8 loads, where there is a high probability of one or more livestock facilities causing high BOD loads.

5.7 Seasonal Variations

The EPA screening procedures watershed and water quality models are based upon several factors that vary seasonally. Both P and TSS predictors include solution of the USLE. Among the seasonally variable factors in the USLE are C, the cover factor, and E, the rainfall/erosivity index. The cover factor**,** C, is the ratio of soil loss under the conditions in question to that which would occur under continuously bare soil. Clearly C will vary during the growing season as foliage develops and is harvested or dies back, and soil roughness, moisture and plant residue changes. During summer, foliage flourishes and is most dense. During summer, the plants intercept the highest proportion of precipitation and seasonally protect soil to a greater extent than other seasons. During winter, the soil is typically frozen, snow covered, or precipitation is snow, so winter is not particularly the season most susceptible to soil erosion. Spring and fall therefore tend to be the seasons most sensitive to erosion, as fields tend to be newly plowed or harvested. As the Jefferson County SWCD was unable to provide seasonal C factors, we utilized information provided by Marion County SWCD for fall (Tables 22 and 23) and spring (Table 58) average C factors for agricultural row crop land. Fall C factors are higher than spring C factors. This is because of the tendency of farmers to turn ground after a crop has been harvested. Following spring tillage, crop land is subsequently planted and C factors are lower.

Table 58

C VALUES FOR LAND USES IN WATERSHED – SPRING SEASON
(Source: Marion County SWCD)

Land Use	C Value
Urban - High Density	0
Urban – Medium Density	0
Agriculture - Row Crop	0.12
Agriculture - Small Grains	0.055
Agriculture - Orchards/Nurseries	0.055
Urban Grassland	0.055
Rural Grassland	0.02
Forested – Deciduous: Closed Canopy	0.004
Forested – Deciduous: Open Canopy	0.004
Water	0
Shallow Marsh/Wet Meadow	0.055
Deep Marsh	0.055
Forested Wetland	0.004
Shallow Water Wetland	0.055

Rain in ILNK01 is not particularly seasonal. Huff and Angel (1992) examined seasonal distribution of rainfall by examining the records of 275 weather stations in Midwestern states. Table 59 compares seasonal statistics for precipitation in Illinois and Indiana. While winter is notably the driest season, and summer the wettest, rain is fairly evenly distributed between spring and fall (Table 59). Huff and Angel's seasonal rainfall frequency curves for the weather station nearest the target watershed (Rockville, Ind.) show nearly identical precipitation amounts for spring and fall storms of similar recurrence intervals. About two-thirds of the most severe 1-day storms occur in summer. The erosive effects of these severe storms are mitigated by an increased density of vegetative cover on the land. Further, farmers typically do not apply manure to crop land during the summer growing season.

Table 59

SEASONAL RAINFALL DISTRIBUTION
(Source: Huff and Angel, 1992)

Season	Annual Contribution		Top-Ranked 1-Day Storms	
	Illinois Average	Indiana Average	Illinois	Indiana
Winter	16.7%	18.8%	3.3%	2.4%
Spring	29.1%	28.9%	20.0%	17.1%
Summer	29.8%	29.1%	65.0%	63.4%
Autumn	24.3%	24.3%	11.7%	17.1%

Little data are available on seasonal DO variation in Rayse Creek. For DO, the worst case condition has been modeled: summer time high temperatures and low flows. As temperature decreases from summer highs and flow increases from summer low, DO concentrations will increase.

5.8 Background Concentrations

Background is defined as those loads that represent a baseline or minimum level of water pollution which are natural and can not be eliminated by local or area-wide water quality management (Mills *et. al.* 1985). Background concentrations of suspended sediment for southern Illinois are between 20 and 50 mg/L (McElroy *et al.* 1976). Comparing these background TSS concentrations with the 3- and 10-year storm TSS concentrations estimated by the model suggests that background concentrations account for between 7 percent and 30 percent of the estimated TSS concentration.

Stream background phosphorous concentrations for undeveloped watersheds in Illinois are not known. Clark et al. (2000) published the most recent national review of background nutrient concentrations we are aware of. These scientists reviewed data from 85 sites representing relatively undeveloped watersheds across the nation. Table 60 is an excerpt from their publication. They admitted that data from the corn belt were scarce, due to extensive agricultural development. It is reasonable to assume that Illinois' fertile prairie soils would have background phosphorus levels at or above the median, 50^{th} percentile levels of the nationwide data set. Based upon the 75^{th} percentile, background phosphorus concentrations in Rayse Creek account for between 3 and 8 percent of total phosphorus.

Table 60

TOTAL PHOSPHORUS CONCENTRATIONS AND MEAN ANNUAL YIELDS FOR 85 UNDEVELOPED WATERSHEDS IN THE US

(Source: Clark *et al.* 2000)

Statistic	Concentration (mg/L)	Yield (kg/ac/yr)
Range	<0.01 to 0.20	<0.004 to 0.332
25^{th} percentile	0.014	0.019
50^{th} percentile	0.022	0.034
75^{th} percentile	0.037	0.049

Background concentrations of BOD and DO for the Rayse Creek watershed are those presented in the QUAL2E model, 2.9 mg/L and 6.0 mg/L, respectively (USEPA 1998a).

5.9 Uncertainty

We have attempted to minimize uncertainty in this modeling task by modeling multiple storm event durations and frequencies, comparison of our results with the scientific literature and making conservative assumptions across all parameters. The principal sources of uncertainty in these findings originated from the following:

- Uncertainty in the empirical equations used to estimate pollutant runoff and yield.
- Model predictions were outside of the range of available calibration data.
- Empirical error associated with the sediment regression model that was used for calibration.
- Hydrologic parameter estimation, such as curve numbers, cover factors, etc.
- Use of specific storm return periods and durations to represent the range of critical periods.
- Lack of data to accurately estimate the 1-year flow in Rayse Creek.
- Lack of watershed specific information regarding the significance of gully erosion, streambed erosion and bank erosion.
- Lack of water quality data to sufficiently model DO, such as DO, BOD, and SOD measurements.
- Lack of data to evaluate manure management practices in ILNK01, and therefore its consequential impact on DO and phosphorus concentrations.

Our evaluations included an analysis of variable storm duration and recurrence period. In comparison to the TMDL design storm (24-hr, 1-in-3 year event) the more intense 12-hour storm increases TSS and phosphorus concentrations about 28 percent, and the less intense 72-hour storm decreases TSS and phosphorus concentrations by about 30 percent. The 10-year storm results in TSS concentrations up to 8 percent higher than three-year storms of similar duration, and up to 25 percent higher than one-year storms. The ten-year storm results in phosphorus concentrations 12 percent higher than three-year storms of similar duration and up to 10 percent higher than one-year storms.

DO model uncertainty is quite high. A sensitivity analysis of two key variables available is presented in Table 57. We recommend additional data be collected by the Agency to confirm ALUS impairment by DO deficits, and to refine the QUAL2E model and increase certainty for water quality management decisions. Data should be collected on manure management in the watershed, including the locations and types of livestock manure lagoons, and the conditions under which manure may enter watercourses. Additional data should also be collected on water quality, sediment quality, and channel hydraulics. We recommend a high priority for investigating manure management practices at livestock facilities in RC-5 and RC-8.

We also recommend additional data be collected to support the suspended solids and phosphorus models as well. Particular uncertainty exists regarding the magnitude of gully erosion, bank erosion, and bed erosion to these load estimates.

TMDL allocations are to include a margin of safety (MOS), a factor that intends to account for, among other things, uncertainties associated with modeling and measurements. The MOS is discussed in the following chapter.

6. TMDL

Pollutant assimilative capacity modeling and load allocation are performed to identify the maximum allowable loads from individual sources that are necessary to meet the water quality endpoint. For this TMDL, the endpoints are the 305(b) assessment guidelines for total suspended solids (TSS) and phosphorus (IEPA 2000) and the DO general use water quality standard. TSS concentration must be less than 116 mg/L. Phosphorus must be less than 0.61 mg/L. Dissolved oxygen must not be less than 5.0 mg/L, and not be less than 6 mg/L during consecutive 16 hours in any 24 hours period when discharge exceeds the 10-day low flow occurring once every 10 years. The compliance of NK 01 and NK 02 with these endpoints is reviewed in Chapter 3.

Since water quality standards and listing/delisting guidelines are based on concentration units, this TMDL uses pollutant concentrations for TMDL target endpoints. We feel this is the best form for the lay audience to understand relationships between land use management and water quality.

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

$$TMDL = \sum WLAs + \sum LAs + MOS + SV \qquad \text{Equation (10)}$$

Discharges from the studied storm events yield TSS concentrations greater than the endpoint concentration of 116 mg/L (Table 54). In order for TSS concentrations in the subwatershed NK 01 to be within the 116 mg/L target, loads need to be reduced by:

- 71 to 89 percent, depending on storm duration, for 1-year return interval storms
- 75 to 89 percent, depending on duration, for 3-year return intervals
- 77 to 89 percent, depending on duration, for 10-year return intervals

Discharges from some storm events yield P concentrations greater than the endpoint concentration of 0.61 mg/L (Table 55). In order for P concentrations in NK 01 to be within the 0.61 mg/L target, loads need to be reduced by:

- Up to 40 percent, depending on storm duration, for 1-year return interval storms

- Up to 38 percent, depending on duration, for 3-year return interval storms
- Up to 29 percent, depending on duration, for 10-year return interval storms

The EPA screening procedures model developed for this target watershed predicts TSS and P concentrations for the fall season. Fall is expected to have TSS concentrations approximately 10 percent higher than in spring. Therefore, the results presented are for a worst-case scenario. Additionally, background concentrations account for 15 percent of the TSS concentration and 5 percent of the phosphorus concentration.

Tables 61 and 62 present the TSS and P concentrations from nonpoint sources expected at NK 01, together with the required reductions in pollutant concentrations in order to meet the water quality target concentrations.

Table 61

ESTIMATED TSS CONCENTRATIONS (MG/L) AND REQUIRED REDUCTIONS AT STATION NK 01

Event Duration	1-Yr Return Period	3-Yr Return Period	10-Yr Return Period
6-hr	1,068 (89)	1,099 (89)	1,100 (89)
12-hr	785 (85)	832 (86)	861 (87)
24-hr	597 (81)	652 (82)	691 (83)
72-hr	399 (71)	459 (75)	498 (77)

Note: Values in parentheses represent the required percent reductions in TSS concentrations in order to meet the TMDL endpoint of 116 mg/L for that storm.

Table 62

ESTIMATED PHOSPHORUS CONCENTRATIONS (MG/L) AND REQUIRED REDUCTIONS AT STATION NK 01

Event Durations	1-Yr Return Period	3-Yr Return Period	10-Yr Return Period
6-hr	1.01 (40)	0.98 (38)	0.86 (29)
12-hr	0.82 (26)	0.74 (18)	0.67 (9)
24-hr	0.63 (3)	0.58 (0)	0.54 (0)
72-hr	0.42 (0)	0.41 (0)	0.39 (0)

Note: Values in parentheses represent the required percent reductions in P concentrations in order to meet the TMDL endpoint of 0.61 mg/L for that storm.

The watershed and water quality models predicts BOD concentration at NK 02 to be 42 mg/L (Appendices B & C). Based upon the BOD and SOD sensitivity analysis (Table 57). a reduction of 78 percent is required to meet the TMDL target BOD concentration of 10 mg/L.

The proposed treatment plant at Richview will have effluent quality regulated under its NPDES permit limiting maximum daily effluent TSS concentrations to 45 mg/L. No phosphorus limits were included in its permit. As discussed earlier, this waste load is negligible compared to the loads associated with all nonpoint sources during events when the water quality endpoint is exceeded.

6.1 MOS

The Margin of Safety (MOS) can be incorporated into conservative assumptions (implicitly) or added as a separate, quantitative component (explicitly) of the TSS and phosphorus TMDL (USEPA 1991). The MOS for this TMDL has been implicitly accounted for in conservative modeling approaches, including:

- The model accounts for 100 percent of sediment entering the waterway to be transported through the system during high flows (i.e., no deposition occurs).
- Use of the worst case season for allocation scenarios. The post-harvest fields contain little vegetative cover to protect the soil. This brings conservatism to the TSS and P estimates.
- Use of 1995 land use and conservation practice data that does not account for approximately five years of BMP implementation on agricultural land.
- Use of historical water quality data for model development and calibration that likewise does not account for recent agricultural BMPs installed after December 1998.

This implicit MOS is exemplified in our development of the watershed model using 1995 land cover and conservation tillage data. The most recent land cover data available reflects 1995 conditions, and we have therefore constructed and calibrated the model for that dataset. While we expect little changes in land cover between 1995 and 2001, agricultural conservation practices have been implemented across Jefferson County, per conversations with representatives of the SWCD, NRCS, and Illinois Department of Agriculture. Tables 19 through 21 provide general data on conservation tillage practices. In Jefferson County, where most of ILNK01 is located, conservation tillage that leaves 30 percent or more of plant residue on the fields was practiced on 48 percent of cropland in 1995, and 64 percent of cropland in 2000. Additionally, investments in other conservation measures have also been made between 1995 and 2000, most notably in conservation buffers (personal communication, Illinois DOA). Quantitative data on these investments currently are not kept in an electronic form that can be used to refine watershed models without major expenditures. By this example, and the other factors listed above, the TSS and phosphorus TMDLs have an implicit MOS.

Our estimate of soil loss is developed based upon an empirical model of sheet and rill erosion. It is calibrated to instream suspended solids and phosphorus concentrations and is a valid tool for predicting the effects of nonpoint pollution control actions on water quality in Rayse Creek. The model does not explicitly include a mechanism accounting for gully or bank erosion. Further, we have found no other studies of these sources for the target watershed and have no data from which to develop an mechanistic estimate. In a watershed with similar soils, land use and topography, the Carlyle Lake Watershed Plan provided estimates of gully and bank erosion in the Kaskaskia River. Unfortunately, that study did not support the estimates with references for their data, evidence of calibration, evaluation of uncertainty, or field surveys (anonymous undated). The Carlyle Lake Watershed Plan estimated bank erosion from a review of aerial photographs and an assumed loading of 2,000 tons per mile of unprotected stream bank. The regulated flows on the Kaskaskia River (from Lake Shelbyville) exacerbate bank erosion in comparison to natural flow regimes in Rayse Creek. Based upon these findings, we judge that our sediment yield model, as calibrated to instream suspended solids concentrations, adequately represents siltation processes in Rayse Creek, given the limitation of site-specific data. The sediment delivery ratio effectively accounts for all sources of erosion: sheet, rill, gully and bank erosion. Nevertheless, we do recommend the Agency fund data collection on these sources.

Given the high uncertainty associated with the DO TMDL, a MOS of 100 percent is suggested.

For the purposes of this TMDL, we considered an allowance for future growth to account for reasonably foreseeable increases in pollutant loads. We requested growth data from the South Central Illinois Regional Planning & Development Commission (SCIRP&DC). The SCRIP&DC indicated that the population will decrease by 6 percent from 2000 to 2020 for Jefferson County and increase 17 percent for Washington County. Our calculations accounted for zero changes in land use (i.e. no agriculture land will be converted to grassland). Therefore, no foreseeable increase in TSS, phosphorus, or BOD loading is expected.

6.2 Total Maximum Daily Loads

6.2.1 Total Suspended Solids

As presented above, the WLA, SV and the MOS terms in Equation 10 are negligible or implicitly included in our analysis. The WLA for the Richview WWTP is insignificant during the critical high flow periods in comparison to all nonpoint source loads. The SV is implicitly included because of our use of the more conservative fall C factors in the loadings analysis. The MOS is implicitly included because of our use of conservative planning factors across all variables, plus the known (but unquantified) implementation of agricultural BMPs in the watershed since December 1998. Therefore, the solution of the TSS TMDL for this target watershed reduces to:

$$TMDL = \sum LAs \leq 116 \frac{mg}{L} \qquad \text{Equation (11)}$$

Equation 11 is applicable to any storm event with a recurrence interval less than or equal to three years (i.e. for a three-year storm the TSS concentration will be less than 116 mg/L). This is the design condition for the watershed implementation plan.

6.2.2 Phosphorus

The phosphorus loadings estimates are based upon the TSS model, supplemented by estimates of the contribution from livestock facilities in the watershed. As with the TSS TMDL, the WLA, SV and the MOS terms in Equation 10 are negligible or implicitly included in our analysis. Therefore, the solution of the phosphorus TMDL for this target watershed reduces to:

$$TMDL = \sum LAs \leq 0.61 \frac{mg}{L} \qquad \text{Equation (12)}$$

Equation 12 is applicable to any storm event with a recurrence interval less than or equal to three years. This is an additional design condition for the watershed implementation plan.

6.2.3 Dissolved Oxygen

Data are lacking to identify the source of DO impairment. Earlier we recommended that additional data be collected by the Agency to confirm DO deficits in ILNK01 and to develop a model with less uncertainty. Data should be collected on manure management in the watershed, water quality, sediment quality, and channel hydraulics.

Limited information is available on stream DO, channel morphology and substrate. Based upon this limited data set and the QUAL2E modeling, we conclude that:

- The DO deficit occurs during low flow periods.
- Field data collected by the Agency indicated a lack of organic matter in the stream substrate (Table 10). This suggests that the cause of DO deficits is not likely SOD.

The DO deficit is likely caused by the direct discharge of BOD from ditches, drains or tributaries upstream of sample location NK 02 from RC-5 and/or RC-8. We recommend that the source of the DO deficit be further studied by the Illinois EPA.

Given the limited data that are available and the QUAL2E modeling, we recommend the following TMDL for BOD in order to have DO concentrations greater than 6.0 mg/L for all times:

$$TMDL = \sum LAs + \sum WLAs + MOS \leq 10 \frac{mg}{L} \text{ of BOD} \qquad \text{Equation (13)}$$

Equation 13 is applicable to all stream flows greater than the $7Q_{10}$. As we have recommended a MOS of 100 percent, this TMDL becomes:

$$TMDL = \sum LAs + \sum WLAs + MOS \leq 5 \frac{mg}{L} \text{ of BOD} \qquad \text{Equation (14)}$$

This should be updated as more data are available.

6.3 Pollutant Reduction Options

The goal of pollutant allocation is to reduce loadings to the stream such that the stream meets its TMDL targets and water use is fully restored:

- No TSS concentrations greater than 116 mg/L in a 3-year storm or less in NK 01,
- No total P concentrations greater than 0.61 mg/L in a 3-year storm or less in NK 01, and,
- No DO concentrations less than 5 mg/L in NK 02 at anytime and not less than 6 mg/L during 16 hours in a day.

Herein we evaluate alternatives to accomplish this. Stream bank and bed erosion are not addressed in this TMDL due to a lack of data on relative sources and loads. Concurrent with the implementation of TMDL options evaluated below, we recommend that the Agency initiate collection of data on bank and bed erosion sources and development of linkages to this allocation, as well as continued support of bank erosion control projects in this and other watersheds.

The alternatives focus on reducing soil erosion from agricultural rowcrop land and the runoff of manure-associated nutrients and BOD, the sources of water quality degradation in NK 02 and NK 01. Current agricultural land use is broken down in Table 63. Sediment yield from row crop agricultural land is more than 100 times greater than for grassland during any storm (Tables 64 and 65). Additionally, soil association IL038 (Bluford-Ava-Hickory) is responsible for almost five times more soil loss per unit area than IL006 (Cisne-Hoyleton-Darmstadt), one of the other two soil associations in the watershed. This is due to the slope length (ls) factor being more than four times greater in IL038 soils (Table 16).

Table 63

EXISTING ROW CROP AND GRASSLAND IN ILNK01
(acres)

Subwatershed	Row Crop Land	Rural Grassland
RC-1	1,599	1,140
RC-2	2,489	2,133
RC-3	2,009	1,002
RC-4	2,928	2,717
RC-5	1,781	1,766

RC-6	1,670	2,229
RC-7	611	1,450
RC-8	4,544	4,502
RC-9	1,640	1,670
RC-10	1,219	527
RC-11	1,273	477
RC-12	1,293	592
Total	23,056	20,205

Note: The total areas presented in Table 63 will not match Table 8, as row crop and rural grassland are just one subset of agricultural and grassland land use types, respectively.

Table 64

ESTIMATED SOIL LOSS FROM SELECTED LAND USES AND SOIL TYPES
(m-tons/ha)

Soils	Land Use	1-Yr Storm	3-Yr Storm	10-Yr Storm
IL006	Agriculture-Row Crop	0.79	1.43	2.42
IL006	Rural Grassland	0.01	0.01	0.02
IL038	Agriculture-Row Crop	3.47	6.30	10.63
IL038	Rural Grassland	0.02	0.05	0.08
IL051	Agriculture-Row Crop	0.94	1.71	2.89
IL051	Rural Grassland	0.01	0.01	0.02

Table 65

ESTIMATED PHOSPHORUS YIELD FROM SELECTED LAND USES AND SOIL TYPES
(kg/ha)

Soils	Land Use	1-Yr Return Interval	3-Yr Return Interval	10-Yr Return Interval
IL006	Agriculture-Row Crop	0.68	1.10	1.86
IL006	Rural Grassland	0.005	0.007	0.01
IL038	Agriculture-Row Crop	2.57	4.15	7.00
IL038	Rural Grassland	0.02	0.03	0.05
IL051	Agriculture-Row Crop	0.70	1.13	1.90
IL051	Rural Grassland	0.006	0.009	0.01

Several options were explored to determine their feasibility for implementation and meeting the water quality endpoints. These include:

- Changing land use in some or all 12 subwatersheds of the Rayse Creek,
- Selectively changing land use based on soil type in the 12 subwatersheds,
- Increasing conservation tillage on row crops in the watershed,
- Installing conservation buffers along Rayse Creek and tributary streams, and,
- Implementing BMPs to reduce slope length on IL038 soils being farmed with row crops.

The TMDL implementation plan must be sufficiently flexible to allow landowners and local agricultural extension agents to make the final decisions for their fields. The objective of this feasibility evaluation is not to specify control options; rather, to identify general success factors and costs related to each of these options. Conservation plans will ultimately need to be prepared at the farm level, with areal soil/nutrient/BOD load reduction estimates evaluated for consistency with this TMDL.

6.3.1 Option 1

Under Option 1, row crop agricultural land use/cover would be modified to rural grassland. This would be independent of soil type (i.e., land cover is adjusted an equal percentage for all soil types) equally in all 12 subwatersheds. By altering the cover factors in the calibrated model to reflect changed land use, we estimated the percent of row crop land requiring conversion to grassland in order to meet the TSS target concentration of 116 mg/L in NK 01 (Table 66). For the TMDL design storm (3-yr recurrence, 24-hour duration), 98 percent of all rowcrop land in the watershed, or about 22,600 acres of corn/soybean fields would require conversion to grassland. This would more than double the area of grassland in the Rayse Creek watershed. Table 66 shows the effect of varying storm magnitudes and durations on land use area changes required to meet the TMDL endpoint under this option. All storm frequencies and durations require significant conversion of land use to meet the water quality target.

Table 66

ROW CROP LAND TO BE CONVERTED TO GRASSLAND TO MEET TSS WATER QUALITY TARGET

Recurrence	Duration	Row Crops to be Converted (%)
1-Year Events	6-hr	106
	12-hr	102
	24-hr	97
	72-hr	85
3-Year Events	6-hr	106
	12-hr	103
	24-hr	98
	72-hr	89
10-Year Events	6-hr	106
	12-hr	104
	24-hr	99
	72-hr	92

By altering the cover factors in the EPA screening procedures to reflect changed land use, we estimated the percent of row crop land requiring conversion to grassland in order to meet the phosphorus target concentration of 0.61 mg/L in NK 01. For the TMDL design storm (3-yr recurrence, 24-hour duration), the target phosphorus concentration is met (Table 55). The shorter duration storms (6 and 12 hour events) are the ones that exceed the water quality target concentration. A 40 percent reduction in phosphorus concentration is required to meet the target concentration for all storm duration and return periods modeled. The model predicts that a 75 percent conversion in land use will improve water quality enough to meet the water quality target. If TSS concentrations are improved to meet the water quality target concentration, phosphorus concentrations will also meet the target concentrations.

6.3.2 Option 2

Under Option 2, a percentage of agricultural rowcrop land would be converted to rural grassland in subwatersheds RC1, RC2, and RC3 rather than the entire watershed. These are the subwatersheds that directly discharge to stream segment NK 01. This conversion would be independent of existing soil type (i.e., land is adjusted an equal percentage for all soil types). Again, we can alter the cover factors in the USLE model to reflect changes in land use.

Option 2 does not lead to attainment of the water quality goal of 116 mg/L for TSS (Table 67). Even if all rowcrop lands in subwatersheds RC1, RC2 and RC3 are converted to rural grassland, TSS concentrations can only be reduced about 15 percent. Upstream subwatersheds are providing more of a sediment load than land use conversions in lower subwatersheds (between NK 01 and NK 02) can offset.

Table 67

TSS CONCENTRATIONS AT NK 01 UNDER OPTION 2

Storm Duration	Storm Frequency		
	1-Year	3-Year	10-Year
6-hr	908	934	935
12-hr	667	707	732
24-hr	507	554	587
72-hr	339	390	423

Phosphorus concentrations are reduced approximately 12 percent if this option is adopted. This option will do little to improve phosphorus concentrations in short duration storm events (6 and 12 hour events) which exceed the target concentration. Neither is it likely to mitigate BOD loads sufficiently. As with TSS, the upstream subwatersheds are contributing more phosphorus and BOD loads than can be mitigated by improvements in the lower watershed.

6.3.3 Option 3

Under Option 3, areas of soil association IL038 (Bluford-Ava-Hickory) being farmed for rowcrops would be converted to rural grassland. Option 3 envisions applying this conversion selectively to soil association IL038, the more erosive soils, throughout the watershed. There are 9,076 acres of rowcrops in soil association IL038 (Exhibit 12). Option 3 assumes an equal modification in agricultural land use (percentage wise) for all twelve subwatersheds (i.e., if 10 percent of rowcrops is changed to rural grassland in subwatershed RC-1, then 10 percent is also changed in the remaining 11 subwatersheds). Modifying the USLE cover factors from rowcrop land to grassland allows us to estimate the benefits of this approach, similar to the analysis performed for Options 1 and 2.

Table 68 indicates the relative area of rowcrop land to be converted to rural grassland to meet the TSS water quality target concentration for one, three and 10-year storms. For the 24-hour, 3-year storm, if all rowcrops on IL038 soils in the Rayse Creek watershed are converted to grassland, the TMDL endpoint would not be met. Option 3 does not meet the TSS endpoint for any of the storms studied.

Table 68

ROW CROPS IN RAYSE CREEK WATERSHED TO BE CONVERTED TO GRASSLAND UNDER OPTION 3

Recurrence	Duration	Row Crops to be Converted (%)
1-Year Events	6-hr	133
	12-hr	127
	24-hr	121
	72-hr	106
3-Year Events	6-hr	133
	12-hr	128
	24-hr	123
	72-hr	112
10-Year Events	6-hr	133
	12-hr	130
	24-hr	124
	72-hr	115

The model predicts that a 100 percent conversion of rowcrops in soil association IL038 to rural grassland will improve phosphorus concentrations approximately 54 percent. A reduction of up to 40 percent is required to meet the target phosphorus concentration for storms of all durations and intensities. This can be accomplished with a 75 percent conversion of row crops.

6.3.4 Option 4

Option 4 focuses on the use of conservation tillage practices. Leaving all or part of the previous crop's residue on the soil surface has three primary effects that reduce sheet and rill erosion. Plant residue reduces the splash effect of rainfall, reduces surface runoff, and increases infiltration. For surface residue to achieve erosion benefits, the residue needs to be evenly distributed over the field. (NRCS 1999). Conservation tillage systems are estimated to reduce sediment loading by as much as 75 percent (NCSU Water Quality Group 2000). This corresponds to a residue cover of approximately 40 percent (Table 69).

Table 69

EFFECT OF RESIDUE COVER ON REDUCING SHEET AND RILL EROSION COMPARED TO CONVENTIONAL TILLAGE WITHOUT RESIDUE
(Source: NRCS 1999)

Residue cover %	Erosion Reduction %
10	30
20	50
30	65
40	75
50	83
60	88
70	91
80	94

We obtained information on local crop rotation and tillage practices from the Jefferson County SWCD. We evaluated each by applying the erosion reduction rates from Table 69 to the sediment yield estimates in our watershed siltation model. Table 70 presents the reduction in TSS concentration at NK 01 for 100 percent implementation of each of these techniques across all 12 subwatersheds. Table 70 indicates C factors and predicted TSS reductions associated with crop rotations and tillage systems. According to the Jefferson County SWCD, corn and soybean rotations are used on 80 percent of the fields. It is assumed that a similar rotation is practiced in the Rayse Creek watershed.

Table 70

CONSERVATION TILLAGE TECHNIQUES AND EXPECTED WATER QUALITY BENEFITS

Tillage Technique	C Factor	Reduction in TSS	Reduction in P
Corn and Soybean Rotations			
No-till corn; mulch till soybeans, 30% residue	0.10	24	19
No-till corn and soybeans, 60% residue	0.08	37	28
No-till soybeans, 60% residue; mulch till corn, 20% residue	0.10	24	19
No-till continuous, 70% residue	0.04	61	49
Corn, Soybean, and Wheat Rotations			
No-till corn; mulch till soybeans and wheat, 30% residue	0.08	37	29
No-till corn and soybeans, mulch till wheat, 60% residue	0.06	49	39
No-till soybeans and wheat, 60% residue; mulch till corn, 20% residue	0.06	49	39
No-till continuous, 70% residue	0.02	73	60
Corn, Soybean, Wheat and Meadow Rotations			
No-till corn; mulch till soybeans and wheat, 30% residue	0.07	43	34
No-till corn and soybeans, mulch till wheat, 60% residue	0.04	61	50
No-till soybeans and wheat, 60% residue; mulch till corn, 20% residue	0.04	61	50
No-till continuous, 70% residue	0.02	73	60

A reduction of TSS concentration of 82 percent is required to meet the 3-year, 24-hour storm TMDL endpoint. A reduction in TSS concentration of up to 89 percent is required to meet the TMDL objective for the 10-year, 6-hour storm. None of the practices implemented alone achieve the TSS TMDL goal (Table 70). Most practices shown above will reduce phosphorus concentrations by greater than 40 percent, and meet the TMDL goal for all storm durations and frequencies.

6.3.5 Option 5

Option 5 is an analysis of the widespread implementation of conservation buffers. Conservation buffers are areas or strips of land with permanent vegetation maintained to control pollutants and manage other environmental problems. Conservation buffers are strategically located on the landscape, and include a variety of practices: field borders, alley cropping, grassed waterways and filter strips, contour buffer strips, and riparian forest buffers. There are many effective applications of buffers, and combinations of buffers, that could be developed for the Rayse Creek watershed. Option 5 specifically evaluates the use of riparian forest buffer strips to meet the TMDL goal. Grasses and trees are better vegetation types than shrubs for filtering sediment and stabilizing banks (Tjaden and Weber 1997). But, riparian buffers are most effective as part of a comprehensive conservation plan that includes additional practices. A comprehensive conservation plan based upon landowner acceptance and needs is the most pragmatic approach to meeting the TMDL requirement.

The literature reports a wide range of effectiveness of buffer strips at reducing TSS concentrations in streams. Sediment trapping efficiency varies with vegetation type, stem density, ponded depth, backwater length, flow rate, sediment size and other factors (NCRS 1999). The state of Michigan specifies minimum riparian buffer width of 100 feet (MDEQ 1997). NRCS defines riparian buffers as minimally 50 feet wide (Palone and Todd 1997). Thirty-foot wide grass buffer strips have been shown to reduce TSS concentrations by 80 percent (Dillaha *et al.* 1989 and Magette *et al.* 1987).

The RF3 stream reach files in the GIS indicate that there are a total of 916,846 feet of streams in the Rayse Creek watershed. Of these, about half pass through agricultural or grass lands, the balance being in forested areas or wetlands. If 50-foot buffer strips are applied on both sides of all streams to achieve an 80 percent reduction in loadings, 1,059 acres of land will need to be used as riparian buffer strips and the TMDL goal can be achieved (Table 71). For cost estimating purposes, we recommend assuming an additional 10 percent of land area will require riparian buffers; the additional MOS is based upon uncertainties in the land use and RF3 GIS file spatial resolution.

Modeling results are shown in Table 72. Option 5 will not bring the targeted watershed below the TMDL TSS endpoint, and return the stream to full use support. As Option 5 alone will not restore use, we have not evaluated its effects on total phosphorus or BOD loadings.

Table 71

STREAM LENGTH THROUGH AGRICULTURAL LANDS AND REQUIRED RIPARIAN BUFFER AREAS

Subwatershed	Agriculture (ft)	Grassland (ft)	Total (ft)	Area (ac)	Areas with 10% MOS
RC-1	17,297	25,047	42,344	97	107
RC-2	25,310	36,036	61,347	141	155
RC-3	5,550	3,264	8,813	20	22
RC-4	23,637	43,745	67,382	155	170
RC-5	10,694	24,780	35,474	81	90
RC-6	3,746	21,575	25,321	58	64
RC-7	3,755	17,552	21,307	49	54
RC-8	39,058	78,159	117,217	269	296
RC-9	6,123	18,077	24,200	56	61
RC-10	6,726	11,791	18,517	43	47
RC-11	6,819	3,372	10,191	23	26
RC-12	11,829	17,459	29,288	67	74
Total	**160,544**	**300,858**	**461,402**	**1,059**	**1,165**

Table 72

ESTIMATED TSS CONCENTRATIONS AT NK 01 – OPTION 5

Event Durations	TSS Concentration (mg/L)		
	1-Yr Storm	3-Yr Storm	10-Yr Storm
6-hr	214	220	220
12-hr	157	166	172
24-hr	119	130	138
72-hr	80	92	100

6.3.6 Option 6

Option 6 analyzes the effectiveness of Best Management Practices (BMPs) specifically directed at reducing slope length on Bluford-Ava-Hickory soils (IL038 soil association) being farmed with row crops. These include:

- Terraces
- Contour buffer strips or contour stripcropping

The effectiveness of such practices at conserving soil is typically evaluated by including recommended P factors less than unity in the USLE. For contour stripcropping, P factors range from 0.25 to 0.7, depending upon crop rotation, strip width, and slope length (NRCS 1981). Terrace P factors are usually greater than 0.6, and vary with the specifics of the field (NRCS 1989).

The Bluford-Ava-Hickory soils (IL038) occur on side slopes along drainages and on broad ridgetops. IL038 slopes vary widely, ranging from one to 45 percent. The general value of this option to meeting the TMDL objective is shown below. We applied a P factor of 0.5 to all rowcrop lands in the watershed in IL038 soils. This factor, taken from the NRCS Conservation Practice Standard for contour stripcropping, reflects strip widths of 100 feet, maximum slope lengths of 600 feet, 3 percent to 5 percent slopes, for alternate strips of row crops and small grains. We judged this a conservative P factor for the area and conditions. Table 73 displays the estimates of TSS concentrations expected under this option, indicating that a sufficient level of protection is not provided under any storm duration modeled.

Table 73

ESTIMATED TSS CONCENTRATIONS AT NK01 – OPTION 6

Event Durations	TSS Concentration (mg/L)		
	1-Yr Storm	3-Yr Storm	10-Yr Storm
6-hr	553	569	570
12-hr	406	431	446
24-hr	309	338	358
72-hr	206	237	258

The model predicts that this option will reduce phosphorus concentrations by approximately 28 percent, again insufficient to meet the phosphorus TMDL objective. Being insufficient controls for TSS or total phosphorus, we have not evaluated effects on controlling BOD.

6.3.7 Controls for Livestock Facilities

Additional environmental monitoring data are required to refine BOD loads and ALUS impairments in ILNK01. The available data include:

- Two of four water samples that have been collected over six years suggest that low DO levels impair ALUS in NK 02. Additional data indicate that DO deficits are also occurring downstream in NK 01.
- A 1995 survey of the Big Muddy River Basin found some livestock facilities in ILNK01 that were rated as being a high risk to stream quality (IEPA 1997).
- The survey shows two "high risk" livestock facilities upstream of NK 02: a swine facility in RC-5 and a cattle feedlot in RC-8.

Detailed information on manure management at these facilities (and possibly others) is not available and should be obtained in order to refine the QUAL2E model and develop manure management plans that would control BOD loads to Rayse Creek.

6.3.8 Summary

Tillage of the IL038 soil association in ILNK01 leads to impaired uses of waterbody NK01. Manure from livestock facilities in the watershed also contributes to impairments. BMPs that are 50 percent effective at reducing soil loss on IL038 soils are insufficient to bring NK 01 into compliance with the TMDL goal. Implemented alone, Options 2, 3, 4 or 6 are insufficient controls to meet the water quality endpoints. Option 1 will only be effective if all row crops in the watershed are replaced with grasslands. Further, implementation of a single type of control or BMP is not a realistic expectation, given rural socioeconomic conditions in southern Illinois. Therefore, we recommend that a combination of these options be employed, at the local level, for meeting the TMDL goal:

- Land use changes, converting IL038 crop land to grass land (Option 3)
- Conservation tillage on all crop land (Option 4)
- Riparian buffers (Option 5)
- Targeting of IL038 crop lands for contour stripcropping and or terracing (Option 6)
- Improved manure management at livestock facilities, especially those in subwatershed RC-5 and RC-8

These BMPs will control all pollutants impairing ALUS in ILNK01: TSS, phosphorus, and BOD. Such controls should bring the waterbody into compliance with the TMDL endpoints for these three causes. Monitoring for refinement of the source loads is also recommended as part of the implementation plan. Bed erosion, bank erosion, and gully erosion contribute to the total TSS load, but data are not available to link these sources to instream water quality. Additionally, data should be collected in NK 02 to confirm ALUS impairment from DO deficits, to strengthen the linkage between BOD sources and DO levels in NK 02, and to develop manure management plans.

Comprehensively applied to the watershed, these practices will be sufficient to bring Rayse Creek into compliance with the TMDL goals. Individual farm conservation plans will need to be prepared, or may need to be revised, to finance and implement the BMPs. These farm conservation plans provide for a higher resolution of watershed resources, greater than this TMDL modeling effort, prepared using the best available existing data, is able to reach.

An example of such an approach is analyzed below, in a stepwise implementation of three options, that in combination bring TSS concentrations into compliance with the TMDL. For this example implementation plan we have used three options, which will cumulatively reduce TSS concentrations below the target of 116 mg/L. Options used include:

- Option 3: Conversion of 15 percent or row crop agricultural land in soil association IL038 to rural grassland
- Option 4: Conversion of 50 percent of row crop land to no-till corn and soybean rotation with 60 percent crop residue (C factor=0.08)
- Option 5: 100 percent installation of riparian buffer strips on both sides of RF3 stream reaches.

Table 74 shows the acres affected and estimated water quality improvement associated with this implementation plan. The estimated costs of this example are provided in the following chapter.

Table 74
EXAMPLE TMDL IMPLEMENTATION PLAN

Option	Description	Affected Area (ac)	3-yr 24-hr Storm		3-yr 24-hr Storm	
			TSS (mg/L)	% Reduction	Total P (mg/L)	% Reduction
0	No action	0	652	0	0.58	0
3	IL038 land use changes	1,361	589	10	0.54	7
4	Conservation tillage	11,528	469	28	0.46	21
5	Riparian buffers	424	94	82	0.092	0.092
Overall		13,313	94	82	0.092	0.092

7. IMPLEMENTATION PLAN

TMDL implementation plans require the following elements:

- Control actions,
- Time line,
- Legal authority,
- Time required to attain water quality standards,
- Monitoring plan,
- Milestones for attaining water quality standards, and
- Revision procedures.

Control actions are evaluated in Chapter 6. The remaining items are presented in this chapter.

These BMPs will control all pollutants impairing ALUS in NK 01: TSS, phosphorus, and BOD and should bring the waterbody into compliance with the TMDL endpoints for these three impairment causes. Monitoring for refinement of the source loads is also recommended as part of the implementation plan. Bed erosion, bank erosion, and gully erosion contribute to the total TSS load, but data are not available to link these sources to instream water quality. Additionally, data should be collected in NK 02 to confirm ALUS impairment from DO deficits, and further development of the linkage between BOD sources and DO levels in NK 02.

7.1 Implementation

Reductions in nonpoint source loadings may be non-regulatory, regulatory, or incentive-based, and consistent with applicable laws and regulations. Non-enforceable, nonpoint source control activities include:

- Demonstration of adequate funding,
- Process by which agreements/arrangements between appropriate parties (e.g. governmental bodies, private landowners) will be reached,
- Assessment of the future of government programs which contribute to implementation actions, and
- Demonstration of anticipated effectiveness of the actions.

7.2 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. Implementation of nonpoint source controls can be strengthened by signing agreements with landowners, non-governmental organizations and local agricultural interest groups.

7.3 Assistance Programs

Implementation of this TMDL will rely on incentive-based programs. This section presents information concerning applicable programs that provide technical and financial assistance and encourage land stewardship. Program information is summarized from the USDA website, www.usda.gov, unless otherwise noted.

7.3.1 Environmental Quality Incentives Program (EQIP)

Under EQIP, technical assistance, cost share, incentive payments, and educational help are provided to farm operators who enter into five to 10 year contracts with USDA. EQIP replaces and combines the functions of previous USDA programs This program provides assistance both within and outside designated priority areas, with half of the resources targeted to livestock-related natural resource concerns and the remainder set aside for other significant conservation priorities.

The Natural Resources Conservation Service (NRCS) and the Farm Service Agency (FSA), both part of the USDA, administer the EQIP. Participants, in cooperation with the local soil and water conservation district, develop a conservation plan for the farm that serves as the basis for the EQIP contract. The Commodity Credit Corporation (CCC) provides cost-share or incentive payments to apply the conservation practices and land use conversions within a specified timeframe. Eligibility requires that the participant:

- Be in compliance with highly erodible land and wetlands conservation provisions
- Have control of the land for the term of the contract
- Submit an acceptable farm conservation plan to NRCS, approved by the SWCD, and in compliance with the terms and conditions of the program, and
- Supply information as required by CCC to determine eligibility for the program.

Public or private land can be enrolled in the EQIP, including crop land, pasture, forest land, and other land on which crops or livestock are produced, including land the NRCS has determined poses a serious threat to soil, water, or related natural resources.

EQIP provides cost-sharing up to 75 percent for certain conservation practices, such as grassed waterways, filter strips, and other practices important to improving and maintaining the health of natural resources in the area. Total EQIP cost-share and incentive payments are limited to $10,000 per person per year and $50,000 for the length of the contract.

7.3.2 Wildlife Habitat Incentives Program (WHIP)

WHIP is a voluntary program for landowners who want to develop and improve fish and wildlife habitat on private land. It provides technical assistance and cost-sharing for practice installation. WHIP participants who own or control land agree to prepare and implement a wildlife habitat development plan. NRCS helps participants prepare a wildlife habitat development plan in consultation with the SWCD. The plan describes the landowner's goals for improving wildlife habitat and lists practices and schedules for the life of the agreement. This plan may or may not be part of a larger conservation plan that addresses other resource needs such as water quality and soil erosion.

USDA and the WHIP participant sign a 5 to 10 year cost-share agreement. Under the agreement:

- The landowner agrees to install and maintain the WHIP practices and allow NRCS access to monitor the effectiveness of the practices.
- USDA agrees to provide technical assistance and pay up to 75 percent of the cost of installing the wildlife habitat practices.
- Cost-share payments may be used to establish new practices or replace practices that fail for reasons beyond the landowner's control.

All lands are eligible for WHIP, except:

- Federal land
- Land currently enrolled in the Water Bank Program, Conservation Reserve Program, Wetlands Reserve Program, or other similar programs
- Land subject to an Emergency Watershed Protection Program floodplain easement
- Land where USDA determines that impacts from onsite or offsite conditions make the success of habitat improvement unlikely.

Forested riparian buffers, for example, would be eligible for WHIP assistance.

7.3.3 Wetland Reserve Program (WRP)

This voluntary program helps landowners protect, restore, and enhance wetlands on private property. It provides an opportunity for landowners to receive financial incentives to restore wetlands in exchange for retiring marginal agricultural land. The NRCS administers the program in consultation with the FSA and other agencies. Funding for WRP comes from the CCC.

The landowner and NRCS jointly develop a plan for the restoration and maintenance of the wetland. The WRP offers landowners three options: permanent easements, 30-year easements, and restoration cost-share agreements of a minimum 10-year duration.

- Permanent Easement. This is a conservation easement in perpetuity. Easement payment will be the least of: the agricultural value of the land, an established payment cap, or an amount offered by the landowner. In addition to paying for the easement, USDA pays 100 percent of the costs of restoring the wetland.
- 30-Year Easement. This is a conservation easement lasting 30 years. Easement payments are 75 percent of what would be paid for a permanent easement. USDA also pays 75 percent of restoration costs.
- Restoration Cost-Share Agreement. This is an agreement (generally for a minimum of 10 years in duration) to re-establish degraded or lost wetland habitat. USDA pays 75 percent of the cost of the restoration activity. This does not place an easement on the property. The landowner provides the restoration site without reimbursement.

Since 1994, Illinois has enrolled over 32,000 acres in WRP. The program's successes have created enormous landowner interest. Illinois has a backlog of eligible applicants for this program. Landowners have expressed various reasons for their interest in the program, but most landowners appreciate the program providing financial compensation for removing their high-risk acreage from agriculture production. WRP funds are subsequently used to reduce debt or invest in more productive land.

7.3.4 Forest Legacy Program (FLP)

The FLP is a federal program administered by the USDA Forest Service. FLP supports state efforts to protect environmentally sensitive forest lands. The program is designed to encourage the protection of privately owned forest lands. FLP is a voluntary program, and focuses on the acquisition of partial interests in privately owned forest lands. FLP encourages and supports acquisition of conservation easements, legally binding agreements transferring a negotiated set of property rights from one party to another, without removing the property from private ownership. Most FLP conservation easements restrict development, require sustainable forestry practices, and protect other values.

Participation in FLP is limited to private forest landowners. To qualify, landowners are required to prepare a multiple resource management plan as part of the conservation easement acquisition. The federal government may fund up to 75 percent of program costs, with at least 25 percent coming from private, state or local sources. Through the end of 2000, only 83 acres of land in Illinois had been enrolled in the FLP (Forest Service 2000). This program is not likely a source of financial assistance for creating new riparian forest buffers, but can be utilized to support protection of existing forested areas.

7.3.5 Small Watershed Program

Watershed Protection and Flood Prevention Program, also known as the Small Watershed Program, or “PL 566 Program,” provides technical and financial assistance to address resource and related economic problems on a watershed basis. This program is administered by the NRCS. Projects related to watershed protection, flood prevention, water supply, water quality, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, and public recreation are eligible for assistance. Technical and financial assistance is also available for planning and installation of works of improvement to protect, develop, and use land and water resources in small watersheds.

Eligibility for assistance extends to any local or state agency, county, municipality, town or township, SWCD, flood prevention/flood control district, or other unit of government with the authority and capacity to carry out, operate, and maintain installed works of improvement. Projects are limited to watersheds smaller than 250,000 acres, indicating that Rayse Creek is eligible for this program.

This program provides technical assistance and cost sharing (amount varies) for implementation of NRCS-authorized watershed plans, including technical assistance on watershed surveys and planning. Although projects vary significantly in scope and complexity, typical projects entail \$3.5 million to \$5 million in federal financial assistance. Funding nationally for this program has decreased in recent years, and about \$100 million annually is currently appropriated, of which about \$50 million is available for financial assistance.

7.3.6 Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP)

These programs are state-federal partnerships that target specific water quality, soil erosion and wildlife habitat issues related to agriculture. Financial incentives encourage farmers to voluntarily enroll in contracts of 10 to 15 years in duration to remove highly erodible lands from agricultural production.

CRP is voluntary. Participants receive an annual rent and half the cost of establishing a conserving land cover in exchange for retiring highly erodible and/or environmentally sensitive land. Approximately 65 percent of cultivated cropland in the United States is eligible for this program (USDA ERS 1997). Limited opportunities now remain for new acreage to be enrolled in the CRP, with relatively little program acreage expiring though 2002. In addition to the regular, periodic CRP signups, USDA conducts a continuous signup of acreage dedicated to specific conservation practices, such as filter strips, riparian buffers, grassed waterways, field windbreaks, shelter belts, living snow fences, shallow water areas for wildlife and well-head protection areas. These practices involve relatively small parcels of land, but are expected to provide disproportionate environmental benefits. Under the continuous signup, if land is suitable for the above practices and the landowner agrees to the annual payment rate, which is based on soil type, the offer is considered immediately accepted under the continuous signup for contracts of up to 15 years. On top of the annual payment, there is a yearly bonus of 20 percent for filter strips, riparian buffers, grassed waterways and field windbreaks.

USDA announced new incentives for participants in continuous signup including a one-time “signing bonus,” additional cost-share assistance and new payment rates for marginal pasture lands. CREP is a new program; it is essentially an enhanced version of the CRP. In Illinois, CREP targets the Illinois River watershed. This is outside our area of concern and therefore the new program is not applicable (NRCS 1998).

7.3.7 Conservation 2000

Conservation 2000 is 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:

- Illinois Department of Natural Resources
    - Ecosystems Program
    - Review of Illinois Water Law
    - Ecosystem Monitoring Program
    - Natural Resources Information Network

- Illinois Environmental Protection Agency
    - Illinois Clean Lakes Program

- Illinois Department of Agriculture
    - Conservation Practices Cost-Share Program
    - Sustainable Agriculture Grants Program
    - SWCD Program Development
    - Expansion Grants
    - Streambank Stabilization and Restoration Program

Several of these are watershed conservation efforts. They are discussed below.

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 Sustainable Agriculture Grants Program funds sustainable agriculture research, education and demonstration through conferences, training, on-farm research and educational outreach. Sustainable agriculture is a system of farming designed to balance environmental and economic concerns. Practices are aimed at maintaining producers' profitability while conserving soil, protecting water resources and controlling pests through means that are not harmful to natural systems, farmers or consumers. Organizations and individuals may apply for sustainable agriculture grants provided they can demonstrate an understanding of sustainable agriculture systems and the ability to complete the project in a timely and professional manner.

The Conservation Practices Cost-Share Program subsidizes landowner implementation of conservation practices, such as terraces, filter strips and grass waterways, are aimed at reducing soil loss on crop land. To qualify for the program, land upon which the owner plans to install a conservation practice must be experiencing erosion at rates greater than one and one-half times the tolerable soil loss level. Landowners must cooperate with their SWCD, including developing a conservation plan. The SWCD sets maximum cost-share rates for each approved practice, up to a maximum of 60 percent. Maximum cost-share payments may also be established for each project. Cost-share payments are based on locally established average costs for similar conservation practices. Conservation practices selected for cost-share assistance include those listed below.

- Contour farming establishment
- Contour stripcropping or contour buffer strip establishment
- Cover and green manure crops
- Critical area planting
- Diversion
- Field border strips
- Filter strips
- Grade stabilization structures
- Grassed waterway
- No-till planting systems
- Pasture and hayfield planting
- Terraces
- Water and sediment control basins

Recipients of cost-share monies must agree to continue or maintain structural conservation practices and possibly some management practices for at least 10 years.

The Streambank Stabilization and Restoration Program is designed to demonstrate effective, inexpensive vegetative and bio-engineering techniques for limiting streambank erosion. Program monies fund demonstration projects at suitable locations statewide and provide cost-share assistance to landowners with severely eroding stream banks. Both cost-share assistance and demonstration project funding are available under this program. Eligibility for participating in this program includes a requirement that sites meet assessment and selection criteria established for successful streambank stabilization using vegetative or other bio-engineering techniques. Proposals must be sponsored by the local SWCD and recipients must agree to maintain streambank stabilization practices for at least 10 years.

The Soil and Water Conservation District Grants Program provides assistance to Illinois' SWCDs to help offset operating expenses.

7.3.8 Section 319

Section 319 of the Clean Water Act authorizes the federal Nonpoint Source Management Program. This program is administered by the Illinois EPA. Under section 319, states receive grant money which support a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific nonpoint source implementation projects. The program requires a 40 percent local match. All control options evaluated for this TMDL are eligible for 319 funds. Fiscal year 2000 included $9.6 million in the Illinois EPA's budget. The development and implementation of nonpoint source TMDLs can be funded under section 319.

7.3.9 Summary of Financing Sources

The matrix below summarizes the eligibility of nonpoint source control options described in Chapter 6. Planning assistance and riparian buffers have the most opportunities for obtaining federal or state financial assistance at some level, but all are eligible for one or more programs.

	Crop Land to Grass Land Conversion	Adoption of Conservation Tillage Practices	Implementation of Riparian Forest Buffers	Implementation of Contour Stripcropping/Terracing	Conservation Planning Assistance	Livestock Manure Management Practices
Environmental Quality Incentives Program	●	●	●	●	●	●
Wildlife Habitat Incentives Program			●		●	
Wetland Reserve Program			●		●	
Forest Legacy Program			●		●	
Small Watershed Program	●	●	●	●	●	
Conservation Reserve Program	●				●	
Conservation Reserve Enhancement						
Conservation 2000	●	●	●	●	●	●
CWA Section 319	●	●	●	●	●	●

7.4 Costs

TMDL implementation costs have been estimated using historical average costs and an estimated combination of BMPs.

7.4.1 Unit Costs

The average CRP rental rate in Jefferson County (majority of the watershed) is $75 per acre based on data collected from 1987 until 2001 (NRCS no date 3). In addition, a one time sign-up bonus of $100 to $150 per acre is also being paid for the land enrolled in the continuous sign-up program (USDA 2000). The cost to establish permanent vegetative cover is $69 to $270 per acre, of which the USDA cost shares 50 percent for the continuous sign-up program (USDA ERS 2000). Therefore, an average rental rate of $75 per acre, a one time sign-up bonus of $125 per acre, and an average installation cost of $85 (50 percent cost share of the average installation cost) is used as the financial commitments in these calculations. Landowners' loss of cropland income is estimated to be $150 per acre.

The two biggest economic factors that may cause producers to consider conservation tillage systems are labor and equipment savings (NRCS 1999). When conservation tillage systems are applied, there are fewer trips made compared to conventional or intensive tillage systems, resulting in fuel savings, less equipment and equipment repairs, and less labor. Operational savings may be substantial because of reduced field operations. If a producer is able to convert to a complete no-till system, then most primary and secondary machinery is not needed. Depending on the size of the operation, less horsepower and fewer tractors may be required, which can substantially reduce operation costs. In addition, less maintenance is needed since the machinery is not being operated as many hours each year. As tillage is decreased, herbicides are more important for weed control. In a 1997 nationwide survey of growers, the NRCS found that operation costs were rarely an impediment to implementing conservation tillage practices (cited in NRCS 1999). More common reasons stated in that survey were the expense of equipment changes and weed problems. As illustrated in Table 75, operating costs may be less under no-till systems than conventional tillage system. Costs for procuring the equipment, however, can be challenging for some operators.

Table 75

OPERATING COSTS ($/acre) FOR CONVENTIONAL TILLAGE VERSUS NO-TILL
(adapted from NRCS 1999)

Crops	Conventional Tillage	No-till System	Increase/decrease
Corn			
Operating/machinery	17	5	–12
Material	100	95	–5
Other	5	5	0
Total	122	105	-17
Soybeans			
Operating/machinery	14	6	–8
Material	55	83	28
Other	3	4	1
Total	72	93	21
Wheat			
Operating/machinery	12	6	–6
Material	38	49	11
Other	3	3	0
Total	53	58	5

Riparian forest buffer unit costs were taken from NRCS (2000a) and Palone and Todd (1997). NRCS estimates that riparian forest buffers developed to their specifications, that is, planted with mixed hardwood seedlings (110 trees/ac), cost about $450/ac. Additionally, under EQIP, the landowner is generally offered an additional $100/ac annual incentive payment. Incentive payments are limited to three years. If herbaceous riparian buffers would be opted for by a landowner instead, the unit cost is estimated by NRCS to be $212/ac, including a $50/ac incentive payment under EQIP.

NRCS contour stripcropping (Practice 585, NRCS 1981) is estimated to cost $30/ac in payments, which are limited to the first year of this practice (NRCS 2000a). Our costs are based on negligible farm income from stripcropped lands.

These unit costs are the basis for programmatic level estimates for the target watershed TMDL implementation.

7.4.2 Program Costs

This TMDL implementation plan is intended to be sufficiently flexible to allow for maximum voluntary adoption at the local level. Therefore, a range of costs is most pragmatic. It is unrealistic to expect one of the six options to be wholly adopted throughout the watershed. Table 76 provides costs for each individual option to be adopted for the entire ILNK01 watershed. Unit costs are provided in Section 7.4.1.

Table 76

ESTIMATED PROGRAM COSTS (MILLION DOLLARS)

Option	Acres Impacted	Public Costs			Landowner Costs		Summary (Million $)	
		Rent[3]	Sign-up	Installation	Loss of Income[4]	Installation	Initial	Annual
1	22,600	$1.70	$2.83	NA[8]	$3.39	$1.92	$4.75	$5.09
2	6,097	$0.46	$0.76	NA	$0.91	$0.52	$1.28	$1.37
3	9,076	$0.68	$1.13	NA	$1.36	$0.77	$1.91	$2.04
4	23,056	NA[4]	NA	NA	NA	NA	NA	NA
5	1,165	$0.09	$0.35	$0.39	$0.17	$0.13	$0.87	$0.26
6	9,076	NA	$0.27	NA	$1.36	NA	$0.27	$1.36

The costs in Table 76 are the basis for development of a range of TMDL implementation cost. Options 1, 4, 5, and 6 are most reasonable options for agricultural BMPs, and, in combination, provide technically and socioeconomically reasonable methods for meeting the TMDL goal. If these four options are implemented at an equal portion of the total (*i.e.* 25 percent of TMDL implementation costs are devoted to each Option), initial and annual costs would average initial costs of $2.0 million and recurring costs of $2.2 million annually.

[3] Cost is per year.
[4] NA – Not Applicable. Government programs do not provide funding.

The example implementation plan in Table 74 included three TSS and phosphorus control options, or BMPs. That example is estimated to have initial costs of $520,000 and recurring costs of $390,000 annually (Table 77).

Table 77

ESTIMATED COSTS OF THE EXAMPLE TMDL IMPLEMENTATION PLAN ILLUSTRATED IN TABLE 49
(million dollars)

Option	Acres Impacted	Public Costs			Landowner Costs		Summary	
		Rent	Sign-up	Installation Cost Share	Loss of Income	Installation	Initial	Annual
3	1,361	0.1	0.17	NA	0.20	0.12	0.29	0.30
4	11,528	NA	NA	NA	NA	NA	NA	NA
5	424	0.03	0.04	0.14	0.06	0.05	0.23	0.09
Total	13,313	0.13	0.21	0.14	0.26	0.17	0.52	0.39

7.5 Monitoring

The implementation plan requires that the TMDL establish a schedule that includes a monitoring or modeling plan to measure the effectiveness of source control measures. The Illinois EPA continues to monitor the Rayse Creek at sample station NK 01 as part of their ambient water quality monitoring network station (AWQMN) sampling from which data is collected nine times a year. The continued collection of this data will allow the implementation plan effectiveness to be calculated. Sampling is less frequent at NK 02 as it is not an AWQMN station. We recommend additional monitoring to address uncertainties in pollutant loadings in ILNK01. As indicated earlier, no data are currently available to allow an estimate of gully erosion, bank erosion or stream bed erosion. We recommend that the Illinois EPA make this a priority for ILNK01. Also, insufficient data are available to confirm ALUS impairment for DO deficits in segment NK 02 or to develop a reliable linkage between pollutant sources and instream DO concentrations.

7.6 Implementation Schedule, Milestones and Revisions

The federal TMDL program seeks to have runoff controls in place five years after approval of the Implementation Plan, and to have use support and water quality standards met after 10 years. Meeting this schedule successfully will require the following:

- Local development of farm conservation plans
- Aggressive preparation of these plans and public education about agricultural conservation

- State and federal funding support for planning, implementation, and monitoring

We recommend that farm conservation plans be completed within the first 18 months. The IEPA will make sufficient grant funding available to the SWCDs to support conservation planning and implementation, contingent upon adequate federal support. Plans will be prepared and implemented on a priority basis, according to the areal soil loss rate for the subwatershed (Table 78).

Table 78

SUBWATERSHED PRIORITIES FOR CONSERVATION PLANNING AND IMPLEMENTATION – SEDIMENT (FROM TABLE 24)

Subwatershed	Areal Soil Loss Rate	Areal Soil Loss Rate	Priority
RC-1	0.96 tons/ac/yr	0.133 kg/ac	1
RC-2	0.88 tons/ac/yr	0.120 kg/ac	2
RC-6	0.88 tons/ac/yr	0.104 kg/ac	3
RC-5	0.60 tons/ac/yr	0.079 kg/ac	4
RC-10	0.60 tons/ac/yr	0.078 kg/ac	5
RC-7	0.58 tons/ac/yr	0.076 kg/ac	6
RC-4	0.57 tons/ac/yr	0.074 kg/ac	7
RC-3	0.55 tons/ac/yr	0.068 kg/ac	8
RC-9	0.51 tons/ac/yr	0.064 kg/ac	9
RC-11	0.35 tons/ac/yr	0.051 kg/ac	10
RC-12	0.35 tons/ac/yr	0.050 kg/ac	11
RC-8	0.34 tons/ac/yr	0.046 kg/ac	12

Consideration must be given to the lag time between source control actions (habitat improvements and loading reductions) and observable/measurable instream effects, especially for nonpoint sources. The time required for Rayse Creek to meet the water quality target for siltation is unknown. It is dependent on voluntary farmer participation in existing government programs such as EQIP and Conservation 2000. The control measures suggested can be implemented expeditiously. These programs are supported by adequate funding, leading to a reasonable assurance that they will be implemented. Additionally, the NRCS funds, recommends, and supports these programs providing the legal authority for these actions. The final TMDL rules state that "implementation will be as expeditious as practicable (i.e., within five years when practicable) for waterbodies impaired only by sources which are not subject to NPDES permits, including nonpoint sources" (Federal Register 2000).

While monitoring and recording of water quality is adequate through the AWQMN, farm conservation plans and BMP implementation are not currently recorded electronically, making rapid integration with watershed assessments cumbersome and inefficient. Development of a GIS-based recording system at the SWCD level would greatly facilitate watershed assessments and determination of linkages between land treatment and water quality. Revisions and updates to modeling and the TMDL can be incorporated as new data are obtained.

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EXHIBITS

LIST OF EXHIBITS

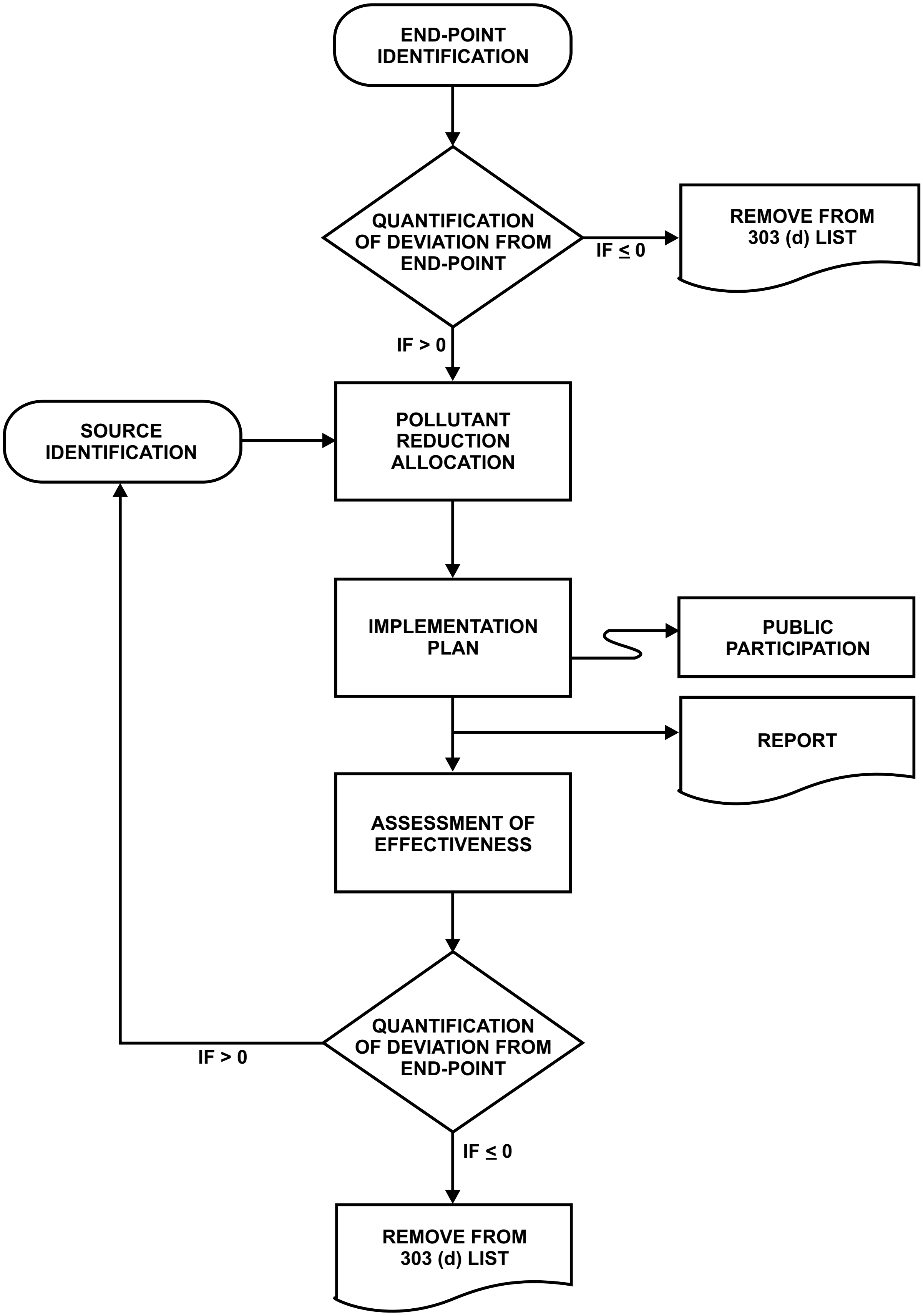
EXHIBIT 18 POINT SOURCES OF POLLUTANTS

EXHIBIT 19 ANIMAL MANAGEMENT FACILITIES

EXHIBIT 20 COMPARISON OF SELECTED CAPABILITIES OF SIMPLE AND MID-RANGE WATERSHED MODELS

EXHIBIT 21 COMPARISON OF CAPABILITIES OF STEADY STATE WATER QUALITY MODELS

EXHIBIT 1



SOURCE: Modified From EPA 100-R-98-006, July 1998.

HIERARCHAL APPROACH TO TMDL DEVELOPMENT

DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS FOR TARGET WATERSHEDS

Watershed ILNK01: Rayse Creek

MWH
MONTGOMERY WATSON HARZA

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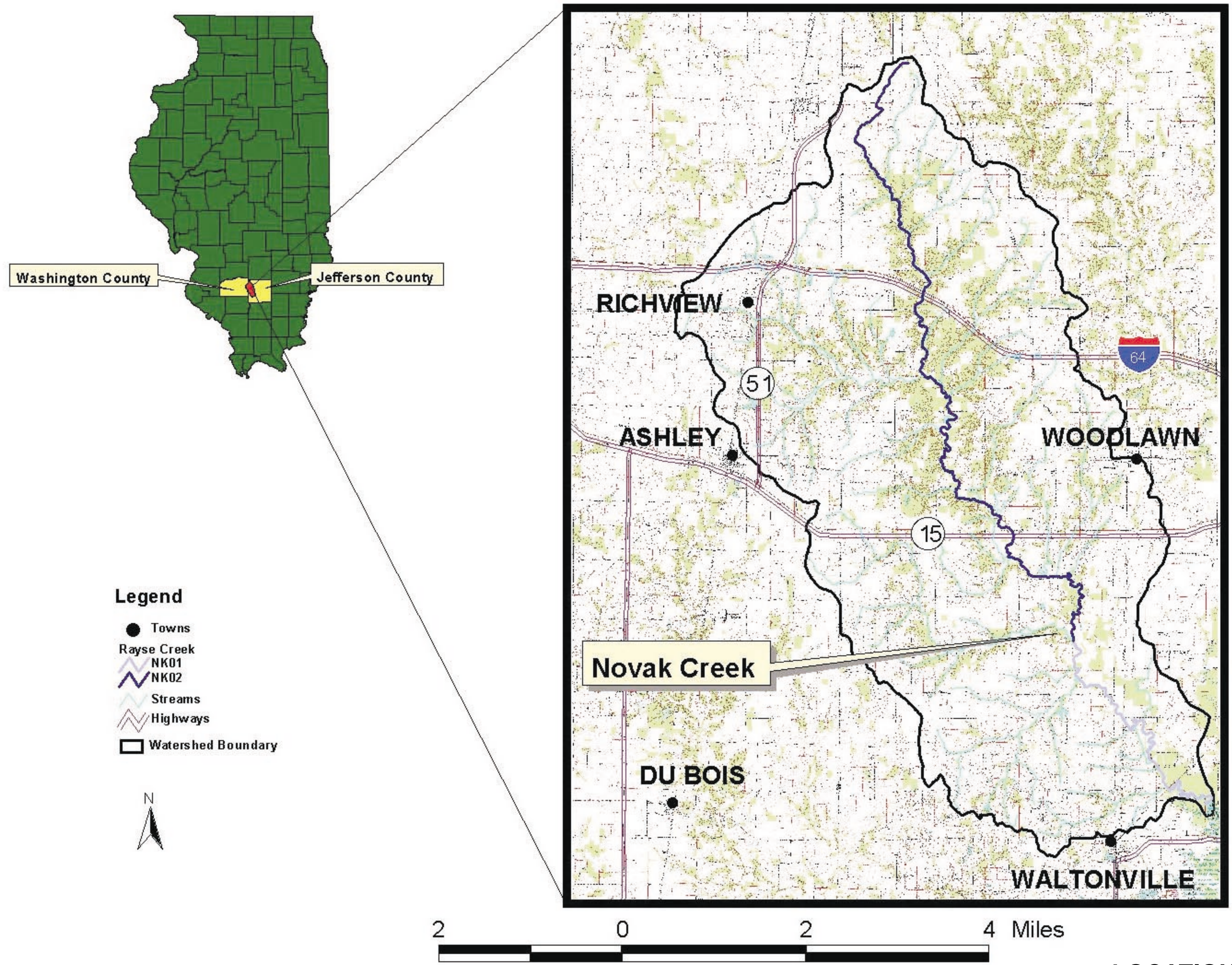
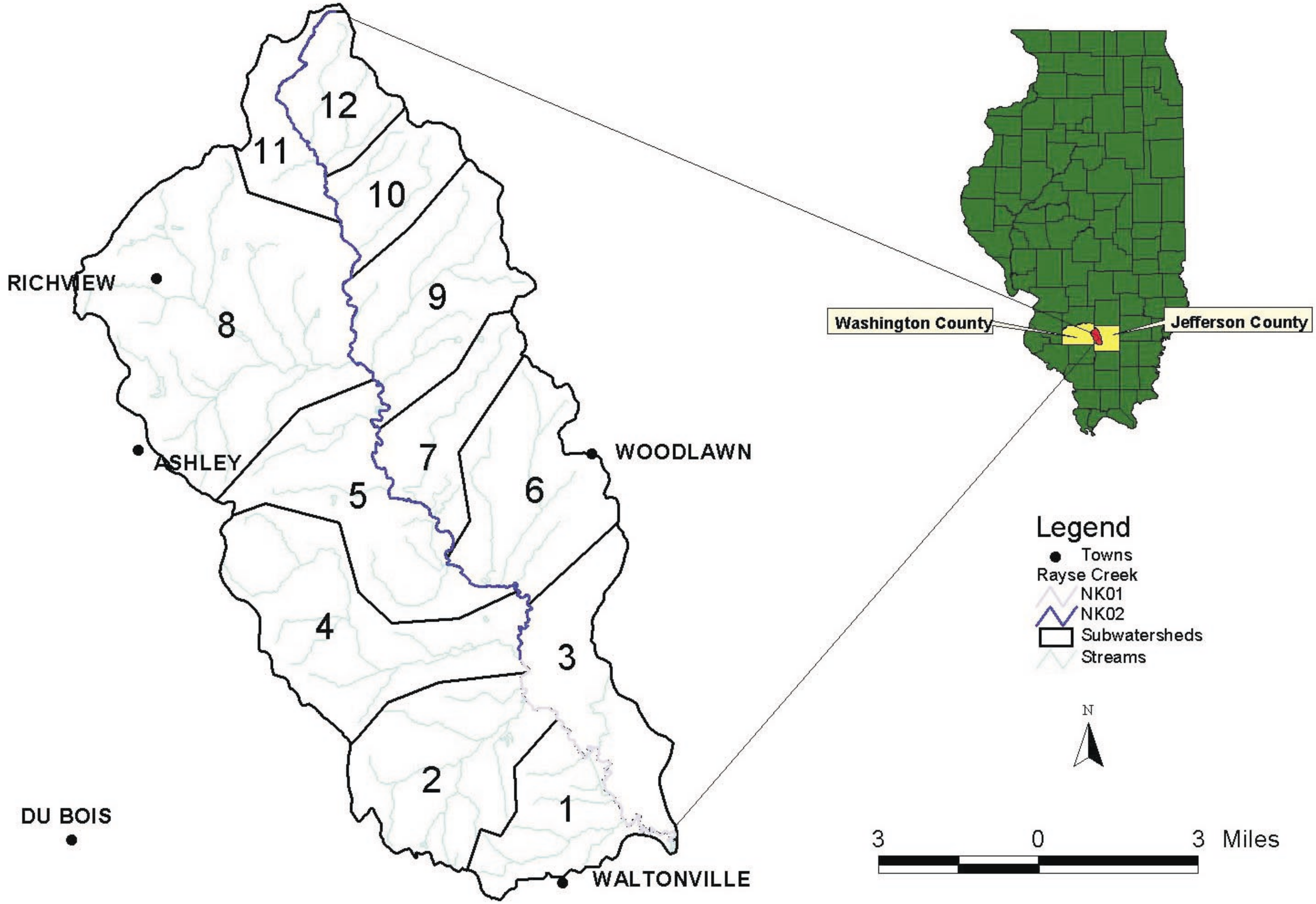


LOCATION MAP
DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 2

MWH
MONTGOMERY WATSON HARZA



SUBWATERSHEDS
DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 3

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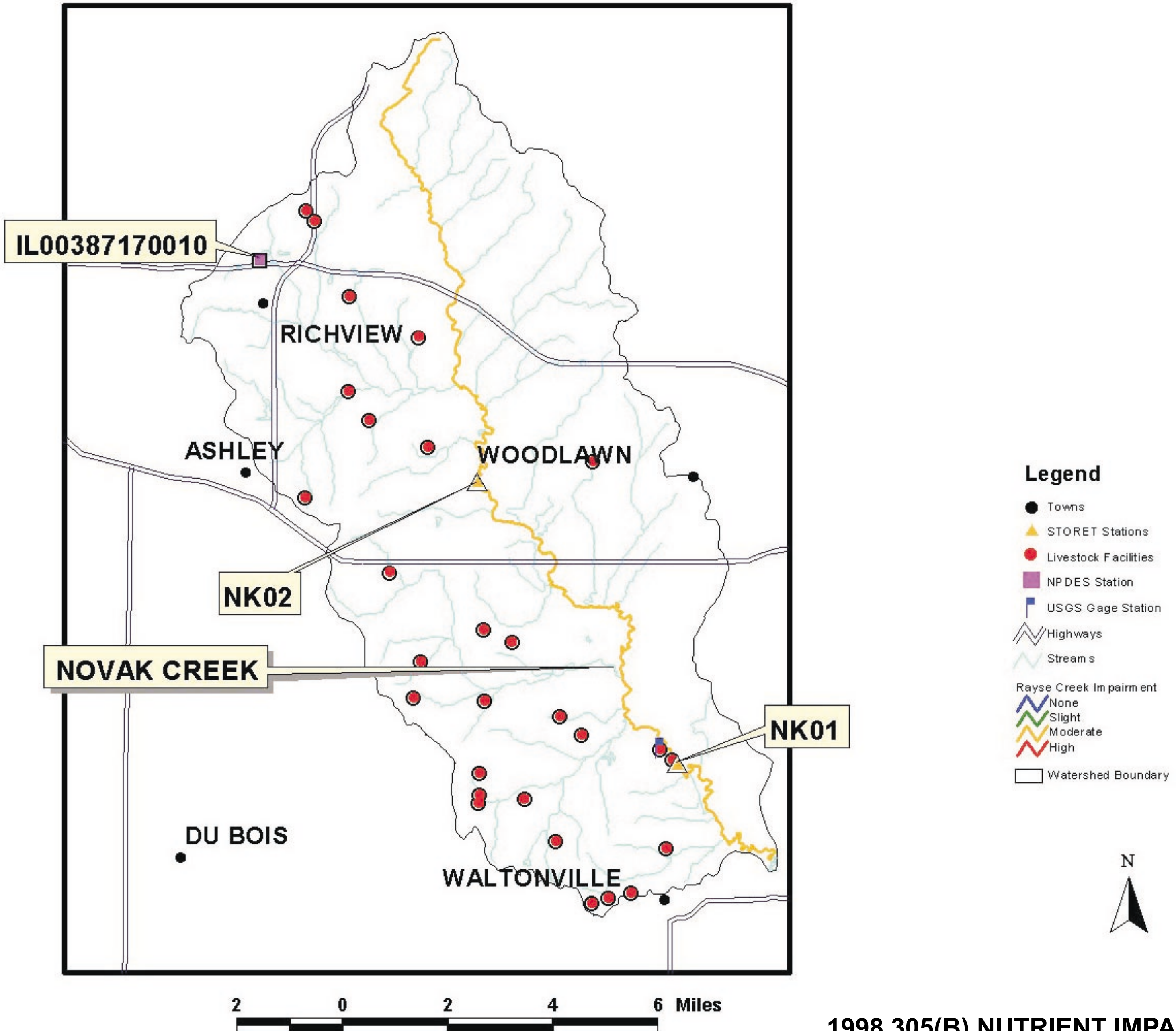

1998 305(B) NUTRIENT IMPAIRMENTS
DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 4

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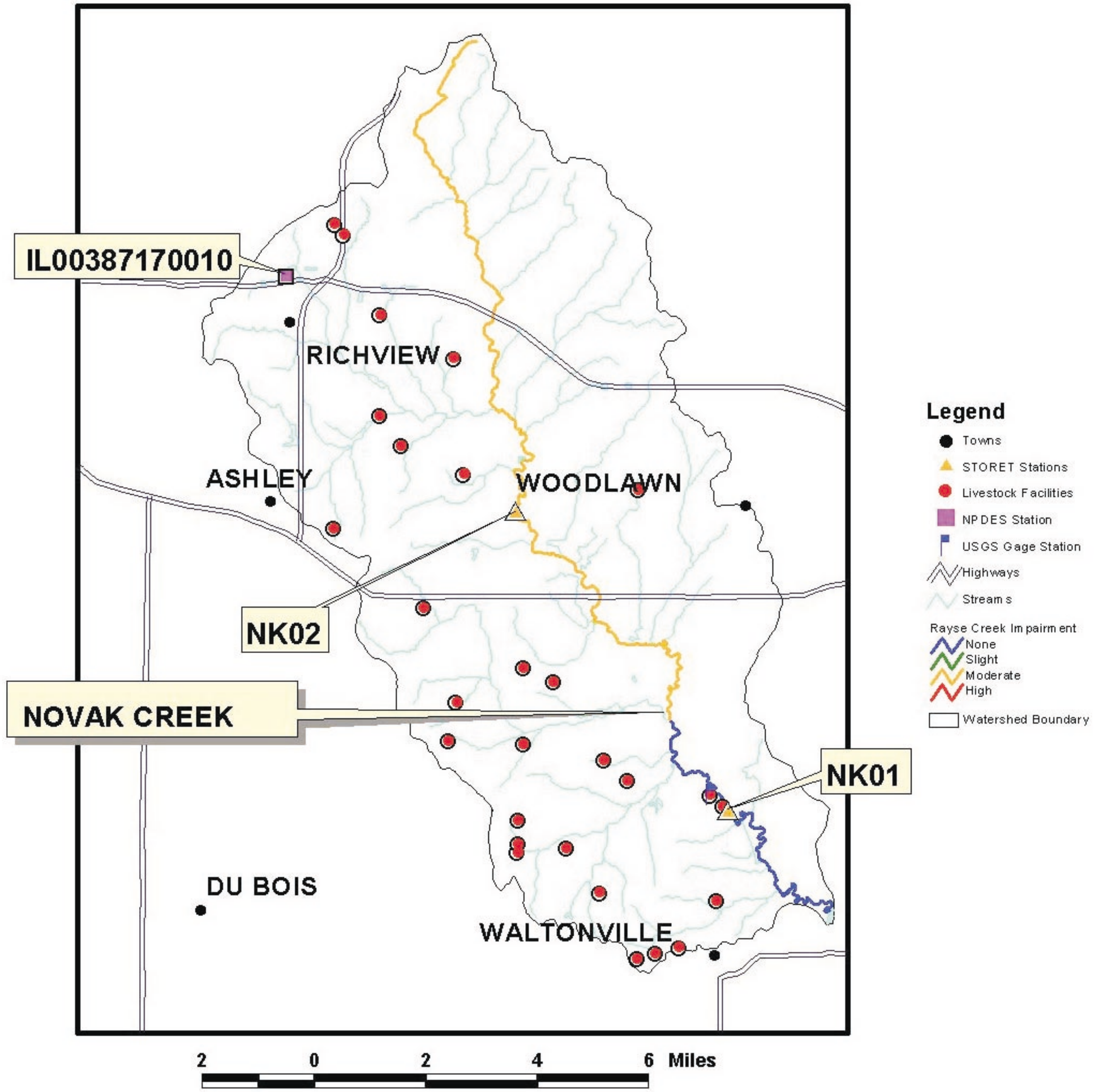

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DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 5

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MONTGOMERY WATSON HARZA

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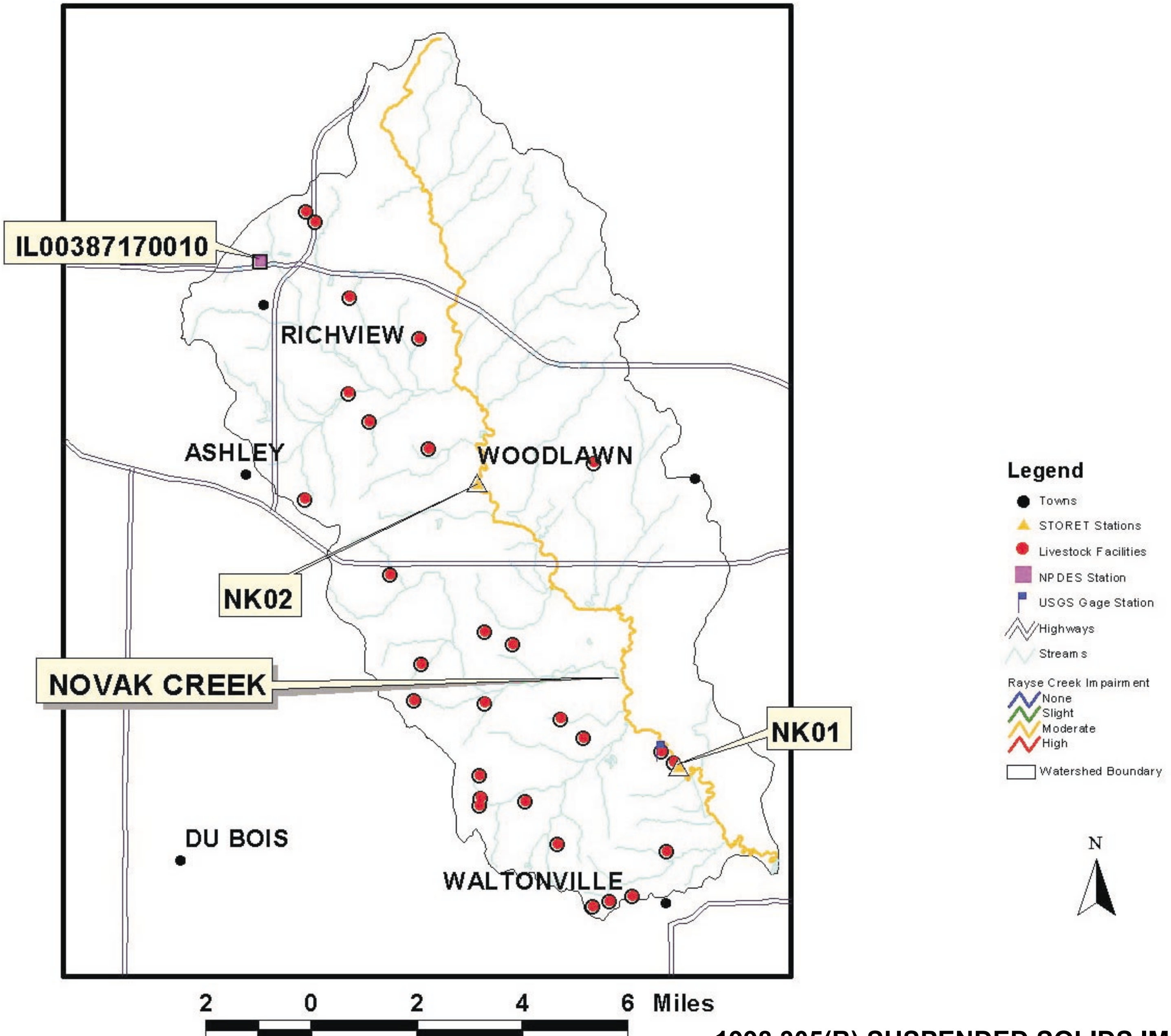

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1998 305(B) SUSPENDED SOLIDS IMPAIRMENTS
DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 6

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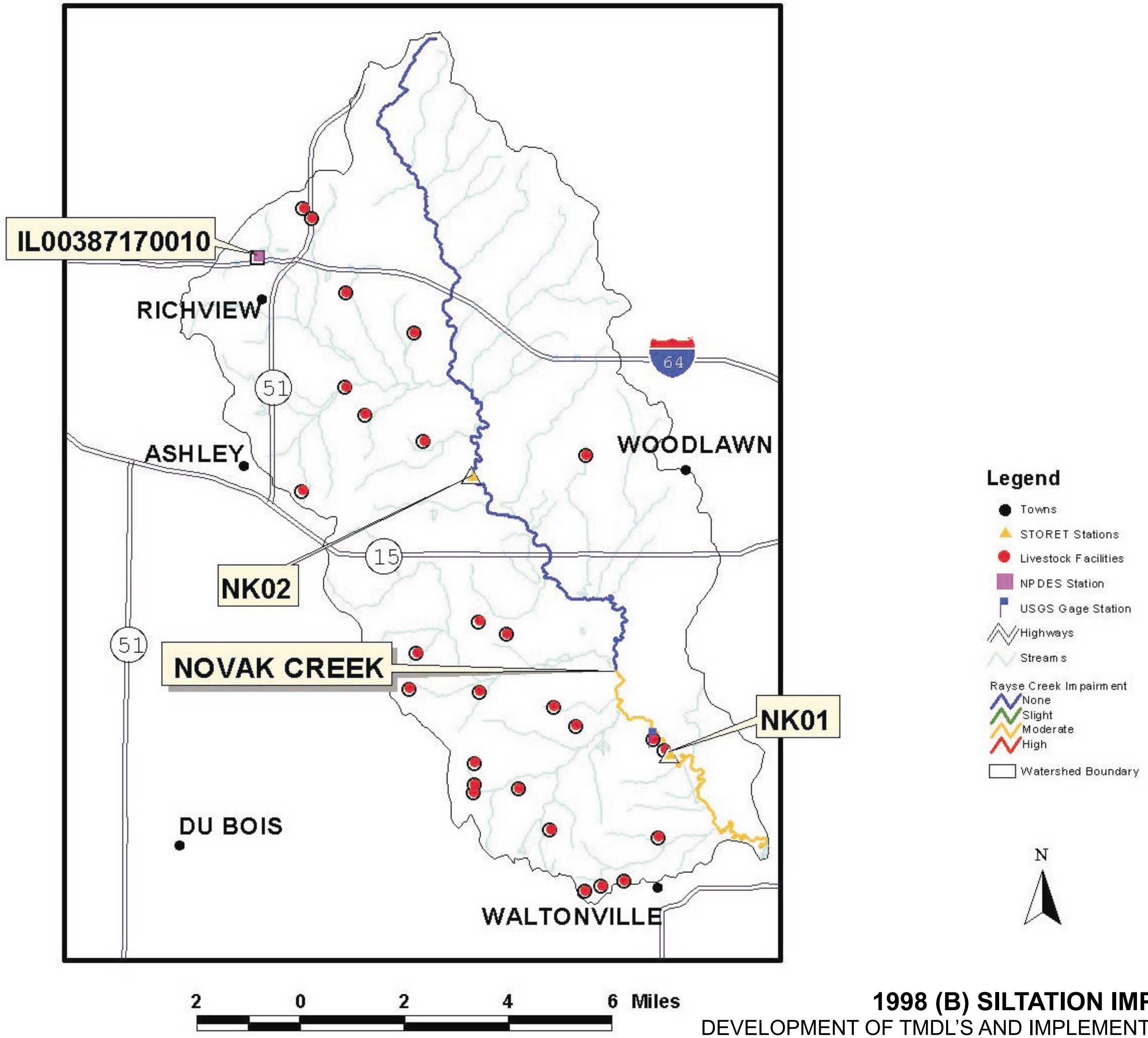

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1998 (B) SILTATION IMPAIRMENTS
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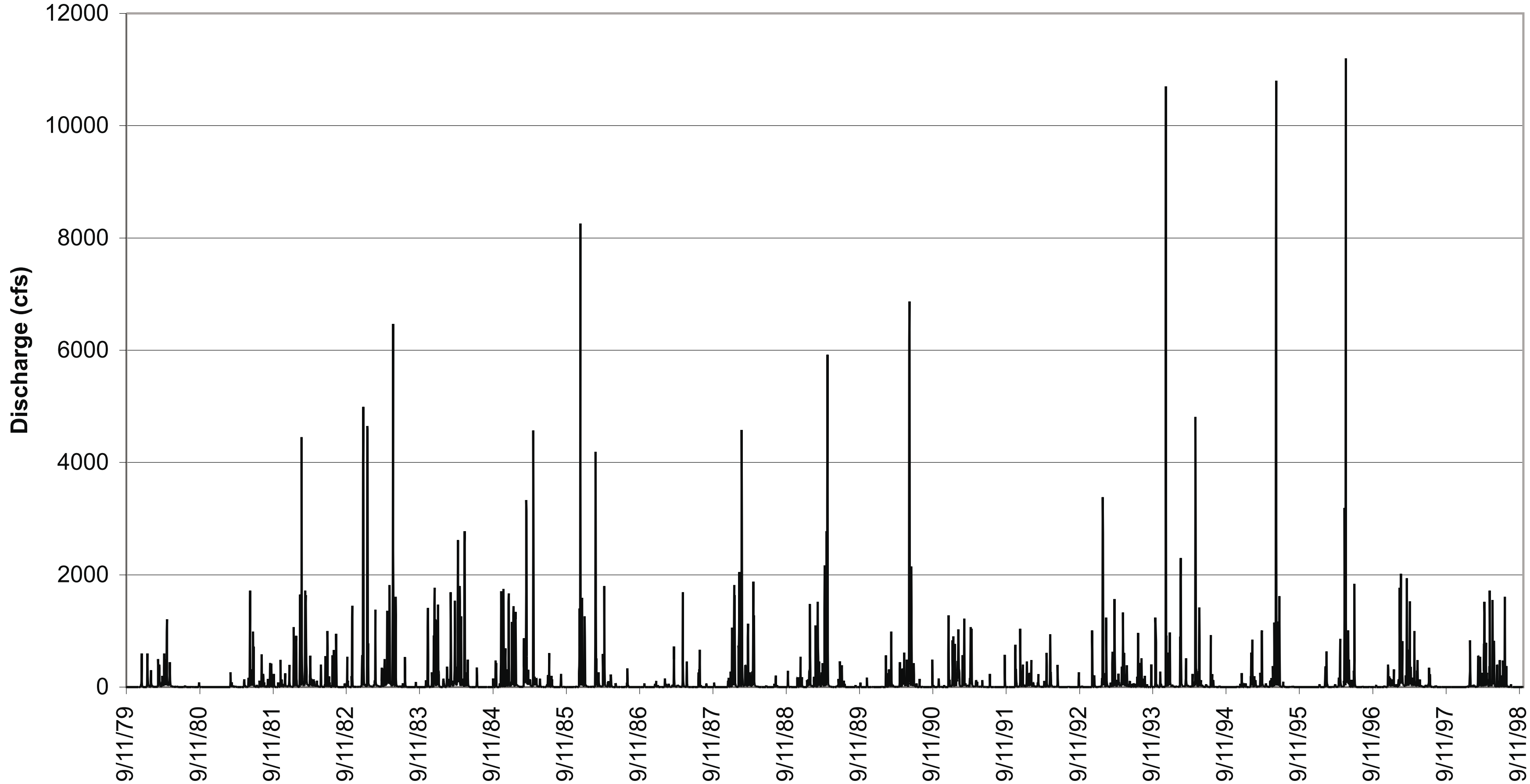
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 7



MWH
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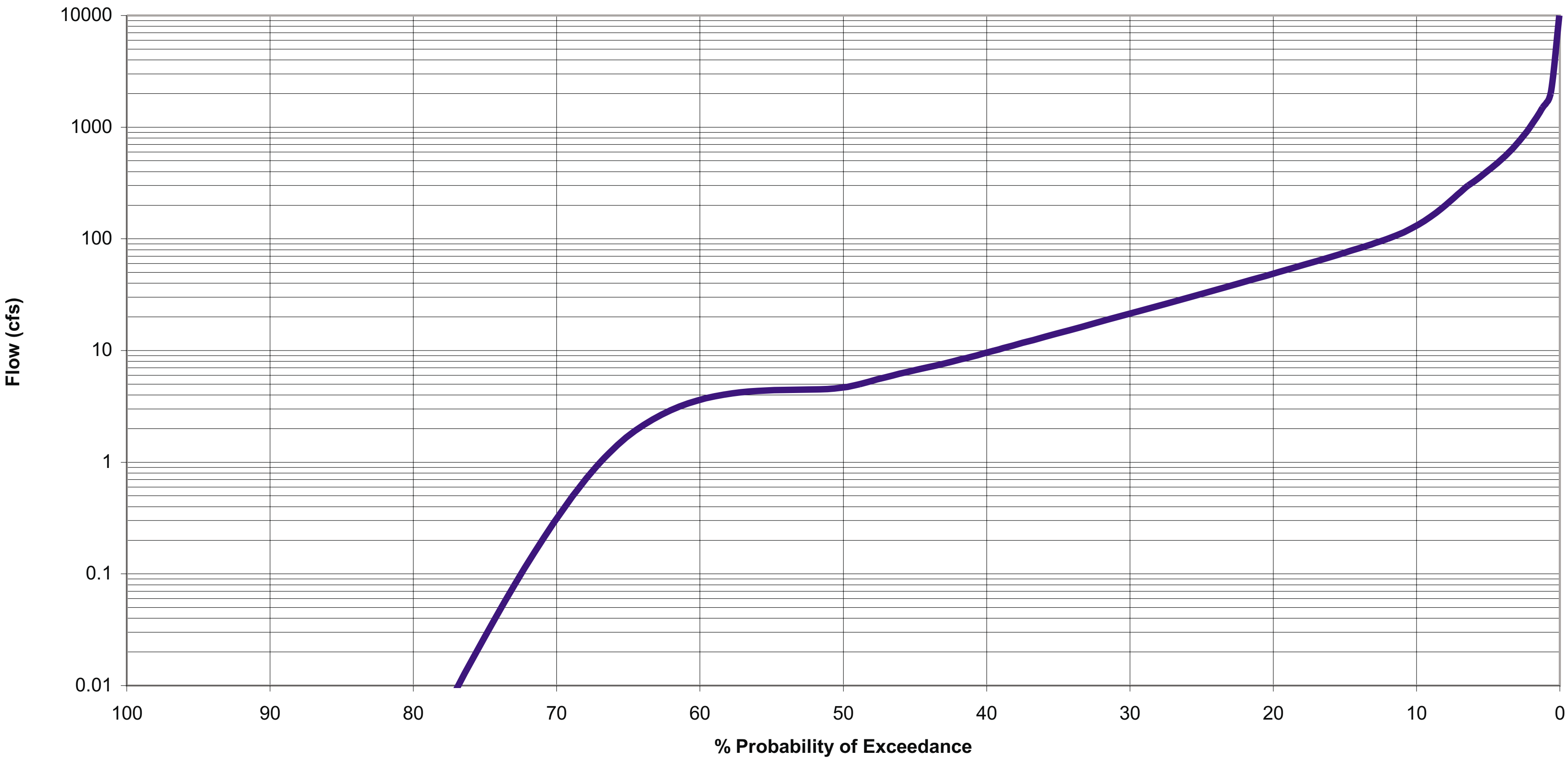
DAILY DISCHARGE AT RAYSE CREEK NEAR WALTONVILLE, IL

DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 8



MWH
MONTGOMERY WATSON HARZA

FLOW DURATION CURVE
DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 9

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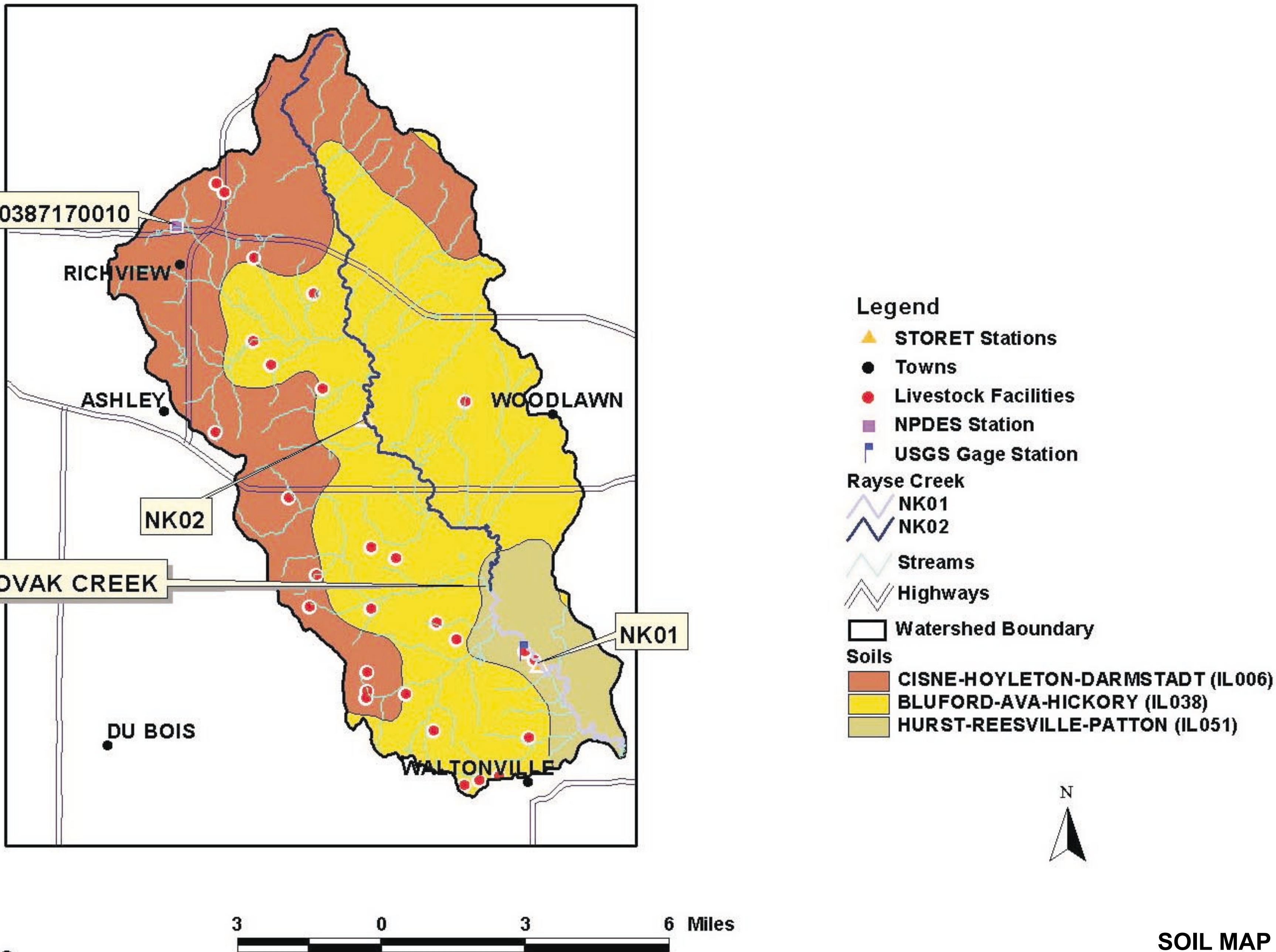

Source: STATSGO

MWH
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SOIL MAP
DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 10

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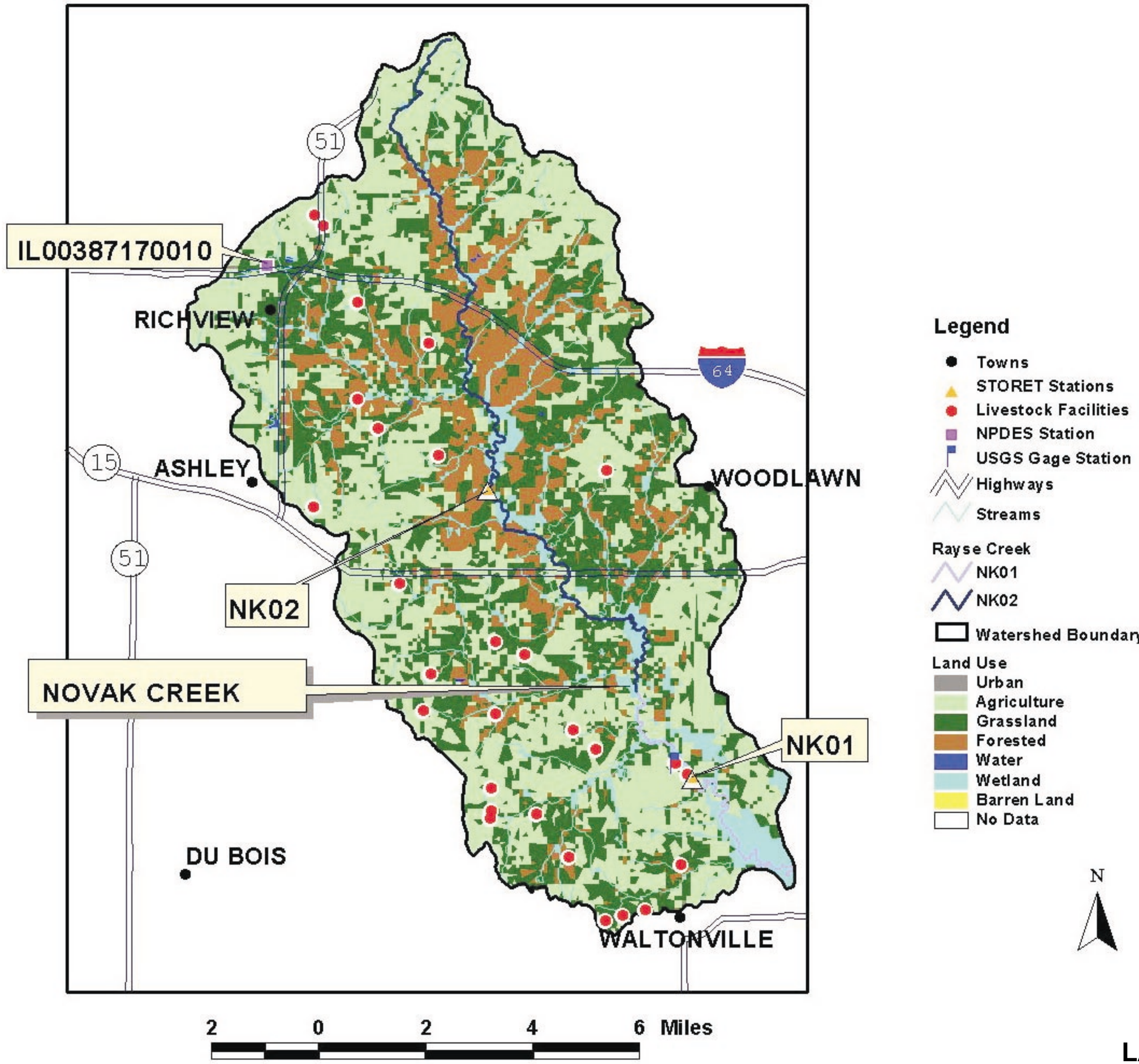

MWH
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LAND USE MAP
DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 11

EXHIBIT 12

LAND USE AREAS (ACRES)

	RC 01				RC 02				RC 03				RC 04				RC 05				RC 06			
Land Use/Land Cover	**IL006**	**IL038**	**IL051**	**Total**	**IL006**	**IL038**	**IL051**	**Total**	**IL006**	**IL038**	**IL051**	**Total**	**IL006**	**IL038**	**IL051**	**Total**	**IL006**	**IL038**	**IL051**	**Total**	**IL006**	**IL038**	**IL051**	**Total**
Urban - High Density	-	0.7	-	0.7	-	2.2	-	2.2	-	-	-	-	3.2	-	-	3.2	-	-	-	-	-	10.6	-	10.6
Urban - Medium Density	-	9.2	-	9.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.2	-	19.2
Agriculture - Row Crop	-	1,031.7	567.4	1,599.1	709.8	1,534.4	244.9	2,489.1	-	475.0	1,533.9	2,008.9	1,864.1	1,028.0	36.2	2,928.2	802.5	978.4	-	1,780.8	-	1,669.8	-	1,669.8
Agriculture - Small Grains	-	340.6	61.3	401.9	162.5	624.5	42.8	829.8	-	111.6	282.6	394.2	552.3	420.1	7.3	979.8	265.0	366.4	-	631.4	-	494.8	-	494.8
Agriculture - Orchards/Nurseries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Urban Grassland	-	12.8	-	12.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	84.8	-	84.8
Rural Grassland	-	915.1	225.0	1,140.2	347.1	1,577.1	209.1	2,133.3	-	254.2	747.7	1,001.9	1,073.8	1,602.0	40.8	2,716.6	335.9	1,429.9	-	1,765.8	-	2,229.3	-	2,229.3
Forested - Deciduous: Closed Canopy	-	119.2	10.3	129.4	25.4	278.3	9.7	313.3	-	29.4	165.0	194.4	84.7	656.7	18.3	759.7	120.2	1,373.0	-	1,493.2	-	857.0	-	857.0
Forested - Deciduous: Open Canopy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	-	-	-	-	-	-	-	2.3	-	2.3	-	-	-	-	-	-	-	-
Shallow Marsh/Wet Meadow	-	-	-	-	-	-	-	-	-	-	15.1	15.1	-	-	-	-	-	21.0	-	21.0	-	3.5	-	3.5
Deep Marsh	-	-	-	-	-	-	-	-	-	1.7	1.8	3.5	-	-	-	-	-	7.2	-	7.2	-	-	-	-
Forested Wetland	-	12.8	279.4	292.2	5.9	99.9	58.5	164.3	-	8.7	898.9	907.6	16.7	158.0	74.5	249.1	-	281.5	-	281.5	-	245.1	-	245.1
Shallow Water Wetland	-	4.0	-	4.0	-	14.4	9.8	24.2	-	-	5.4	5.4	-	9.7	-	9.7	3.4	12.8	-	16.2	-	11.7	-	11.7
Total	-	2,446.2	1,143.4	3,589.6	1,250.6	4,130.8	574.7	5,956.2	-	880.6	3,650.4	4,531.0	3,594.7	3,876.9	177.0	7,648.7	1,527.1	4,470.0	-	5,997.1	-	5,625.9	-	5,625.9

	RC 07				RC 08				RC 09				RC 10				RC 11				RC 12			
Land Use/Land Cover	**IL006**	**IL038**	**IL051**	**Total**	**IL006**	**IL038**	**IL051**	**Total**	**IL006**	**IL038**	**IL051**	**Total**	**IL006**	**IL038**	**IL051**	**Total**	**IL006**	**IL038**	**IL051**	**Total**	**IL006**	**IL038**	**IL051**	**Total**
Urban - High Density	-	-	-	-	31.1	-	-	31.1	-	1.0	-	1.0	-	-	-	-	0.1	-	-	0.1	-	-	-	-
Urban - Medium Density	-	-	-	-	23.7	-	-	23.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agriculture - Row Crop	-	611.0	-	611.0	4,006.3	537.2	-	4,543.5	842.3	797.2	-	1,639.5	835.1	384.1	-	1,219.2	1,272.0	0.9	-	1,272.9	1,264.8	28.7	-	1,293.5
Agriculture - Small Grains	-	189.2	-	189.2	1,578.2	488.1	-	2,066.3	30.7	164.2	-	194.9	119.1	37.3	-	156.5	180.9	-	-	180.9	132.5	9.9	-	142.4
Agriculture - Orchards/Nurseries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Urban Grassland	-	-	-	-	101.5	-	-	101.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rural Grassland	-	1,449.5	-	1,449.5	2,849.1	1,652.8	-	4,501.9	259.3	1,410.9	-	1,670.2	230.6	296.2	-	526.8	473.5	3.7	-	477.2	539.5	52.7	-	592.1
Forested - Deciduous: Closed Canopy	-	692.6	-	692.6	820.3	1,498.1	-	2,318.3	132.2	1,690.2	-	1,822.4	97.5	549.2	-	646.6	253.3	19.3	-	272.7	224.6	160.7	-	385.4
Forested - Deciduous: Open Canopy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	16.8	2.2	-	19.1	-	3.4	-	3.4	-	7.9	-	7.9	-	-	-	-	-	-	-	-
Shallow Marsh/Wet Meadow	-	2.3	-	2.3	3.7	6.8	-	10.5	-	4.5	-	4.5	-	-	-	-	0.4	-	-	0.4	0.7	-	-	0.7
Deep Marsh	-	1.3	-	1.3	-	-	-	-	-	1.1	-	1.1	-	1.9	-	1.9	-	-	-	-	-	-	-	-
Forested Wetland	-	247.2	-	247.2	60.6	197.3	-	257.9	-	362.0	-	362.0	2.2	85.3	-	87.5	41.9	25.3	-	67.3	25.9	15.4	-	41.3
Shallow Water Wetland	-	8.6	-	8.6	49.8	13.8	-	63.6	1.3	14.9	-	16.1	1.5	1.0	-	2.6	-	-	-	-	6.1	-	-	6.1
Total	-	3,201.7	-	3,201.7	9,541.1	4,396.4	-	13,937.5	1,265.7	4,449.3	-	5,715.0	1,286.0	1,362.9	-	2,648.9	2,222.3	49.2	-	2,271.5	2,194.1	267.4	-	2,461.5

Exhibit 13
WATER QUALITY DATA FOR SEGMENT NK02
(Source: STORET)

Date	July 27, 1995	February 27, 1996	July 18, 2000	September 25, 2000
Water Temperature (C)	24.0	13.7	24.2	14.4
Turbidity (FTU)	5.2	5.3	14	52
Conductivity (umho/cm)	495	1060	365	500
Dissolved Oxygen (mg/L)	3.5	8.0	3.4	8.5
pH	7.0	7.2	7	7.7
Total Suspended Solids (mg/L)	50	12		
Ammonia Nitrogen (mg/L)	0.71	0.38		
Unionized Ammonia Nitrogen (mg/L)	0.004	0.001		
Total Kjeldahl Nitrogen (mg/L)	1.70	0.96		
Nitrate+Nitrite Nitrogen (mg/L)	2.0	0.9		
Total Phosphorus (mg/L)	0.46	0.13		
Dissolved Phosphorus (mg/L)	0.34	0.02		
Total Organic Carbon (mg/L)	12.0	6.0		

Exhibit 14

WATER QUALITY STATISTICS FOR SEGMENT NK01
FEBRUARY, 1991 THROUGH DECEMBER, 1998

(Source: STORET)

Analytical Parameter	N	Mean	Maximum	Minimum	Variance	Standard Deviation	No. Exceedances of Standard
Water Temperature (C)	71	14.2	26.5	0.6	62.5	7.9	
Fecal Coliform (/100mL)	57	2,943	97,000	4	1.7+E08	13,092	
Turbidity (FTU)	69	25	300	2	1562	40	
Conductivity (umho/cm)	71	620	1,550	188.0	83,468	289	
Dissolved Oxygen (mg/L)	71	7.4	13.9	1.0	11.2	3.3	19
Chemical Oxygen Demand (mg/L)	25	26	71	14	147	12	
pH	71	7.3	8.5	6.2	0.1	0.4	
Total Suspended Solids (mg/L)	71	72	844	4	17,336	132	
Ammonia Nitrogen (mg/L)	71	0.34	9.70	0.010	1.47	1.21	
Unionized Ammonia N (mg/L)	71	0.0016	0.029[1]	0.00001	2E-05	4E-03	1[1]
Total Kjeldahl Nitrogen (mg/L)	71	1.6	24.0	0.10	9.13	3.02	
Nitrite+Nitrate Nitrogen (mg/L)	71	0.90	8.0	0.010	1.68	1.30	
Total Phosphorus (mg/L)	70	0.27	2.50	0.030	0.13	0.36	5
Dissolved Phosphorus (mg/L)	71	0.12	2.2	0.010	0.08	0.28	
Total Organic Carbon (mg/L)	70	10.2	32.8	4.0	28.2	5.3	

[1] Occurred 11/18/91, exceeds the November through March Chronic Standard of 0.025 mg/L

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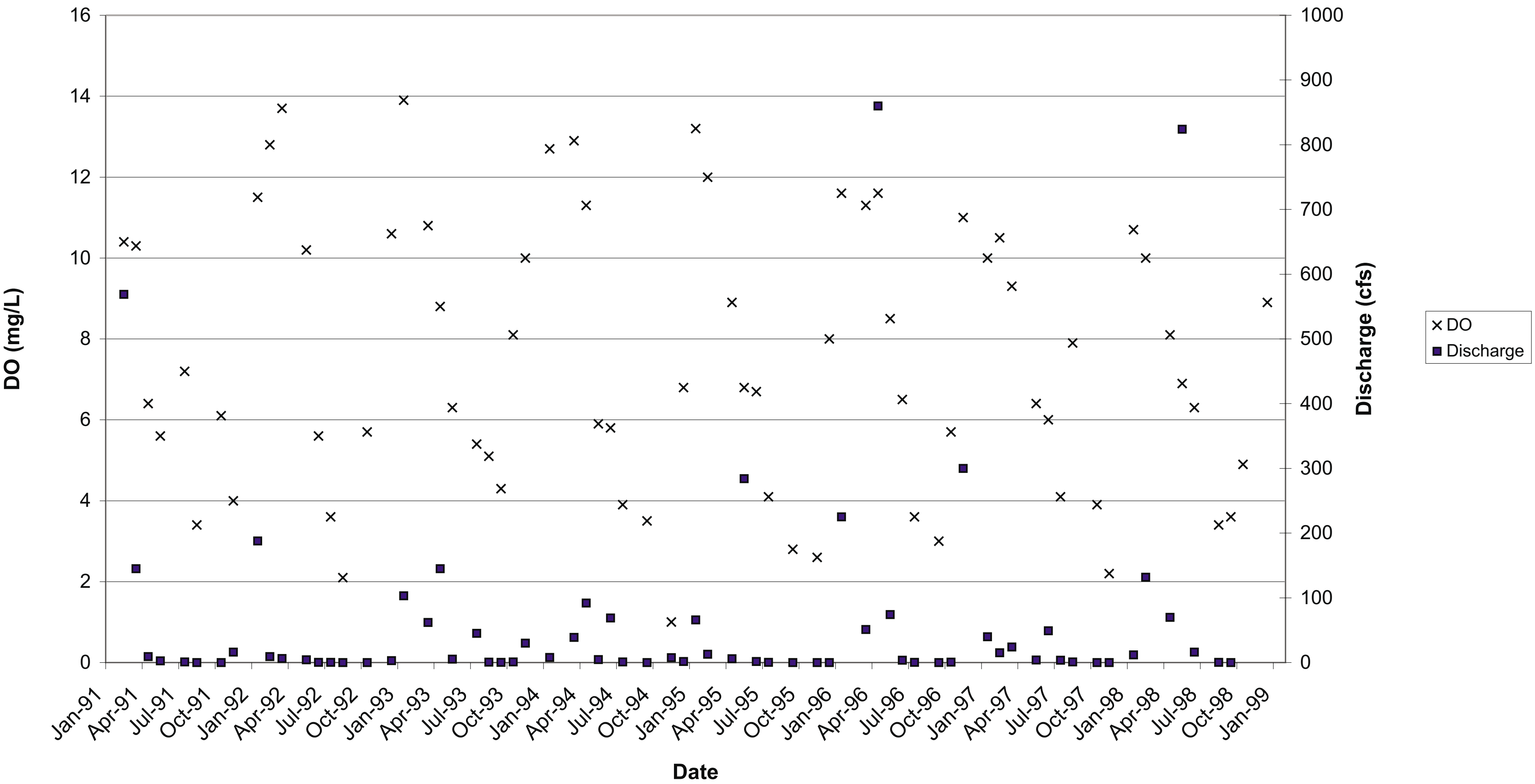

SOURCE: STORET

MWH
MONTGOMERY WATSON HARZA

WATER QUALITY AT NK01
DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 15

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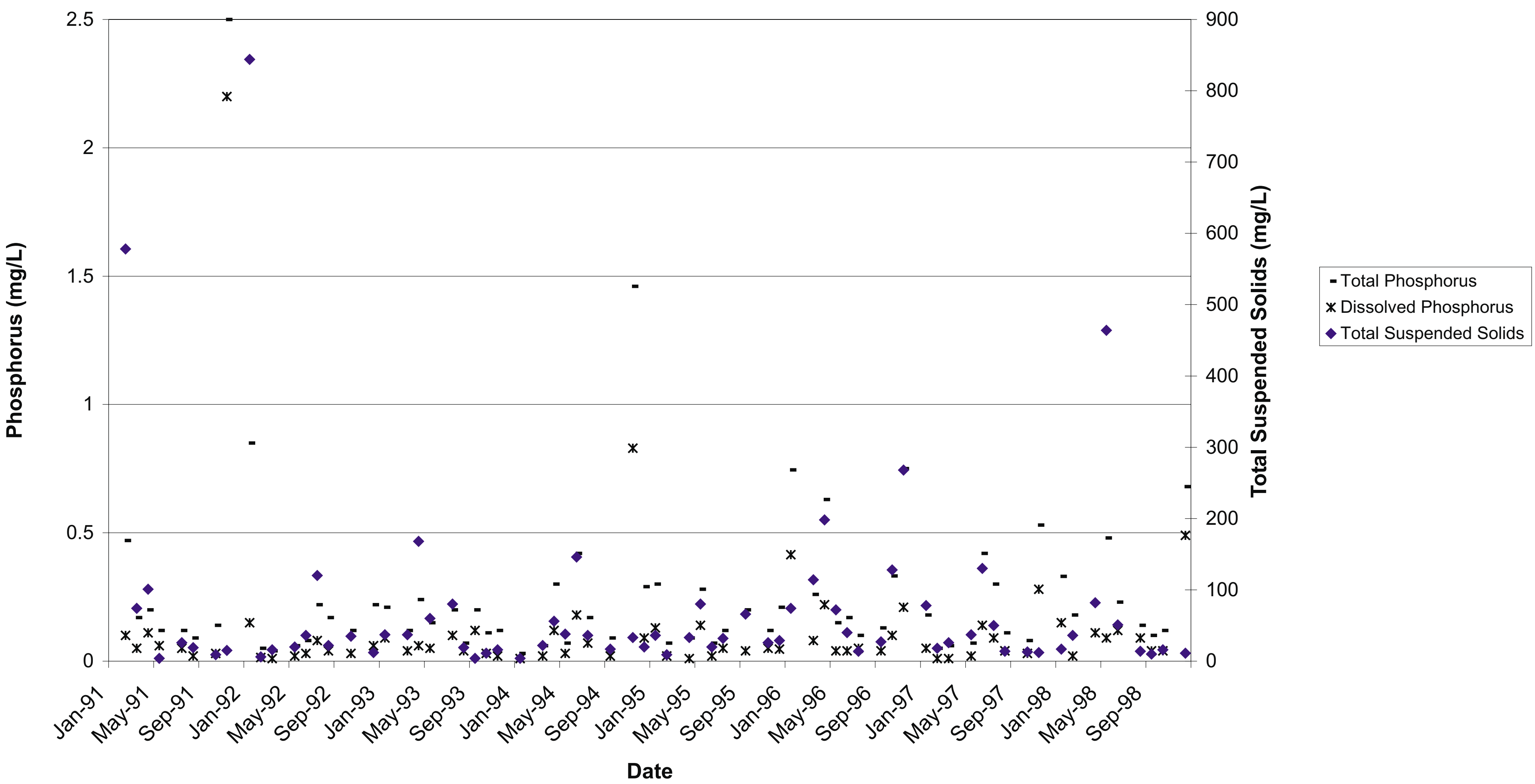

SOURCE: STORET

MWH
MONTGOMERY WATSON HARZA

WATER QUALITY AT NK01
DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 16

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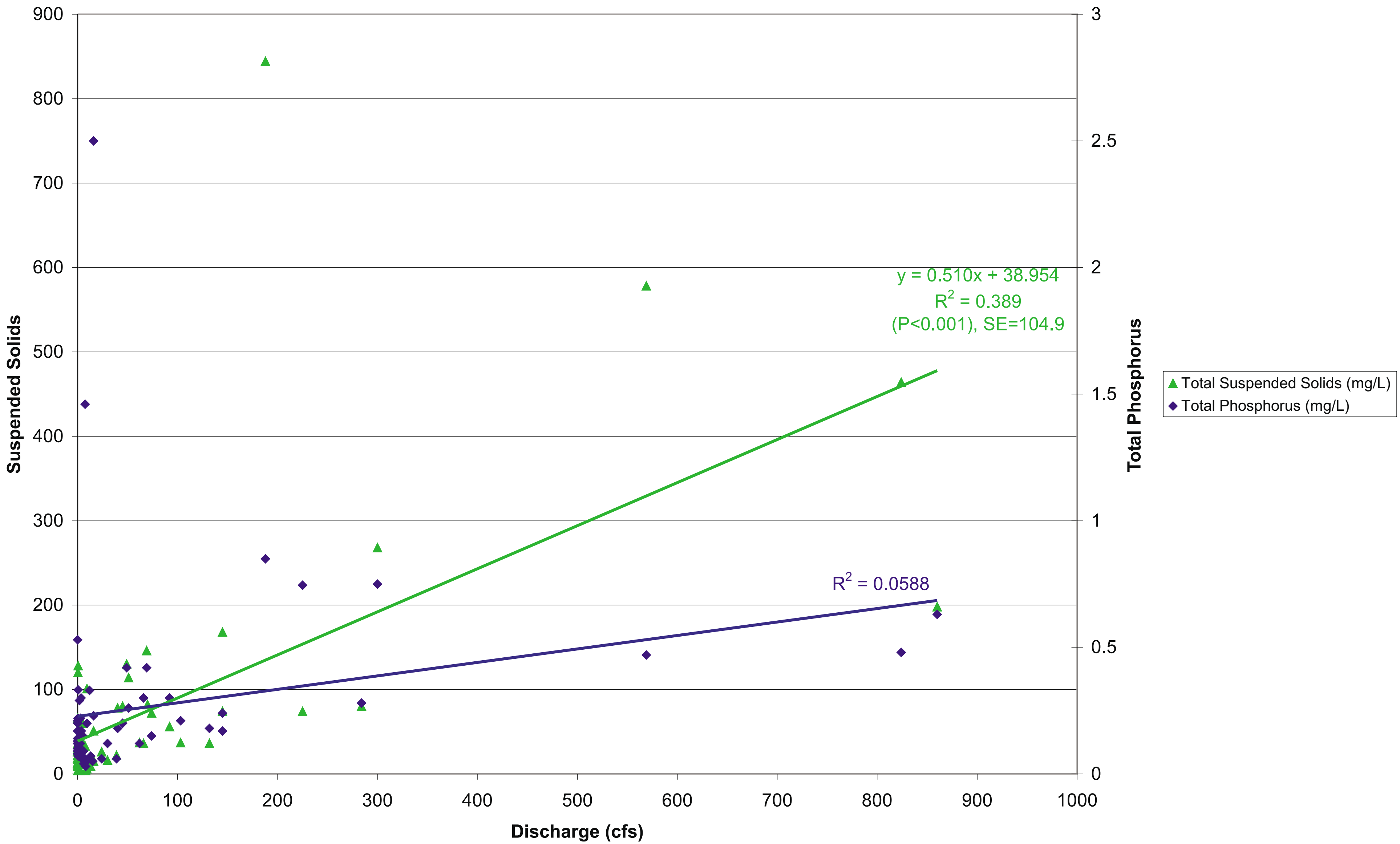

DISCHARGE-WATER QUALITY RELATIONSHIPS AT NK01

DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 17

MWH
MONTGOMERY WATSON HARZA

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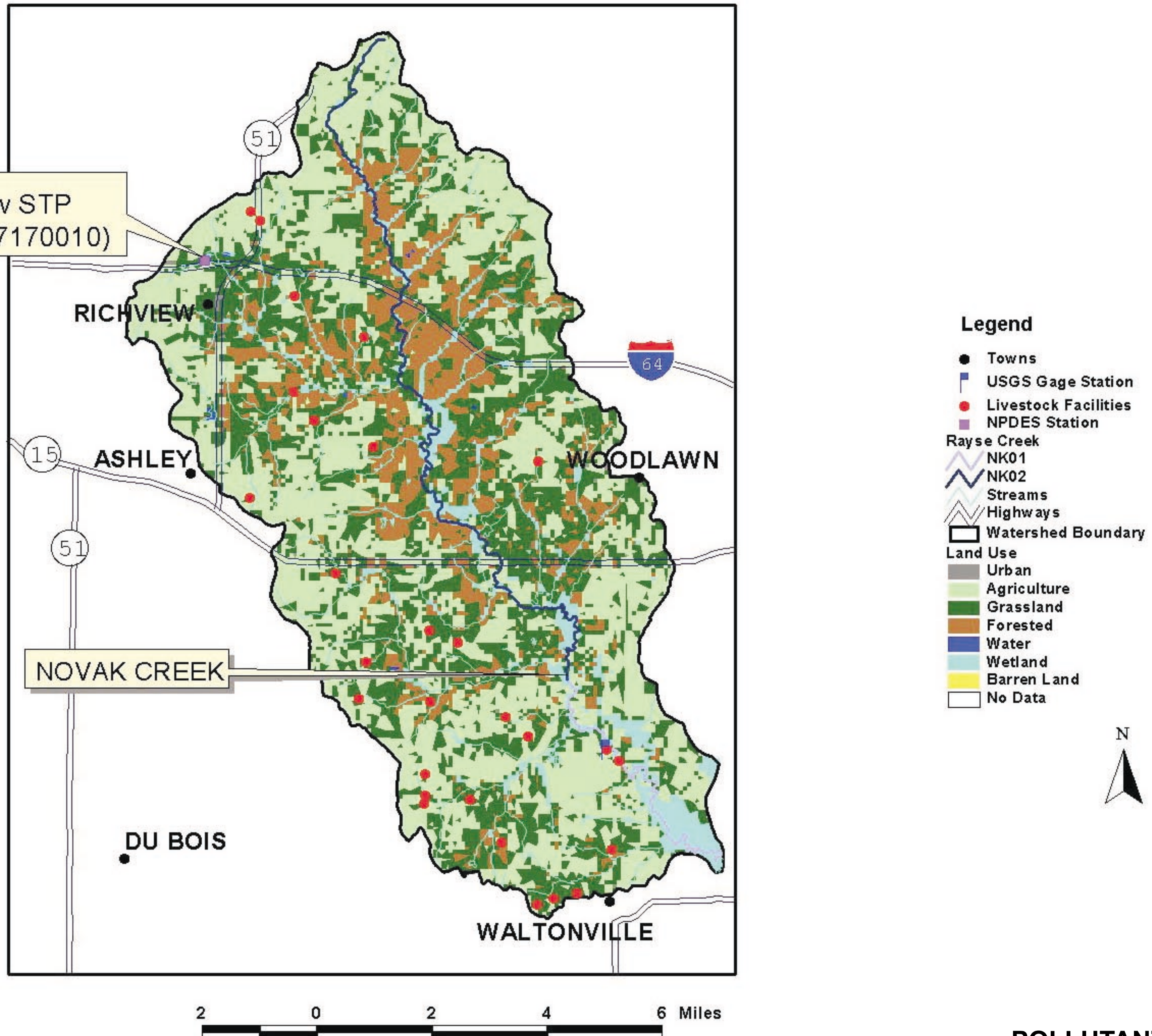

POLLUTANT SOURCES
DEVELOPMENT OF TMDL'S AND IMPLEMENTATION PLANS
FOR TARGET WATERSHEDS
Watershed ILNK01: Rayse Creek

EXHIBIT 18

MWH
MONTGOMERY WATSON HARZA

EXHIBIT 19

ANIMAL MANAGEMENT FACILITIES IN THE ILNK01 WATERSHED
(Source: IEPA Bureau of Water, Marion)

County	Section	Receiving Stream	Rm_Trib1	Rm_Trib2	Rm_Trib3	Monitoring Station	Distance to Monitoring Station	Description
Jefferson	3603S01E3	NKB	2.8	1.0	0.3	N10	20.2	Livestock Facility
Jefferson	2403S01E3	NK	6.8			NK01	0.1	Livestock Facility
Jefferson	1903S02E3	NK	6.3			N10	22.4	Livestock Facility
Jefferson	2302S01E3	NK	12.3	3.8		NK01	9.4	Feedlot
Jefferson	1503S01E3	NK	9.8	1.4		NK01	4.5	Livestock Facility
Jefferson	1403S01E3	NK	9.4	1.0		NK01	3.7	Livestock Facility
Jefferson	0204S01E3	NKB	2.8	3.0		N10	21.9	Feedlot
Jefferson	0204S01E3	NKB	2.8	2.8		N10	21.7	Feedlot
Jefferson	3603S02E3	NKB	2.8	1.9	0.2	N10	21.0	Feedlot
Jefferson	2703S01E3	NK	8.1	2.7		NK01	4.1	Feedlot
Jefferson	2703S01E3	NK	8.1	2.4		NK01	3.8	Livestock Facility
Jefferson	2803S01E3	NK	8.1	3.4		NK01	4.8	Feedlot
Jefferson	2803S01E3	NK	8.1	3.5		NK01	4.9	Feedlot
Jefferson	2103S01E3	NK	8.1	3.9		NK01	5.3	Livestock Facility
Jefferson	1603S01E3	NKC	9.1	3.3		NK01	5.7	Livestock Facility
Jefferson	0903S01E3	NK	13.5	1.5		NK01	8.3	Livestock Facility
Jefferson	1003S01E3	NK	13.5	1.1		NK01	7.9	Feedlot
Jefferson	2002S01E3	NK	18.4	0.8		NK02	2.2	Livestock Facility
Jefferson	0702S01E3	NK	19.8	1.8		NK02	4.6	Feedlot
Jefferson	3102S01E3	NKC	9.1	8.2		NK01	10.6	Livestock Facility
Jefferson	1703S01E3	NKC	9.1	4.2	1.4	NK01	8.0	Feedlot
Jefferson	0803S01E3	NKC	9.1	5.0	0.8	NK01	8.2	Pasture
Washington	2602S01W3	NK	3.4	2.8		N10	22.3	Feedlot
Jefferson	1802S01E3	NK	2.5	0.8		N10	19.4	Livestock Facility
Washington	1302S01W3	NK	2.5	1.3		N10	19.9	Livestock Facility
Washington	0102S01W3	NK	20.8	3.4		NK02	7.2	Livestock Facility
Washington	3601S01W3	NK	20.8	6.6		NK02	10.4	Feedlot
Washington	2601S01W3	NK	20.8	6.4		NK02	10.2	Feedlot

EXHIBIT 20

COMPARISON OF SELECTED CAPABILITIES OF SIMPLE AND MID-RANGE WATERSHED MODELS

(after 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	-	-	-	-	-	-
	Single Event	3	3	3	-	-	3	-	3	-	1	-	1	-
	Continuous	-	-	-	-	-	-	-	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	1	1	1	1	1	1
	Others	3	2	2	-	2	2	2	-	-	1	1	-	1

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

EXHIBIT 21

COMPARISON OF CAPABILITIES OF STEADY STATE WATER QUALITY MODELS

(After EPA 1997)

		EPA Screening	EUTROMOD	PHOSMOD	BATHTUB	QUAL2E	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

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

APPENDICES

LIST OF APPENDICES

APPENDIX A

APPENDIX A – AVAILABLE WATER QUALITY DATA

The Illinois EPA Bureau of Water has provided the following water quality data used in this report.

Segment	NK02	NK02	NK02	NK02	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01
Date	7/27/95	2/27/96	7/18/00	9/25/00	2/6/91	3/19/91	4/29/91	5/28/91	7/15/91	8/22/91	10/3/91	11/18/91	1/2/92	2/6/92	3/17/92	5/6/92	6/10/92	7/20/92	8/19/92	10/8/92	12/2/92	1/12/93	3/8/93	4/21/93	5/25/93
Water Temperature (C)	24.0	13.7	24.2	14.4	5.8	8.4	18.8	26.2	25.1	22.5	18.2	13.4	4.9	3	9.3	14.4	21.5	25.5	20.7	14.8	4.1	1.1	6.9	11.8	18.3
Fecal Coliforms (/100mL)														34	30	200	210	800	100	400	50	600	110		
Turbidity (FTU)	5.2	5.3	14	52	110	57	19	2.1	15	2.8	15	12	300	4.7	5.7	6.9	6.3	43	7.7	3.3	28		19	81	3
Conductivity (umho/cm)	495	1060	365	500	386	434	872	958	458	512	352	1166	385	1243	1187	944	1088	456	497	580	822	513	540	315	985
DO (mg/L)	3.5	8.0	3.4	8.5	10.4	10.3	6.4	5.6	7.2	3.4	6.1	4	11.5	12.8	13.7	10.2	5.6	3.6	2.1	5.7	10.6	13.9	10.8	8.8	6.3
BOD-5 day (mg/L)																									
COD (mg/L)					51.0	25.0	20.0	24.0	21.0	25.0	24.0	38	71	14	19	16	21	21	27	24	23	22	16	35	23
pH	7.0	7.2	7.0	7.7	7.4	7.3	7.3	7.4	7.6	7.4	7.6	7.1	7.4	7.9	8	7.9	7.3	7.1	7.1	7.1	7.2	7.1	7.6	7.4	7.3
Total Suspended Solids (mg/L)	50	12			578	74	101	4	26	19	9	15	844	6	16	20	36	120	22	35	12	37	37	168	60
Ammonia N (mg/L)	0.71	0.38			0.44	0.36	0.09	0.26	0.13	0.05	0.11	9.7	0.13	0.06	0.01	0.06	0.01	0.23	0.21	0.02	0.14	0.05	0.14	0.19	0.01
Unionized Ammonia N (mg/L)	0.004	0.001			0.001	0.001	0.0006	0.004	0.003	0.0006	0.001	0.029	0.0004	0.0005	0.0002	0.001	0.00009	0.002	0.001	0.00007	0.0003	0.00006	0.0008	0.001	0.00007
Total Kjeldhal N (mg/L)	1.70	0.96			3.2	1	1.2	1.1	1.5	0.9	0.6	11	4.1	0.5	0.5	0.6	0.8	0.9	1	0.7	0.751	1.15	0.498	1.62	1.28
Nitrate+Nitrite N (mg/L)	2.0	0.9			1.6	0.7	0.34	0.35	0.47	0.01	0.08	3.5	1.4	0.8	0.07	0.31	0.48	0.63	0.06	0.01	0.31	0.7	8	0.18	1
Total Phosphorus (mg/L)	0.46	0.13			0.47	0.17	0.2	0.12	0.12	0.09	0.14	2.5	0.85	0.05	0.04	0.06	0.08	0.22	0.17	0.12	0.22	0.21	0.12	0.24	0.15
Dissolved Phosphorus (mg/L)	0.34	0.02			0.1	0.05	0.11	0.06	0.05	0.02	0.03	2.2	0.15	0.014	0.01	0.02	0.03	0.08	0.04	0.03	0.06	0.09	0.04	0.06	0.05
Total Organic Carbon (mg/L)	12.0	6.0			19.0	12.0	8.4	10.0	11.0	11.0	9.8	18.3	26.9	6	7	8	8	9	11	10	10	9	7	14	11

Segment	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01
Date	7/1/93	8/17/93	9/21/93	10/13/93	11/22/93	1/6/94	3/2/94	4/6/94	5/23/94	6/27/94	7/27/94	9/22/94	11/10/94	12/7/94	1/30/95	2/21/95	4/12/95	5/10/95	6/19/95	7/20/95	9/6/95	11/15/95	12/18/95	1/23/96	3/7/96	4/1/96
Water Temperature (C)	24.5	26.5	18.6	12.2	6.7	1.2	3.6	6.1	20	22	21.4	18.9	12.2	9.7	0.6	3.8	14.6	18.8	24	24.6	21.9	6.7	5.6	1.5	3.9	7.2
Fecal Coliforms (/100mL)	980	260	300	310		80	90		222		570	40	97,000	170	360	22	160	6,300	194	480	90	160	100	19,000	8,200	2,600
Turbidity (FTU)	37	2	11	6.4	14	7	6.1	31		26	10	3.1	20	11	3.4	3.7	2.7	17	2.6	6.9	3.7	16	3.9	17	36	25
Conductivity (umho/cm)	442	1550	538	730	739	1148	947	898	890	370	332	708	514	430	468	1036	1123	443	693	606	439	456	417	316	1001	275
DO (mg/L)	5.4	5.1	4.3	8.1	10	12.7	12.9	11.3	5.9	5.8	3.9	3.5	1	6.8	13.2	12	8.9	6.8	6.7	4.1	2.8	2.6	8	11.6	11.3	11.6
BOD-5 day (mg/L)																										
COD (mg/L)	26	16	27	23																						
pH	7.3	7.3	7.4	7.5	7.3	7.7	7.9	7.8	7.6	6.9	7.6	7.5	7.4	7.2	7.4	7.6	7.1	7	7.5	7.1	7.7	7.3	7	7	7.1	7.4
Total Suspended Solids (mg/L)	80	19	4	11	16	4	22	56	38	146	36	17	33	20	36	9	33	80	20	32	66	26	29	74	114	198
Ammonia N (mg/L)	0.32	0.06	0.12	0.01	0.07	0.01	0.1	0.35	0.09	0.38	0.04	0.01	3.8	0.16	0.29	0.21	0.15	0.17	0.26	0.06	0.09	0.14	0.01	0.48	0.56	0.17
Unionized Ammonia N (mg/L)	0.003	0.0007	0.001	0.00007	0.0002	0.00005	0.0009	0.003	0.001	0.001	0.0007	0.0001	0.021	0.0005	0.0006	0.0009	0.0005	0.0006	0.004	0.0004	0.002	0.0004	0.00001	0.0004	0.0008	0.0006
Total Kjeldhal N (mg/L)	0.83	0.45	0.61	0.58	0.53	0.63	0.63	2.2	0.88	1.24	1.1	0.98	24	1.1	1.33	0.1	0.92	1.3	0.5	0.24	0.9	2	1.2	1.9	1.8	2
Nitrate+Nitrite N (mg/L)	2.8	0.44	0.58	0.22	0.39	0.28	0.6	1.94	0.56	4.4	0.44	0.04	0.01	0.28	0.78	0.6	0.02	1.22	0.33	0.08	0.02	0.01	0.06	1.53	1.45	4.2
Total Phosphorus (mg/L)	0.2	0.07	0.2	0.11	0.12	0.03	0.06	0.3	0.07	0.42	0.17	0.09	1.46	0.29	0.3	0.07	0.09	0.28	0.07	0.12	0.2	0.12	0.21	0.745	0.26	0.63
Dissolved Phosphorus (mg/L)	0.1	0.04	0.12	0.03	0.02	0.01	0.02	0.12	0.03	0.18	0.07	0.02	0.83	0.09	0.13	0.02	0.01	0.14	0.02	0.05	0.04	0.05	0.047	0.415	0.08	0.22
Total Organic Carbon (mg/L)	12	9	12	10	7	4	6	15	7.9	19.9	7.2	5.6	32.8	10.4	7.8	5.3	7.5	12.9	30.7	8.3	8.8	11.2	9.3	11	7.7	10.4

Segment	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01	NK01
Date	5/2/96	6/4/96	7/25/96	9/12/96	10/1/96	11/26/96	1/6/97	2/20/97	3/25/97	5/22/97	6/23/97	7/24/97	8/25/97	10/7/97	11/19/97	1/14/98	2/19/98	4/2/98	5/7/98	6/17/98	8/5/98	9/9/98	10/21/98	12/2/98
Water Temperature (C)	14.9	18.7	23.6	21.3	17.6	3.3	6.7	9.2	12.2	15.5	23	25.1	23.3	20.9	4.2	2.8	8.3	14.7	17.8	20.5	24.9	21.6	14.2	12.5
Fecal Coliforms (/100mL)	210	430	360	350	570	4,200	2,900	114	197	60	1,373	480	220	76	4	90	400	1,065	13,200	620	240	200	88	100
Turbidity (FTU)	2.2	41	16	24	81	12	61	14	27	17	31	59	16	16	7.6	16	42	21	17	32	36	9.4	23	17
Conductivity (umho/cm)	443	512	566	401	292	188	795	828	677	884	412	263	515	385	391	502	407	405	278	485	408	586	491	735
DO (mg/L)	8.5	6.5	3.6	3	5.7	11	10	10.5	9.3	6.4	6	4.1	7.9	3.9	2.2	10.7	10	8.1	6.9	6.3	3.4	3.6	4.9	8.9
BOD-5 day (mg/L)																								
COD (mg/L)																								
pH	7.1	7	6.9	6.8	6.9	6.7	6.8	8.5	7.5	7.4	7	7.2	7.4	7.5	6.2	7.6	7.8	6.8	7.3	7.3	6.6	7.2	7.1	7.4
Total Suspended Solids (mg/L)	72	40	14	27	128	268	78	18	26	37	130	50	14	13	12	17	36	82	464	51	14	10	16	11
Ammonia N (mg/L)	0.06	0.05	0.08	0.19	0.16	0.2	0.07	0.06	0.03	0.07	0.13	0.25	0.12	0.31	0.15	0.03	0.11	0.21	0.22	0.2	0.44	0.28	0.05	0.11
Unionized Ammonia N (mg/L)	0.0002	0.0002	0.0003	0.0005	0.0004	0.0001	0.00006	0.003	0.0002	0.0005	0.0006	0.002	0.001	0.004	0.00003	0.0001	0.001	0.0004	0.001	0.002	0.001	0.002	0.0002	0.0006
Total Kjeldhal N (mg/L)	0.79	1.4	0.84	0.86	1.3	2.1	1.3	0.58	0.63	0.7	2.3	1.4	2.6	0.53	0.86	0.54	1.3	0.97	1.8	1.23	0.66	0.6	0.51	0.74
Nitrate+Nitrite N (mg/L)	0.95	1.65	0.38	0.05	1.15	1.17	0.79	0.84	0.56	0.01	3.5	0.74	0.33	0.01	0.01	1.26	0.47	0.42	0.35	1.91	0.56	0.01	0.01	2.4
Total Phosphorus (mg/L)	0.15	0.17	0.1	0.13	0.332	0.75	0.18	0.05	0.06	0.07	0.42	0.3	0.11	0.08	0.53	0.33	0.18		0.48	0.23	0.14	0.1	0.12	0.68
Dissolved Phosphorus (mg/L)	0.04	0.04	0.05	0.04	0.1	0.21	0.05	0.01	0.01	0.02	0.14	0.09	0.04	0.03	0.28	0.15	0.02	0.11	0.09	0.12	0.09	0.04	0.04	0.49
Total Organic Carbon (mg/L)	5.8	9	8.7	7.3	7.5	8.2	7.4	4.2	5.2	6	11.3	8.7	6.5	7.7	15.4	9.7	5.6	11		9.1	7.1	8.8	7.2	7.7

APPENDIX B

APPENDIX B – WATERSHED MODEL

The Illinois EPA Bureau of Water has been provided with the GIS and spreadsheets used to calculate sediment loadings to the Rayse Creek watershed. The spreadsheets are reprinted in this appendix.

Rayse Creek Watershed
Summary Sheet - Fall

Sediment Yield to Stream (Soil Loss multiplied by Delivery Ratio)

Subwatershed	Area (acres)	Sediment Yield (tons) 3-Year Storm	tons sediment/acre 3-Year Storm	Sediment Phosphorus Yield (kg) 3-Year Storm	Sediment kgs phosphorus/acre 3-Year Storm	Sediment Yield (tons) 10-Year Storm	tons sediment/acre 10-Year Storm	Sediment Phosphorus Yield (kg) 10-Year Storm	Sediment kgs phosphorus/acre 10-Year Storm	Sediment Yield (tons) 1-Year Storm	tons sediment/acre 1-Year Storm	Sediment Phosphorus Yield (kg) 1 Year Storm	Sediment kgs phosphorus/acre 1 Year Storm
1	3590	652	0.18	488	0.14	1100	0.31	741	0.21	359	0.10	303	0.08
2	5956	997	0.17	758	0.13	1681	0.28	1151	0.19	549	0.09	470	0.08
3	4531	476	0.10	397	0.09	802	0.18	603	0.13	262	0.06	246	0.05
4	7649	789	0.10	661	0.09	1331	0.17	1004	0.13	435	0.06	410	0.05
5	5997	680	0.11	559	0.09	1147	0.19	849	0.14	375	0.06	347	0.06
6	5626	945	0.17	718	0.13	1594	0.28	1091	0.19	521	0.09	446	0.08
7	3202	371	0.12	303	0.09	626	0.20	461	0.14	204	0.06	188	0.06
8	13937	717	0.05	690	0.05	1209	0.09	1048	0.08	395	0.03	428	0.03
9	5715	550	0.10	467	0.08	927	0.16	709	0.12	303	0.05	290	0.05
10	2649	317	0.12	258	0.10	535	0.20	392	0.15	175	0.07	160	0.06
11	2271	166	0.07	149	0.07	281	0.12	227	0.10	92	0.04	93	0.04
12	2461	174	0.07	157	0.06	293	0.12	239	0.10	96	0.04	97	0.04
Total	**63584**	**6834**		**5604**		**11526**		**8513**		**3765**		**3478**	

Soil Loss Calculated from USLE

Subwatershed	Area (acres)	Soil Loss (tons) 3-Year Storm	tons sediment/acre 3-Year Storm	Soil Loss (tons) 10-Year Storm	tons sediment/acre 10-Year Storm	Soil Loss (tons) 1-Year Storm	tons sediment/acre 1-Year Storm
1	3590	3,432	0.96	5,788	1.61	1,891	0.53
2	5956	5,247	0.88	8,848	1.49	2,890	0.49
3	4531	2,504	0.55	4,222	0.93	1,379	0.30
4	7649	4,384	0.57	7,393	0.97	2,415	0.32
5	5997	3,580	0.60	6,037	1.01	1,972	0.33
6	5626	4,975	0.88	8,390	1.49	2,740	0.49
7	3202	1,855	0.58	3,128	0.98	1,022	0.32
8	13937	4,781	0.34	8,063	0.58	2,634	0.19
9	5715	2,893	0.51	4,878	0.85	1,593	0.28
10	2649	1,586	0.60	2,675	1.01	874	0.33
11	2271	792	0.35	1,336	0.59	436	0.19
12	2461	869	0.35	1,466	0.60	479	0.19
Total	**63584**	**36,898**	**0.58**	**62,226**	**0.98**	**20,325**	**0.32**

Rayse Creek - 1
Sediment Yield - 3-year storm

Sediment Yield (tons)
570.0

Soils	Land Use	Xk	Ak(acres)	Ak (ha)	Xk*Ak	sd
IL005	Urban - High Density	0.00	0	0	0	0.19
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.94	0	0	0	
	Agriculture - Small Grains	0.76	0	0	0	
	Agriculture - Orchards/Nurseries	0.76	0	0	0	
	Urban Grassland	0.76	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.06	0	0	0	
	Forested - Deciduous: Open Canopy	0.06	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.76	0	0	0	
	Deep Marsh	0.76	0	0	0	
	Forested Wetland	0.06	0	0	0	
	Shallow Water Wetland	0.76	0	0	0	
IL006	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.43	0	0	0	
	Agriculture - Small Grains	0.56	0	0	0	
	Agriculture - Orchards/Nurseries	0.56	0	0	0	
	Urban Grassland	0.56	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.04	0	0	0	
	Forested - Deciduous: Open Canopy	0.04	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.56	0	0	0	
	Deep Marsh	0.56	0	0	0	
	Forested Wetland	0.04	0	0	0	
	Shallow Water Wetland	0.56	0	0	0	
IL038	Urban - High Density	0.00	1	0	0	
	Urban - Medium Density	0.00	9	4	0	
	Agriculture - Row Crop	5.40	1032	418	2,255	
	Agriculture - Small Grains	2.48	341	138	341	
	Agriculture - Orchards/Nurseries	2.48	0	0	0	
	Urban Grassland	2.48	13	5	13	
	Rural Grassland	0.05	915	370	17	
	Forested - Deciduous: Closed Canopy	0.18	119	48	9	
	Forested - Deciduous: Open Canopy	0.18	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	2.48	0	0	0	
	Deep Marsh	2.48	0	0	0	
	Forested Wetland	0.18	13	5	1	
	Shallow Water Wetland	2.48	4	2	4	
IL051	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.47	567	230	337	
	Agriculture - Small Grains	0.67	61	25	17	
	Agriculture - Orchards/Nurseries	0.67	0	0	0	
	Urban Grassland	0.67	0	0	0	
	Rural Grassland	0.01	225	91	1	
	Forested - Deciduous: Closed Canopy	0.05	10	4	0	
	Forested - Deciduous: Open Canopy	0.05	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.67	0	0	0	
	Deep Marsh	0.67	0	0	0	
	Forested Wetland	0.05	279	113	6	
	Shallow Water Wetland	0.67	0	0	0	
			3590	1453	3,000	

Sd = Sediment Delivery Ratio (based on watershed size of 3,590 acres and Figure III-13)

Rayse Creek - 2
Annual Watershed Phosphorus Loading
10-year storm

Cs(mg/kg)	Ci (mg/kg)	en	Sediment Loading (ton/yr)	Sediment Discharge (ton/ha)
684.6781293	343	1.99	1,681	0.697471

Phosphorus Loading (kg)
1151.1

Ci assumes 0.09 % P2O5 in soil, Figure III-15
en assumes enrichment ratio of 7.39/Sed^(0.2),
where Sed= sediment discharge load (during storm event) Equation III-20

Rayse Creek - 3
Sediment Yield - 1-year storm

Sediment Yield (tons)
262.0

Soils	Land Use	Xk	Ak(acres)	Ak (ha)	Xk*Ak	sd
IL005	Urban - High Density	0.00	0	0	0	0.19
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.07	0	0	0	
	Agriculture - Small Grains	0.42	0	0	0	
	Agriculture - Orchards/Nurseries	0.42	0	0	0	
	Urban Grassland	0.42	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.42	0	0	0	
	Deep Marsh	0.42	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.42	0	0	0	
IL006	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.79	0	0	0	
	Agriculture - Small Grains	0.31	0	0	0	
	Agriculture - Orchards/Nurseries	0.31	0	0	0	
	Urban Grassland	0.31	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.02	0	0	0	
	Forested - Deciduous: Open Canopy	0.02	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.31	0	0	0	
	Deep Marsh	0.31	0	0	0	
	Forested Wetland	0.02	0	0	0	
	Shallow Water Wetland	0.31	0	0	0	
IL038	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	3.47	475	192	667	
	Agriculture - Small Grains	1.36	112	45	62	
	Agriculture - Orchards/Nurseries	1.36	0	0	0	
	Urban Grassland	1.36	0	0	0	
	Rural Grassland	0.02	254	103	3	
	Forested - Deciduous: Closed Canopy	0.10	29	12	1	
	Forested - Deciduous: Open Canopy	0.10	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	1.36	0	0	0	
	Deep Marsh	1.36	2	1	1	
	Forested Wetland	0.10	9	4	0	
	Shallow Water Wetland	1.36	0	0	0	
IL051	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.94	1534	621	586	
	Agriculture - Small Grains	0.37	283	114	42	
	Agriculture - Orchards/Nurseries	0.37	0	0	0	
	Urban Grassland	0.37	0	0	0	
	Rural Grassland	0.01	748	303	2	
	Forested - Deciduous: Closed Canopy	0.03	165	67	2	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.37	15	6	2	
	Deep Marsh	0.37	2	1	0	
	Forested Wetland	0.03	899	364	10	
	Shallow Water Wetland	0.37	5	2	1	
			4531	1834	1,379	

Sd = Sediment Delivery Ratio (based on watershed size of 4,531 acres and Figure III-13)

Universal Soil Loss Equation
1-year storm

Soil Type	Land Use	X (ton/ha)	E (10^2 m-ton-cm/ha-hr)	k (ton/ha per unit of E)	ls	C	P
IL005	Urban - High Density	0.00	65.00	0.36	0.25	0.000	1
	Urban - Medium Density	0.00	65.00	0.36	0.25	0.000	1
	Agriculture - Row Crop	1.07	65.00	0.36	0.25	0.140	1
	Agriculture - Small Grains	0.42	65.00	0.36	0.25	0.055	1
	Agriculture - Orchards/Nurseries	0.42	65.00	0.36	0.25	0.055	1
	Urban Grassland	0.42	65.00	0.36	0.25	0.055	1
	Rural Grassland	0.01	65.00	0.36	0.25	0.001	1
	Forested - Deciduous: Closed Canopy	0.03	65.00	0.36	0.25	0.004	1
	Forested - Deciduous: Open Canopy	0.03	65.00	0.36	0.25	0.004	1
	Water	0.00	65.00	0.36	0.25	0.000	1
	Shallow Marsh/Wet Meadow	0.42	65.00	0.36	0.25	0.055	1
	Deep Marsh	0.42	65.00	0.36	0.25	0.055	1
	Forested Wetland	0.03	65.00	0.36	0.25	0.004	1
	Shallow Water Wetland	0.42	65.00	0.36	0.25	0.055	1
IL006	Urban - High Density	0.00	65.00	0.34	0.20	0.000	1
	Urban - Medium Density	0.00	65.00	0.34	0.20	0.000	1
	Agriculture - Row Crop	0.79	65.00	0.34	0.20	0.140	1
	Agriculture - Small Grains	0.31	65.00	0.34	0.20	0.055	1
	Agriculture - Orchards/Nurseries	0.31	65.00	0.34	0.20	0.055	1
	Urban Grassland	0.31	65.00	0.34	0.20	0.055	1
	Rural Grassland	0.01	65.00	0.34	0.20	0.001	1
	Forested - Deciduous: Closed Canopy	0.02	65.00	0.34	0.20	0.004	1
	Forested - Deciduous: Open Canopy	0.02	65.00	0.34	0.20	0.004	1
	Water	0.00	65.00	0.34	0.20	0.000	1
	Shallow Marsh/Wet Meadow	0.31	65.00	0.34	0.20	0.055	1
	Deep Marsh	0.31	65.00	0.34	0.20	0.055	1
	Forested Wetland	0.02	65.00	0.34	0.20	0.004	1
	Shallow Water Wetland	0.31	65.00	0.34	0.20	0.055	1
IL038	Urban - High Density	0.00	65.00	0.42	0.70	0.000	1
	Urban - Medium Density	0.00	65.00	0.42	0.70	0.000	1
	Agriculture - Row Crop	3.47	65.00	0.42	0.70	0.140	1
	Agriculture - Small Grains	1.36	65.00	0.42	0.70	0.055	1
	Agriculture - Orchards/Nurseries	1.36	65.00	0.42	0.70	0.055	1
	Urban Grassland	1.36	65.00	0.42	0.70	0.055	1
	Rural Grassland	0.02	65.00	0.42	0.70	0.001	1
	Forested - Deciduous: Closed Canopy	0.10	65.00	0.42	0.70	0.004	1
	Forested - Deciduous: Open Canopy	0.10	65.00	0.42	0.70	0.004	1
	Water	0.00	65.00	0.42	0.70	0.000	1
	Shallow Marsh/Wet Meadow	1.36	65.00	0.42	0.70	0.055	1
	Deep Marsh	1.36	65.00	0.42	0.70	0.055	1
	Forested Wetland	0.10	65.00	0.42	0.70	0.004	1
	Shallow Water Wetland	1.36	65.00	0.42	0.70	0.055	1
IL051	Urban - High Density	0.00	65.00	0.43	0.19	0.000	1
	Urban - Medium Density	0.00	65.00	0.43	0.19	0.000	1
	Agriculture - Row Crop	0.94	65.00	0.43	0.19	0.140	1
	Agriculture - Small Grains	0.37	65.00	0.43	0.19	0.055	1
	Agriculture - Orchards/Nurseries	0.37	65.00	0.43	0.19	0.055	1
	Urban Grassland	0.37	65.00	0.43	0.19	0.055	1
	Rural Grassland	0.01	65.00	0.43	0.19	0.001	1
	Forested - Deciduous: Closed Canopy	0.03	65.00	0.43	0.19	0.004	1
	Forested - Deciduous: Open Canopy	0.03	65.00	0.43	0.19	0.004	1
	Water	0.00	65.00	0.43	0.19	0.000	1
	Shallow Marsh/Wet Meadow	0.37	65.00	0.43	0.19	0.055	1
	Deep Marsh	0.37	65.00	0.43	0.19	0.055	1
	Forested Wetland	0.03	65.00	0.43	0.19	0.004	1
	Shallow Water Wetland	0.37	65.00	0.43	0.19	0.055	1

E= Calculated from III-14 with average of Warm Season "a" coefficient and Cool season "a" coefficent, and Midwestern Climate Center 10yr 24 hr storm
C=Taken from Tables III-4 through III-8

Rayse Creek - 5
Annual Watershed Phosphorus Loading
3-year storm

			Phosphorus Loading (kg)	
			558.9	
Cs(mg/kg)	**Ci (mg/kg)**	**en**	**Sediment Loading (ton/yr)**	**Sediment Discharge (ton/ha)**
821.6331902	343	2.39	680	0.280265

Ci assumes 0.09 % P2O5 in soil, Figure III-15
en assumes enrichment ratio of 7.39/Sed^(0.2),
where Sed= sediment discharge load (during storm event)Equation III-20

Rayse Creek - 6
Sediment Yield - 3-year storm

Sediment Yield (tons)
945.2

Soils	Land Use	Xk	Ak(acres)	Ak (ha)	Xk*Ak	sd
IL005	Urban - High Density	0.00	0	0	0	0.19
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.94	0	0	0	
	Agriculture - Small Grains	0.76	0	0	0	
	Agriculture - Orchards/Nurseries	0.76	0	0	0	
	Urban Grassland	0.76	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.06	0	0	0	
	Forested - Deciduous: Open Canopy	0.06	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.76	0	0	0	
	Deep Marsh	0.76	0	0	0	
	Forested Wetland	0.06	0	0	0	
	Shallow Water Wetland	0.76	0	0	0	
IL006	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.43	0	0	0	
	Agriculture - Small Grains	0.56	0	0	0	
	Agriculture - Orchards/Nurseries	0.56	0	0	0	
	Urban Grassland	0.56	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.04	0	0	0	
	Forested - Deciduous: Open Canopy	0.04	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.56	0	0	0	
	Deep Marsh	0.56	0	0	0	
	Forested Wetland	0.04	0	0	0	
	Shallow Water Wetland	0.56	0	0	0	
IL038	Urban - High Density	0.00	11	4	0	
	Urban - Medium Density	0.00	19	8	0	
	Agriculture - Row Crop	6.30	1670	676	4,258	
	Agriculture - Small Grains	2.48	495	200	496	
	Agriculture - Orchards/Nurseries	2.48	0	0	0	
	Urban Grassland	2.48	85	34	85	
	Rural Grassland	0.05	2229	902	41	
	Forested - Deciduous: Closed Canopy	0.18	857	347	62	
	Forested - Deciduous: Open Canopy	0.18	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	2.48	4	1	4	
	Deep Marsh	2.48	0	0	0	
	Forested Wetland	0.18	245	99	18	
	Shallow Water Wetland	2.48	12	5	12	
IL051	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.71	0	0	0	
	Agriculture - Small Grains	0.67	0	0	0	
	Agriculture - Orchards/Nurseries	0.67	0	0	0	
	Urban Grassland	0.67	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.05	0	0	0	
	Forested - Deciduous: Open Canopy	0.05	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.67	0	0	0	
	Deep Marsh	0.67	0	0	0	
	Forested Wetland	0.05	0	0	0	
	Shallow Water Wetland	0.67	0	0	0	
			5626	2277	4,975	

Sd = Sediment Delivery Ratio (based on watershed size of 5,626 acres and Figure III-13)

Rayse Creek - 7
Sediment Yield - 1-year storm

Sediment Yield (tons)
204.3

Soils	Land Use	Xk	Ak(acres)	Ak (ha)	Xk*Ak	sd
IL005	Urban - High Density	0.00	0	0	0	0.2
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.07	0	0	0	
	Agriculture - Small Grains	0.42	0	0	0	
	Agriculture - Orchards/Nurseries	0.42	0	0	0	
	Urban Grassland	0.42	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.42	0	0	0	
	Deep Marsh	0.42	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.42	0	0	0	
IL006	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.79	0	0	0	
	Agriculture - Small Grains	0.31	0	0	0	
	Agriculture - Orchards/Nurseries	0.31	0	0	0	
	Urban Grassland	0.31	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.02	0	0	0	
	Forested - Deciduous: Open Canopy	0.02	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.31	0	0	0	
	Deep Marsh	0.31	0	0	0	
	Forested Wetland	0.02	0	0	0	
	Shallow Water Wetland	0.31	0	0	0	
IL038	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	3.47	611	247	858	
	Agriculture - Small Grains	1.36	189	77	104	
	Agriculture - Orchards/Nurseries	1.36	0	0	0	
	Urban Grassland	1.36	0	0	0	
	Rural Grassland	0.02	1450	587	15	
	Forested - Deciduous: Closed Canopy	0.10	693	280	28	
	Forested - Deciduous: Open Canopy	0.10	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	1.36	2	1	1	
	Deep Marsh	1.36	1	1	1	
	Forested Wetland	0.10	247	100	10	
	Shallow Water Wetland	1.36	9	3	5	
IL051	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.94	0	0	0	
	Agriculture - Small Grains	0.37	0	0	0	
	Agriculture - Orchards/Nurseries	0.37	0	0	0	
	Urban Grassland	0.37	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.37	0	0	0	
	Deep Marsh	0.37	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.37	0	0	0	
			3202	1296	1,022	

Sd = Sediment Delivery Ratio (based on watershed size of 3,202 acres and Figure III-13)

Rayse Creek - 8
Sediment Yield - 1-year storm

Sediment Yield (tons)
395.0

Soils	Land Use	Xk	Ak(acres)	Ak (ha)	Xk*Ak	sd
IL005	Urban - High Density	0.00	0	0	0	0.15
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.07	0	0	0	
	Agriculture - Small Grains	0.42	0	0	0	
	Agriculture - Orchards/Nurseries	0.42	0	0	0	
	Urban Grassland	0.42	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.42	0	0	0	
	Deep Marsh	0.42	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.42	0	0	0	
IL006	Urban - High Density	0.00	31	13	0	
	Urban - Medium Density	0.00	24	10	0	
	Agriculture - Row Crop	0.79	4006	1,621	1,281	
	Agriculture - Small Grains	0.31	1578	639	198	
	Agriculture - Orchards/Nurseries	0.31	0	0	0	
	Urban Grassland	0.31	101	41	13	
	Rural Grassland	0.01	2849	1,153	7	
	Forested - Deciduous: Closed Canopy	0.02	820	332	7	
	Forested - Deciduous: Open Canopy	0.02	0	0	0	
	Water	0.00	17	7	0	
	Shallow Marsh/Wet Meadow	0.31	4	1	0	
	Deep Marsh	0.31	0	0	0	
	Forested Wetland	0.02	61	25	1	
	Shallow Water Wetland	0.31	50	20	6	
IL038	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	3.47	537	217	755	
	Agriculture - Small Grains	1.36	488	198	269	
	Agriculture - Orchards/Nurseries	1.36	0	0	0	
	Urban Grassland	1.36	0	0	0	
	Rural Grassland	0.02	1653	669	17	
	Forested - Deciduous: Closed Canopy	0.10	1498	606	60	
	Forested - Deciduous: Open Canopy	0.10	0	0	0	
	Water	0.00	2	1	0	
	Shallow Marsh/Wet Meadow	1.36	7	3	4	
	Deep Marsh	1.36	0	0	0	
	Forested Wetland	0.10	197	80	8	
	Shallow Water Wetland	1.36	14	6	8	
IL051	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.94	0	0	0	
	Agriculture - Small Grains	0.37	0	0	0	
	Agriculture - Orchards/Nurseries	0.37	0	0	0	
	Urban Grassland	0.37	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.37	0	0	0	
	Deep Marsh	0.37	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.37	0	0	0	
			13937	5640	2,634	

Sd = Sediment Delivery Ratio (based on watershed size of 13,937 acres and Figure III-13)

Rayse Creek - 9
Sediment Yield - 1-year storm

Sediment Yield (tons)
302.7

Soils	Land Use	Xk	Ak(acres)	Ak (ha)	Xk*Ak	sd
IL005	Urban - High Density	0.00	0	0	0	0.19
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.07	0	0	0	
	Agriculture - Small Grains	0.42	0	0	0	
	Agriculture - Orchards/Nurseries	0.42	0	0	0	
	Urban Grassland	0.42	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.42	0	0	0	
	Deep Marsh	0.42	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.42	0	0	0	
IL006	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.79	842	341	269	
	Agriculture - Small Grains	0.31	31	12	4	
	Agriculture - Orchards/Nurseries	0.31	0	0	0	
	Urban Grassland	0.31	0	0	0	
	Rural Grassland	0.01	259	105	1	
	Forested - Deciduous: Closed Canopy	0.02	132	53	1	
	Forested - Deciduous: Open Canopy	0.02	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.31	0	0	0	
	Deep Marsh	0.31	0	0	0	
	Forested Wetland	0.02	0	0	0	
	Shallow Water Wetland	0.31	1	1	0	
IL038	Urban - High Density	0.00	1	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	3.47	797	323	1,120	
	Agriculture - Small Grains	1.36	164	66	91	
	Agriculture - Orchards/Nurseries	1.36	0	0	0	
	Urban Grassland	1.36	0	0	0	
	Rural Grassland	0.02	1411	571	14	
	Forested - Deciduous: Closed Canopy	0.10	1690	684	68	
	Forested - Deciduous: Open Canopy	0.10	0	0	0	
	Water	0.00	3	1	0	
	Shallow Marsh/Wet Meadow	1.36	4	2	2	
	Deep Marsh	1.36	1	0	1	
	Forested Wetland	0.10	362	146	15	
	Shallow Water Wetland	1.36	15	6	8	
IL051	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.94	0	0	0	
	Agriculture - Small Grains	0.37	0	0	0	
	Agriculture - Orchards/Nurseries	0.37	0	0	0	
	Urban Grassland	0.37	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.37	0	0	0	
	Deep Marsh	0.37	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.37	0	0	0	
			5715	2313	1,593	

Sd = Sediment Delivery Ratio (based on watershed size of 5,715 acres and Figure III-13)

Rayse Creek - 10
Sediment Yield - 1-year storm

Sediment Yield (tons)
174.8

Soils	**Land Use**	**Xk**	**Ak(acres)**	**Ak (ha)**	**Xk*Ak**	**sd**
IL005	Urban - High Density	0.00	0	0	0	0.2
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.07	0	0	0	
	Agriculture - Small Grains	0.42	0	0	0	
	Agriculture - Orchards/Nurseries	0.42	0	0	0	
	Urban Grassland	0.42	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.42	0	0	0	
	Deep Marsh	0.42	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.42	0	0	0	
IL006	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.79	835	338	267	
	Agriculture - Small Grains	0.31	119	48	15	
	Agriculture - Orchards/Nurseries	0.31	0	0	0	
	Urban Grassland	0.31	0	0	0	
	Rural Grassland	0.01	231	93	1	
	Forested - Deciduous: Closed Canopy	0.02	97	39	1	
	Forested - Deciduous: Open Canopy	0.02	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.31	0	0	0	
	Deep Marsh	0.31	0	0	0	
	Forested Wetland	0.02	2	1	0	
	Shallow Water Wetland	0.31	2	1	0	
IL038	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	3.47	384	155	540	
	Agriculture - Small Grains	1.36	37	15	21	
	Agriculture - Orchards/Nurseries	1.36	0	0	0	
	Urban Grassland	1.36	0	0	0	
	Rural Grassland	0.02	296	120	3	
	Forested - Deciduous: Closed Canopy	0.10	549	222	22	
	Forested - Deciduous: Open Canopy	0.10	0	0	0	
	Water	0.00	8	3	0	
	Shallow Marsh/Wet Meadow	1.36	0	0	0	
	Deep Marsh	1.36	2	1	1	
	Forested Wetland	0.10	85	35	3	
	Shallow Water Wetland	1.36	1	0	1	
IL051	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.94	0	0	0	
	Agriculture - Small Grains	0.37	0	0	0	
	Agriculture - Orchards/Nurseries	0.37	0	0	0	
	Urban Grassland	0.37	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.37	0	0	0	
	Deep Marsh	0.37	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.37	0	0	0	
			2649	1072	874	

Sd = Sediment Delivery Ratio (based on watershed size of 2,649 acres and Figure III-13)

Rayse Creek - 11
Sediment Yield - 1-year storm

Sediment Yield (tons)
91.6

Soils	Land Use	Xk	Ak(acres)	Ak (ha)	Xk*Ak	sd
IL005	Urban - High Density	0.00	0	0	0	0.21
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.07	0	0	0	
	Agriculture - Small Grains	0.42	0	0	0	
	Agriculture - Orchards/Nurseries	0.42	0	0	0	
	Urban Grassland	0.42	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.42	0	0	0	
	Deep Marsh	0.42	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.42	0	0	0	
IL006	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.79	1272	515	407	
	Agriculture - Small Grains	0.31	181	73	23	
	Agriculture - Orchards/Nurseries	0.31	0	0	0	
	Urban Grassland	0.31	0	0	0	
	Rural Grassland	0.01	473	192	1	
	Forested - Deciduous: Closed Canopy	0.02	253	103	2	
	Forested - Deciduous: Open Canopy	0.02	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.31	0	0	0	
	Deep Marsh	0.31	0	0	0	
	Forested Wetland	0.02	42	17	0	
	Shallow Water Wetland	0.31	0	0	0	
IL038	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	3.47	1	0	1	
	Agriculture - Small Grains	1.36	0	0	0	
	Agriculture - Orchards/Nurseries	1.36	0	0	0	
	Urban Grassland	1.36	0	0	0	
	Rural Grassland	0.02	4	1	0	
	Forested - Deciduous: Closed Canopy	0.10	19	8	1	
	Forested - Deciduous: Open Canopy	0.10	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	1.36	0	0	0	
	Deep Marsh	1.36	0	0	0	
	Forested Wetland	0.10	25	10	1	
	Shallow Water Wetland	1.36	0	0	0	
IL051	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.94	0	0	0	
	Agriculture - Small Grains	0.37	0	0	0	
	Agriculture - Orchards/Nurseries	0.37	0	0	0	
	Urban Grassland	0.37	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.37	0	0	0	
	Deep Marsh	0.37	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.37	0	0	0	
			2271	919	436	

Sd = Sediment Delivery Ratio (based on watershed size of 2,271 acres and Figure III-13)

Rayse Creek - 12
Sediment Yield - 1-year storm

Sediment Yield (tons)
95.8

Soils	Land Use	Xk	Ak(acres)	Ak (ha)	Xk*Ak	sd
IL005	Urban - High Density	0.00	0	0	0	0.2
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	1.07	0	0	0	
	Agriculture - Small Grains	0.42	0	0	0	
	Agriculture - Orchards/Nurseries	0.42	0	0	0	
	Urban Grassland	0.42	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.42	0	0	0	
	Deep Marsh	0.42	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.42	0	0	0	
IL006	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.79	1265	512	404	
	Agriculture - Small Grains	0.31	132	54	17	
	Agriculture - Orchards/Nurseries	0.31	0	0	0	
	Urban Grassland	0.31	0	0	0	
	Rural Grassland	0.01	539	218	1	
	Forested - Deciduous: Closed Canopy	0.02	225	91	2	
	Forested - Deciduous: Open Canopy	0.02	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.31	1	0	0	
	Deep Marsh	0.31	0	0	0	
	Forested Wetland	0.02	26	10	0	
	Shallow Water Wetland	0.31	6	2	1	
IL038	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	3.47	29	12	40	
	Agriculture - Small Grains	1.36	10	4	5	
	Agriculture - Orchards/Nurseries	1.36	0	0	0	
	Urban Grassland	1.36	0	0	0	
	Rural Grassland	0.02	53	21	1	
	Forested - Deciduous: Closed Canopy	0.10	161	65	6	
	Forested - Deciduous: Open Canopy	0.10	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	1.36	0	0	0	
	Deep Marsh	1.36	0	0	0	
	Forested Wetland	0.10	15	6	1	
	Shallow Water Wetland	1.36	0	0	0	
IL051	Urban - High Density	0.00	0	0	0	
	Urban - Medium Density	0.00	0	0	0	
	Agriculture - Row Crop	0.94	0	0	0	
	Agriculture - Small Grains	0.37	0	0	0	
	Agriculture - Orchards/Nurseries	0.37	0	0	0	
	Urban Grassland	0.37	0	0	0	
	Rural Grassland	0.01	0	0	0	
	Forested - Deciduous: Closed Canopy	0.03	0	0	0	
	Forested - Deciduous: Open Canopy	0.03	0	0	0	
	Water	0.00	0	0	0	
	Shallow Marsh/Wet Meadow	0.37	0	0	0	
	Deep Marsh	0.37	0	0	0	
	Forested Wetland	0.03	0	0	0	
	Shallow Water Wetland	0.37	0	0	0	
			2461	996	479	

Sd = Sediment Delivery Ratio (based on watershed size of 2,461 acres and Figure III-13)

APPENDIX C

APPENDIX C – WATER QUALITY MODEL

The Illinois EPA Bureau of Water has been provided with the spreadsheets used to calculate water quality in Rayse Creek from the information reprinted in Appendix A. The spreadsheets follow the EPA Screening Procedures described in the main body of this report, as well as in Mills *et al.* (1985). The water quality model spreadsheets are reprinted in this appendix, followed by the input and output files of the QUAL2E model. Details on QUAL2E modeling techniques are provided in Brown and Barnwell (1987).

The QUAL2E model was developed and calibrated with very little data. The intention of this model is to make preliminary estimates based on those data currently available. As more data are collected, this model should be updated to reflect these data and to confirm our assumptions linking BOD sources and water quality. Recommendations for supplemental data collection are described in the main body of this report.

The QUAL2E model has been developed as diagrammed on the attached pages. There are 27 stream reaches and three stream headwaters. The headwaters are Novak Creek, the branch from Richview, and the branch from near Suburban Heights. There are approximately 56 smaller streams or drainage ditches (locations shown on the stick diagram) that discharge into Rayse Creek. 47 of these point sources, or tributaries, are not modeled, but rather, are treated by QUAL2E as point sources. Of the 56 streams and ditches, nine discharge into the same computational element and therefore are modeled in QUAL2E as a single source, leaving 47 point sources in the input file. Flow, DO and BOD concentrations in these point sources are shown below, as taken from the attached input data file.

TRIBUTARY FLOW, DO AND BOD

Point Load Order	Description	Flow (cfs)	DO (mg/L)	BOD (mg/L)
1	Creek 56	0	5.5	0
2	Creek 55	0.44	5.5	10
3	Creek 54	0	5.5	0
4	Creek 53 & 5	0.89	5.5	10
5	Creek 51	0	5.5	0
6	Creek 49,50	0	5.5	0
7	Creek 46,47,	0.88	5.5	10
8	Creek 45	0	5.5	0
9	Creek 42,43	0	5.5	0
10	Creek 40,41	0	5.5	0
11	Creek 38,39	0	5.5	0
12	Creek 37	0	5.5	0

TRIBUTARY FLOW, DO AND BOD

Point Load Order	Description	Flow (cfs)	DO (mg/L)	BOD (mg/L)
13	Creek 35,36	0	5.5	0
14	Creek 34	0	5.5	0
15	Creek 32,33	0.92	5.5	12
16	Creek 30	2.15	5.5	10
17	Creek 28,29	0.62	5.5	500
18	Creek 27	0	5.5	0
19	Creek 26	0	5.5	0
20	Creek 25	0	5.5	0
21	Creek 24	0.92	5.5	14
22	Creek 23	0	5.5	0
23	Creek 21,22	0.24	5.5	12
24	Creek 19,20	1.76	5.5	13
25	Creek 17,18	0	5.5	0
26	Creek 15,16	0	5.5	0
27	Creek 14	0	5.5	0
28	Creek 13	0	5.5	0
29	Creek 12	0	5.5	0
30	Creek 11	0	5.5	0
31	Creek 71	0	5.5	0
32	Creek 69,70	0	5.5	0
33	Creek 68	0	5.5	0
34	Creek 67	0	5.5	0
35	Creek 66	0	5.5	0
36	Creek 65	0	5.5	0
37	Creek 64	0	5.5	0
38	Creek 62,63	0	5.5	0
39	Creek 60,61	0	5.5	0
40	Creek 59	0	5.5	0
41	Creek 58	0	5.5	0
42	Creek 57	0	5.5	0
43	Creek 10	2.22	5.5	14
44	Back Branch	0	5.5	0
45	Creek 9	0.79	5.5	10
46	Creeks 5,6,7	0	5.5	0
47	Creek 4	1.32	5.5	15

Landuse	Area (sf)	Area (acres)	Percentage	Curve Number[1]	Weighted Curve Number
Urban - High Density[2]	0	0	0	83	0.00
Urban - Medium Density[3]	0	0	0	80	0.00
Agriculture - Row Crop[4]	56343930	1293	53	85	44.67
Agriculture - Small Grains[5]	6202960	142	6	83	4.80
Agriculture - Orchards/Nurseries[6]	0	0	0	71	0.00
Urban Grassland[7]	0	0	0	74	0.00
Rural Grassland[8]	25793811	592	24	79	19.00
Forested - Deciduous: Closed Canopy[9]	16786260	385	16	70	10.96
Forested - Deciduous: Open Canopy[10]	0	0	0	73	0.00
Water	0	0	0	0	0.00
Shallow Marsh/Wet Meadow[11]	30655	1	0	86	0.02
Deep Marsh	0	0	0	0	0.00
Forested Wetland[12]	1797417	41	2	77	1.29
Shallow Water Wetland	265742	6	0	0	0.00
		2461	**100**		**81**

[1] Assumes Group C soils:clay loams, shallow sandy loams, soils low in organic content, and soil usually high in clay.
[2] Assumes 1/4 acre residential lots
[3] Assumes 1/2 acre residential lots
[4] Assumes Cultivated Land withou conservation treatment
[5] Assumes Small grain, straight row, good condition
[6] Assumes Meadow
[7] Assumes Open Spaces, good condition
[8] Assumes Open Spaces, fair condition
[9] Assumes Woods, good condition
[10] Assumes Woods, fair condition
[11] Assumes Pasture, poor condition
[12] Assumes Woods, poor condition

Excess Precipitation Calculations (P_e) (inches)

S 2.38420289

Duration	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	3 yr
10 d	2.74	3.62	4.86	5.78	7.18	8.27	9.34	4.02
5 d	1.89	2.51	3.47	4.32	5.63	6.81	8.16	2.87
72 h	1.51	2.03	2.89	3.63	4.82	5.93	7.04	2.35
48 h	1.30	1.77	2.54	3.21	4.30	5.32	6.30	2.06
24 h	1.01	1.42	2.10	2.63	3.67	4.51	5.46	1.67
18 h	0.87	1.23	1.84	2.31	3.25	4.01	4.88	1.44
12 h	0.78	1.11	1.67	2.12	3.00	3.71	4.52	1.31
6 h	0.58	0.84	1.30	1.67	2.39	2.99	3.68	1.00
3 h	0.40	0.61	0.97	1.27	1.86	2.35	2.92	0.74
2 h	0.33	0.50	0.83	1.09	1.62	2.07	2.58	0.54
1 h	0.18	0.30	0.52	0.72	1.09	1.41	1.80	0.38
30 m	0.08	0.16	0.29	0.43	0.68	0.91	1.19	0.20
15 m	0.02	0.05	0.12	0.19	0.34	0.48	0.65	0.08
10 m	0.00	0.02	0.06	0.10	0.20	0.30	0.41	0.03
5 m	0.01	0.00	0.00	0.00	0.02	0.04	0.07	0.00

Runoff Volume (ac-ft)

Duration	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	3 yr
10 d	562.61	743.00	997.04	1185.33	1471.85	1696.46	1916.64	824.96
5 d	388.45	514.63	711.60	885.11	1154.41	1397.40	1674.72	587.72
72 h	309.10	417.30	593.12	744.86	989.41	1216.30	1444.39	483.00
48 h	266.10	363.29	521.70	658.41	881.34	1090.86	1292.04	422.43
24 h	208.10	291.42	431.00	539.43	752.27	924.81	1119.71	341.74
18 h	177.55	252.08	376.67	474.27	667.54	823.09	1000.86	296.22
12 h	159.27	227.58	343.39	434.44	614.78	761.55	926.70	269.24
6 h	117.95	171.87	266.10	341.74	490.00	612.97	754.12	205.14
3 h	82.77	124.37	199.25	259.85	381.71	481.25	598.52	151.01
2 h	68.33	102.94	170.46	223.05	331.88	424.14	528.78	111.62
1 h	37.09	61.98	106.63	148.29	223.05	289.82	368.30	77.11
30 m	17.34	32.03	59.91	88.56	140.19	187.60	244.36	41.51
15 m	4.26	10.36	24.98	38.84	69.41	98.07	133.53	15.45
10 m	0.88	3.92	11.96	20.67	40.61	60.94	85.07	6.58
5 m	2.27	0.84	0.00	0.45	3.59	8.38	14.85	0.28

Sediment Load Calculations

1 year sediment loading (tons)	95.78
3 year sediment loading (tons)	173.87
10 year sediment loading (tons)	293.22

Phosphorus Load Calculations

1 year storm phosphorus loading (kgs)	97
3 year storm phosphorus loading (kgs)	157
10 year storm phosphorus loading (kgs)	239

Sediment Loading (mg/L)

	Return Period		
Duration	3 yr	10 yr	1 yr
12 hr	523.07	546.70	487.08
24 hr	412.10	440.29	372.79
72 hr	291.58	318.86	250.98
6 hr	686.52	694.99	657.74

Phosphorus Loading (mg/L)

	Return Period		
Duration	3 yr	10 yr	1 yr
12 hr	0.47	0.45	0.50
24 hr	0.37	0.36	0.38
72 hr	0.26	0.26	0.26
6 hr	0.62	0.57	0.67

ID	Reach	Station	Distance Between Segments (Ft)	Distance to Discharge (ft)	Distance to Discharge (mi)	COMMENTS	Channel Slope	Average Reach Slope	Manning n	Top Width (ft)	Depth (ft)	Side Slopes	Calculated Flow (CFS)	Dissolved Oxygen (mg/L)	Total Suspended Solids (mg/L)
59	1		1160	142023	26.9	Unnamed Creek 55 to Unnamed Creek 54	0.0039	0.0039							
60	1	1	6220	148243	28.1	Unnamed Creek 56 to Unnamed Creek 55	0.0039		**0.039**	**15**	**0.8**	**2 to 1**	**2.44**	**6.1**	
61	1		13024	161267	30.5	Headwater of Rayse Creek to Unnamed Creek 56	0.0038								
57	2		1521	138101	26.2	Unnamed Creek 53 to Unnamed Creek 52	0.0047	0.0047	**0.039**	**18**		**2 to 1**			
58	2		2762	140863	26.7	Unnamed Creek 54 to Unnamed Creek 53	0.0047								
55	3		1702	132503	25.1	Unnamed Creek 51 to Unnamed Creek 50	0.0014	0.0014	**0.039**	**20**		**2 to 1**			
56	3		4077	136580	25.9	Unnamed Creek 52 to Unnamed Creek 51	0.0014								
53	4		1675	126681	24.0	Unnamed Creek 49 to Unnamed Creek 48	0.0024	0.0024							
54	4	2	4120	130801	24.8	Unnamed Creek 50 to Unnamed Creek 49	0.0024		**0.039**	**22**	**2.46**	**2 to 1**	**22**	**6.5**	
48	5		698	109251	20.7	Unnamed Creek 44 to Unnamed Creek 31	0.0009	0.0009	**0.039**	**23**		**2 to 1**			
49	5		4500	113751	21.5	Unnamed Creek 45 to Unnamed Creek 44	0.0009								
50	5		10131	123882	23.5	Unnamed Creek 46 to Unnamed Creek 45	0.0009								
51	5		689	124571	23.6	Unnamed Creek 47 to Unnamed Creek 46	0.0009								
52	5		435	125006	23.7	Unnamed Creek 48 to Unnamed Creek 47	0.0009								
1	6		4450	145942	27.6	Richview Branch Headwater to Unnamed Creek 4	0.0034	0.0032	**0.039**	**25**		**2 to 1**			
2	6		1483	141492	26.8	Unnamed Creek 43 to Unnamed Creek 42	0.0029								
3	7		6411	140009	26.5	Unnamed Creek 42 to Unnamed Creek 41	0.0033	0.0033	**0.039**	**26**		**2 to 1**			
4	7		1661	133598	25.3	Unnamed Creek 41 to Unnamed Creek 40	0.0033								
5	8		1408	131937	25.0	Unnamed Creek 40 to Unnamed Creek 39	0.0030	0.0030	**0.039**	**27**		**2 to 1**			
6	8		1920	130529	24.7	Unnamed Creek 39 to Unnamed Creek 38	0.0030								
7	9		4873	128609	24.4	Unnamed Creek 38 to Unnamed Creek 37	0.0013	0.0013	**0.039**	**28**		**2 to 1**			
8	9		3810	123736	23.4	Unnamed Creek 37 to Unnamed Creek 36	0.0013								
9	10		732	119926	22.7	Unnamed Creek 36 to Unnamed Creek 35	0.0009	0.0009							
10	10		3130	119194	22.6	Unnamed Creek 35 to Unnamed Creek 34	0.0009								
11	10		1671	116064	22.0	Unnamed Creek 34 to Unnamed Creek 33	0.0009								
12	10	4	1992	114393	21.7	Unnamed Creek 33 to Unnamed Creek 32	0.0009		**0.039**	**30**	**1.23**	**2 to 1**	**13.5**	**5.75/5.6**	
13	11		3848	112401	21.3	Unnamed Creek 32 to Unnamed Creek 31	0.0009	0.0009	**0.039**	**30**		**2 to 1**			
14	12		2661	108553	20.6	Unnamed Creek 31 to Unnamed Creek 30	0.0007	0.0007	**0.039**	**30**		**2 to 1**			
15	13		2593	105892	20.1	Unnamed Creek 30 to Unnamed Creek 29	0.0007	0.0007	**0.039**	**30**		**2 to 1**			
16	13		360	103299	19.6	Unnamed Creek 29 to Unnamed Creek 28	0.0007								
17	13		3189	102939	19.5	Unnamed Creek 28 to Unnamed Creek 27	0.0007								
18	13		3365	99750	18.9	Unnamed Creek 27 to Unnamed Creek 26	0.0007								
19	14	5	7033	96385	18.3	Unnamed Creek 26 to Unnamed Creek 25	0.0006	0.0006	**0.039**	**35**	**4**	**2.5 to 1**	**219**	**5.5**	
20	14		4818	89352	16.9	Unnamed Creek 25 to Unnamed Creek 24	0.0006								
21	14		3744	84534	16.0	Unnamed Creek 24 to Unnamed Creek 23	0.0006								

ID	Reach	Station	Distance Between Segments (Ft)	Distance to Discharge (ft)	Distance to Discharge (mi)	COMMENTS	Channel Slope	Average Reach Slope	Manning n	Top Width (ft)	Depth (ft)	Side Slopes	Calculated Flow (CFS)	Dissolved Oxygen (mg/L)	Total Suspended Solids (mg/L)
22	14		1461	80790	15.3	Unnamed Creek 23 to Unnamed Creek 22	0.0006								
23	15		828	79329	15.0	Unnamed Creek 22 to Unnamed Creek 21	0.0006	0.0006	**0.039**	**35**		**2.5 to 1**			
24	15		4484	78501	14.9	Unnamed Creek 21 to Unnamed Creek 20	0.0006								
25	15		484	74017	14.0	Unnamed Creek 20 to Unnamed Creek 19	0.0006								
26	15		2725	73533	13.9	Unnamed Creek 19 to Unnamed Creek 18	0.0006								
27	15		459	70808	13.4	Unnamed Creek 18 to Unnamed Creek 17	0.0006								
28	15		4737	70349	13.3	Unnamed Creek 17 to Unnamed Creek 16	0.0006								
29	15		219	65612	12.4	Unnamed Creek 16 to Unnamed Creek 15	0.0006								
30	15		1857	65393	12.4	Unnamed Creek 15 to Unnamed Creek 14	0.0006								
31	15		1722	63536	12.0	Unnamed Creek 14 to Unnamed Creek 13	0.0006								
32	16		8068	61814	11.7	Unnamed Creek 13 to Unnamed Creek 12	0.0006	0.0006	**0.039**	**35**		**2.5 to 1**			
33	16		3851	53746	10.2	Unnamed Creek 12 to Unnamed Creek 11	0.0006								
34	17		1428	49895	9.4	Unnamed Creek 11 to Novak Creek	0.0006	0.0006	**0.039**	**35**		**2.5 to 1**			
76	18		5360	92101	17.4	Unnamed Creek 71 to Unnamed Creek 70	0.0043	0.0042	**0.039**	**6**		**2 to 1**			
77	18		4267	96368	18.3	Headwater of Novak Creek to Unnamed Creek 71	0.0040								
73	19		1885	83101	15.7	Unnamed Creek 68 to Unnamed Creek 67	0.0030	0.0031							
74	19	9A	2674	85775	16.2	Unnamed Creek 69 to Unnamed Creek 68	0.0032		**0.039**	**8**	**0**	**2 to 1**	**0**	**--**	
75	19		966	86741	16.4	Unnamed Creek 70 to Unnamed Creek 69	0.0032								
70	20		4333	73049	13.8	Unnamed Creek 65 to Unnamed Creek 64	0.0014	0.0017							
71	20	9	4746	77795	14.7	Unnamed Creek 66 to Unnamed Creek 65	0.0014		**0.039**	**20**	**0.5**	**2 to 1**	**0.001**	**5.5**	
72	20		3421	81216	15.4	Unnamed Creek 67 to Unnamed Creek 66	0.0022								
69	21		2678	68716	13.0	Unnamed Creek 64 to Unnamed Creek 63	0.0039	0.0039	**0.039**	**25**		**1.5 to 1**			
64	22	10	5536	60678	11.5	Unnamed Creek 59 to Unnamed Creek 58	0.0021	0.0019	**0.039**	**30**	**0.83**	**1.5 to 1**	**19**	**4.2/6.6**	
65	22		3173	63851	12.1	Unnamed Creek 60 to Unnamed Creek 59	0.0018								
66	22		339	64190	12.2	Unnamed Creek 61 to Unnamed Creek 60	0.0018								
67	22		1210	65400	12.4	Unnamed Creek 62 to Unnamed Creek 61	0.0018								
68	22		638	66038	12.5	Unnamed Creek 63 to Unnamed Creek 62	0.0018								
62	23		4200	52667	10.0	Unnamed Creek 57 to end of Novak Creek	0.0014	0.0014	**0.039**	**30**		**1.5 to 1**			
63	23		2475	55142	10.4	Unnamed Creek 58 to Unnamed Creek 57	0.0014								
35	24	11	3974	48467	9.2	Novak Creek to Unnamed Creek 10	0.0002	0.0002	**0.039**	**35**	**0.5**	**1.5 to 1**	**43.8**	**5**	
36	25		2528	44493	8.4	Unnamed Creek 10 to Back Branch	0.0002	0.0002	**0.039**	**35**		**1.5 to 1**			
37	25		1844	41965	7.9	Back Branch to Unnamed Creek 9	0.0002								
38	26	13	7511	40121	7.6	Unnamed Creek 9 to Unnamed Creek 8	0.0002	0.0002	**0.039**	**30**	**2**	**2 to 1**		**4.5/6**	
39	26		1470	32610	6.2	Unnamed Creek 8 to Unnamed Creek 7	0.0002								
40	26		70	31140	5.9	Unnamed Creek 7 to Unnamed Creek 6	0.0002								

ID	Reach	Station	Distance Between Segments (Ft)	Distance to Discharge (ft)	Distance to Discharge (mi)	COMMENTS	Channel Slope	Average Reach Slope	Manning n	Top Width (ft)	Depth (ft)	Side Slopes	Calculated Flow (CFS)	Dissolved Oxygen (mg/L)	Total Suspended Solids (mg/L)
41	26		813	31070	5.9	Unnamed Creek 6 to Unnamed Creek 5	0.0002								
42	26		2729	30257	5.7	Unnamed Creek 5 to Unnamed Creek 4	0.0002								
43	26		5632	27528	5.2	Unnamed Creek 4 to Unnamed Creek 3	0.0002								
44	26		2607	21896	4.1	Unnamed Creek 3 to Unnamed Creek 2	0.0002								
45	27		1135	19289	3.7	Unnamed Creek 2 to Unnamed Creek 1	0.0002	0.0002	**0.039**	**30**		**2 to 1**			
46	27		2877	18154	3.4	Unnamed Creek 1 to Prairie Creek	0.0002								
47	27		15277	15277	2.9	Prairie Creek to End of Rayse Creek	0.0002								

Measured Values

Estimated Values calculated from Measured Values

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                                                   * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                                                                Version 3.21  -  Feb. 1995
 $$$ (PROBLEM TITLES) $$$
CARD TYPE                             QUAL-2E PROGRAM TITLES
TITLE01              Rayse Creek DO Calibrated Model
TITLE02
TITLE03  NO          CONSERVATIVE MINERAL I      TSS IN mg/L
TITLE04  NO          CONSERVATIVE MINERAL II
TITLE05  NO          CONSERVATIVE MINERAL III
TITLE06  YES         TEMPERATURE
TITLE07  YES         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  NO          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
NO 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)=      0.00000           5D-ULT BOD CONV K COEF  =   0.23000
INPUT METRIC            =      0.00000           OUTPUT METRIC           =   0.00000
NUMBER OF REACHES       =     27.00000           NUMBER OF JUNCTIONS     =   2.00000
NUM OF HEADWATERS       =      3.00000           NUMBER OF POINT LOADS   =  47.00000
TIME STEP (HOURS)       =      1.00000           LNTH. COMP. ELEMENT (DX)=   0.25000
MAXIMUM ROUTE TIME (HRS)=     30.00000           TIME INC. FOR RPT2 (HRS)=   1.00000
LATITUDE OF BASIN (DEG) =     38.00000           LONGITUDE OF BASIN (DEG)=  89.00000
STANDARD MARIDIAN (DEG) =    180.00000           DAY OF YEAR START TIME  = 180.00000
EVAP. COEF.,(AE)        =      0.00103           EVAP. COEF.,(BE)        =   0.00016
ELEV. OF BASIN (ELEV)   =    450.00000           DUST ATTENUATION COEF.  =   0.06000
ENDATA1                        0.00000                                      0.00000

 $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$
CARD TYPE                                              CARD TYPE
ENDATA1A                             0.0000                                                 0.0000
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$$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

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
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=	1	FROM	30.5	TO	27.0
STREAM REACH	2.0	RCH=	2	FROM	27.0	TO	26.0
STREAM REACH	3.0	RCH=	3	FROM	26.0	TO	25.0
STREAM REACH	4.0	RCH=	4	FROM	25.0	TO	24.0
STREAM REACH	5.0	RCH=	5	FROM	24.0	TO	20.8
STREAM REACH	6.0	RCH=	6	FROM	7.0	TO	6.0
STREAM REACH	7.0	RCH=	7	FROM	6.0	TO	4.5
STREAM REACH	8.0	RCH=	8	FROM	4.5	TO	3.8
STREAM REACH	9.0	RCH=	9	FROM	3.8	TO	2.0
STREAM REACH	10.0	RCH=	10	FROM	2.0	TO	0.0
STREAM REACH	11.0	RCH=	11	FROM	20.8	TO	20.0
STREAM REACH	12.0	RCH=	12	FROM	20.0	TO	19.5
STREAM REACH	13.0	RCH=	13	FROM	19.5	TO	18.3
STREAM REACH	14.0	RCH=	14	FROM	18.3	TO	15.3
STREAM REACH	15.0	RCH=	15	FROM	15.3	TO	12.0
STREAM REACH	16.0	RCH=	16	FROM	12.0	TO	9.5
STREAM REACH	17.0	RCH=	17	FROM	9.5	TO	9.0
STREAM REACH	18.0	RCH=	18	FROM	9.0	TO	7.3
STREAM REACH	19.0	RCH=	19	FROM	7.3	TO	6.3
STREAM REACH	20.0	RCH=	20	FROM	6.3	TO	3.8
STREAM REACH	21.0	RCH=	21	FROM	3.8	TO	3.3

```
STREAM REACH    22.0  RCH=              22   FROM           3.3    TO            1.3
STREAM REACH    23.0  RCH=              23   FROM           1.3    TO            0.0
STREAM REACH    24.0  RCH=              24   FROM           9.0    TO            8.5
STREAM REACH    25.0  RCH=              25   FROM           8.5    TO            7.5
STREAM REACH    26.0  RCH=              26   FROM           7.5    TO            3.8
STREAM REACH    27.0  RCH=              27   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.       14.         1.2.2.2.2.2.2.2.2.6.2.2.2.2.0.0.0.0.0.0.
FLAG FIELD         2.        4.         6.2.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         3.        4.         2.2.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         4.        4.         6.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         5.       13.         6.2.2.2.2.2.2.2.2.2.2.6.3.0.0.0.0.0.0.0.
FLAG FIELD         6.        4.         1.2.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         7.        6.         2.2.2.2.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         8.        3.         6.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         9.        7.         2.2.6.2.2.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        10.        8.         2.6.2.2.6.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        11.        3.         4.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        12.        2.         2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        13.        5.         2.6.2.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        14.       12.         2.2.2.2.6.2.2.2.6.2.2.6.0.0.0.0.0.0.0.0.
FLAG FIELD        15.       13.         2.2.2.2.6.2.2.6.2.2.6.2.6.0.0.0.0.0.0.0.
FLAG FIELD        16.       10.         6.2.2.2.2.2.6.2.2.6.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        17.        2.         2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        18.        7.         1.2.6.2.2.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        19.        4.         2.2.6.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        20.       10.         2.2.6.2.2.2.6.2.2.6.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        21.        2.         2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        22.        8.         6.2.2.6.2.2.2.6.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        23.        5.         2.6.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        24.        2.         4.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        25.        4.         2.6.2.6.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        26.       15.         2.2.2.2.2.6.2.2.6.2.2.2.2.2.6.0.0.0.0.0.
FLAG FIELD        27.       15.         2.6.2.2.2.2.2.2.2.2.2.2.2.2.5.0.0.0.0.0.
ENDATA4            0.        0.         0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

 $$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$
CARD TYPE         REACH  COEF-DSPN    SS1       SS2     WIDTH     SLOPE     CMANN
HYDRAULICS         1.    375.00     2.000     2.000    15.000     0.004     0.035
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HYDRAULICS	2.	375.00	2.000	2.000	18.000	0.005	0.035
HYDRAULICS	3.	375.00	2.000	2.000	20.000	0.001	0.035
HYDRAULICS	4.	375.00	2.000	2.000	22.000	0.002	0.035
HYDRAULICS	5.	375.00	2.000	2.000	23.000	0.001	0.035
HYDRAULICS	6.	375.00	2.000	2.000	25.000	0.003	0.035
HYDRAULICS	7.	375.00	2.000	2.000	26.000	0.003	0.035
HYDRAULICS	8.	375.00	2.000	2.000	27.000	0.003	0.035
HYDRAULICS	9.	375.00	2.000	2.000	28.000	0.001	0.035
HYDRAULICS	10.	375.00	2.000	2.000	30.000	0.001	0.035
HYDRAULICS	11.	375.00	2.000	2.000	30.000	0.001	0.035
HYDRAULICS	12.	375.00	2.000	2.000	30.000	0.001	0.035
HYDRAULICS	13.	375.00	2.000	2.000	30.000	0.001	0.035
HYDRAULICS	14.	375.00	2.500	2.500	35.000	0.001	0.035
HYDRAULICS	15.	375.00	2.500	2.500	35.000	0.001	0.035
HYDRAULICS	16.	375.00	2.500	2.500	35.000	0.001	0.035
HYDRAULICS	17.	375.00	2.500	2.500	35.000	0.001	0.035
HYDRAULICS	18.	375.00	2.000	2.000	6.000	0.004	0.035
HYDRAULICS	19.	375.00	2.000	2.000	8.000	0.003	0.035
HYDRAULICS	20.	375.00	2.000	2.000	20.000	0.002	0.035
HYDRAULICS	21.	375.00	1.500	1.500	25.000	0.004	0.035
HYDRAULICS	22.	375.00	1.500	1.500	30.000	0.002	0.035
HYDRAULICS	23.	375.00	1.500	1.500	30.000	0.001	0.035
HYDRAULICS	24.	375.00	1.500	1.500	35.000	0.000	0.035
HYDRAULICS	25.	375.00	1.500	1.500	35.000	0.000	0.035
HYDRAULICS	26.	375.00	1.500	1.500	30.000	0.000	0.035
HYDRAULICS	27.	375.00	2.000	2.000	30.000	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.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	2.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	3.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	4.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	5.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	6.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	7.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	8.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	9.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	10.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	11.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	12.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	13.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	14.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	15.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	16.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	17.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	18.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	19.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	20.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	21.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	22.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	23.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	24.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	25.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	26.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	1.00
TEMP/LCD	27.	450.00	0.06	0.30	85.00	85.00	30.00	5.00	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 FOR OPT 8	OR OR	EXPQK2 SLOPE FOR OPT 8
REACT COEF	1.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	2.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	3.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	4.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	5.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	6.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	7.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	8.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	9.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	10.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	11.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	12.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	13.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	14.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	15.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	16.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	17.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	18.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	19.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	20.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	21.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	22.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	23.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	24.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	25.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	26.	1.00	0.00	0.500	3.	0.00	0.000		0.00000
REACT COEF	27.	1.00	0.00	0.500	3.	0.00	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
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
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	2.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

INITIAL COND-1	3.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	4.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	5.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	6.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	7.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	8.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	9.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	10.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	11.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	12.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	13.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	14.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	15.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	16.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	17.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	18.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	19.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	20.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	21.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	22.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	23.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	24.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	25.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	26.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	27.	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	4.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	5.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	6.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	8.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	9.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	10.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	11.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	12.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	13.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	14.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	15.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	16.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	17.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	18.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	19.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	20.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	21.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	22.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	23.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	24.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	25.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	26.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	27.	0.000	70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
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	39.	68.	67.
STREAM JUNCTION	2.	JNC=	2	114.	151.	150.
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.	1	0.00	79.00	5.50	2.90	30.00	0.00	0.00
HEADWTR-1	2.	6	0.00	79.00	5.50	2.90	30.00	0.00	0.00
HEADWTR-1	3.	18	0.00	79.00	5.50	2.90	30.00	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
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.	Creek 56	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	2.	Creek 55	0.00	0.44	79.00	5.50	10.00	385.00	0.00	0.00
POINTLD-1	3.	Creek 54	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	4.	Creek 53 & 5	0.00	0.89	79.00	5.50	10.00	829.00	0.00	0.00
POINTLD-1	5.	Creek 51	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	6.	Creek 49,50	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	7.	Creek 46,47,	0.00	0.88	79.00	5.50	10.00	534.00	0.00	0.00
POINTLD-1	8.	Creek 45	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	9.	Creek 42,43	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	10.	Creek 40,41	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	11.	Creek 38,39	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	12.	Creek 37	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	13.	Creek 35,36	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	14.	Creek 34	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	15.	Creek 32,33	0.00	0.92	79.00	5.50	12.00	588.00	0.00	0.00
POINTLD-1	16.	Creek 30	0.00	2.15	79.00	5.50	10.00	237.00	0.00	0.00
POINTLD-1	17.	Creek 28,29	0.00	0.62	79.00	5.50	500.00	543.00	0.00	0.00
POINTLD-1	18.	Creek 27	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	19.	Creek 26	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	20.	Creek 25	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	21.	Creek 24	0.00	0.92	79.00	5.50	14.00	383.00	0.00	0.00
POINTLD-1	22.	Creek 23	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	23.	Creek 21,22	0.00	0.24	79.00	5.50	12.00	738.00	0.00	0.00
POINTLD-1	24.	Creek 19,20	0.00	1.76	79.00	5.50	13.00	662.00	0.00	0.00
POINTLD-1	25.	Creek 17,18	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	26.	Creek 15,16	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	27.	Creek 14	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	28.	Creek 13	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	29.	Creek 12	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	30.	Creek 11	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	31.	Creek 71	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	32.	Creek 69,70	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	33.	Creek 68	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	34.	Creek 67	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	35.	Creek 66	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	36.	Creek 65	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	37.	Creek 64	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	38.	Creek 62,63	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	39.	Creek 60,61	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	40.	Creek 59	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	41.	Creek 58	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	42.	Creek 57	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00

POINTLD-1	43.	Creek 10	0.00	2.22	79.00	5.50	14.00	980.00	0.00	0.00
POINTLD-1	44.	Back Branch	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	45.	Creek 9	0.00	0.79	79.00	5.50	10.00	980.00	0.00	0.00
POINTLD-1	46.	Creeks 5,6,7	0.00	0.00	79.00	5.50	0.00	0.00	0.00	0.00
POINTLD-1	47.	Creek 4	0.00	1.32	79.00	5.50	15.00	547.00	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
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
ENDATA13	DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED							

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

CARD TYPE	CHL-A	ORG-N	NH3-N	NO2-N	NH3-N	ORG-P	DIS-P
ENDATA13A	DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED						

STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:

ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
1	186
2	179
3	0

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

DAILY NET SOLAR RADIATION = 2724.776 BTU/FT-2 (739.424 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 14.6

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

1	96.24	9	262.75	17	0.00
2	158.49	10	214.06	18	0.00
3	216.19	11	156.08	19	0.00
4	264.42	12	93.75	20	0.00
5	299.09	13	31.63	21	0.00
6	317.21	14	0.00	22	0.00
7	316.84	15	0.00	23	0.00
8	298.02	16	0.00	24	0.00

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	30.50	30.25	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
2	1	2	30.25	30.00	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
3	1	3	30.00	29.75	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
4	1	4	29.75	29.50	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
5	1	5	29.50	29.25	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
6	1	6	29.25	29.00	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
7	1	7	29.00	28.75	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
8	1	8	28.75	28.50	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
9	1	9	28.50	28.25	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
10	1	10	28.25	28.00	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
11	1	11	28.00	27.75	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
12	1	12	27.75	27.50	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
13	1	13	27.50	27.25	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
14	1	14	27.25	27.00	0.00	0.00	0.00	0.055	0.276	0.003	15.006	0.06	19.82	0.05	0.02
15	2	1	27.00	26.75	0.44	0.44	0.00	0.429	0.036	0.057	18.114	1.36	24.10	1.03	1.98
16	2	2	26.75	26.50	0.44	0.00	0.00	0.429	0.036	0.057	18.114	1.36	24.10	1.03	1.98
17	2	3	26.50	26.25	0.44	0.00	0.00	0.429	0.036	0.057	18.114	1.36	24.10	1.03	1.98
18	2	4	26.25	26.00	0.44	0.00	0.00	0.429	0.036	0.057	18.114	1.36	24.10	1.03	1.98
19	3	1	26.00	25.75	0.44	0.00	0.00	0.285	0.054	0.077	20.157	2.05	26.85	1.55	1.69
20	3	2	25.75	25.50	0.44	0.00	0.00	0.285	0.054	0.077	20.157	2.05	26.85	1.55	1.69
21	3	3	25.50	25.25	0.44	0.00	0.00	0.285	0.054	0.077	20.157	2.05	26.85	1.55	1.69
22	3	4	25.25	25.00	1.34	0.89	0.00	0.441	0.035	0.149	20.298	4.00	27.28	3.03	4.54
23	4	1	25.00	24.75	1.34	0.00	0.00	0.501	0.030	0.120	22.240	3.52	29.75	2.67	4.29
24	4	2	24.75	24.50	1.34	0.00	0.00	0.501	0.030	0.120	22.240	3.52	29.75	2.67	4.29
25	4	3	24.50	24.25	1.34	0.00	0.00	0.501	0.030	0.120	22.240	3.52	29.75	2.67	4.29
26	4	4	24.25	24.00	1.34	0.00	0.00	0.501	0.030	0.120	22.240	3.52	29.75	2.67	4.29
27	5	1	24.00	23.75	1.34	0.00	0.00	0.366	0.042	0.157	23.313	4.82	31.28	3.65	3.92
28	5	2	23.75	23.50	1.34	0.00	0.00	0.366	0.042	0.157	23.313	4.82	31.28	3.65	3.92
29	5	3	23.50	23.25	1.34	0.00	0.00	0.366	0.042	0.157	23.313	4.82	31.28	3.65	3.92
30	5	4	23.25	23.00	1.34	0.00	0.00	0.366	0.042	0.157	23.313	4.82	31.28	3.65	3.92
31	5	5	23.00	22.75	1.34	0.00	0.00	0.366	0.042	0.157	23.313	4.82	31.28	3.65	3.92
32	5	6	22.75	22.50	1.34	0.00	0.00	0.366	0.042	0.157	23.313	4.82	31.28	3.65	3.92
33	5	7	22.50	22.25	1.34	0.00	0.00	0.366	0.042	0.157	23.313	4.82	31.28	3.65	3.92
34	5	8	22.25	22.00	1.34	0.00	0.00	0.366	0.042	0.157	23.313	4.82	31.28	3.65	3.92
35	5	9	22.00	21.75	1.34	0.00	0.00	0.366	0.042	0.157	23.313	4.82	31.28	3.65	3.92
36	5	10	21.75	21.50	1.34	0.00	0.00	0.366	0.042	0.157	23.313	4.82	31.28	3.65	3.92
37	5	11	21.50	21.25	1.34	0.00	0.00	0.366	0.042	0.157	23.313	4.82	31.28	3.65	3.92
38	5	12	21.25	21.00	2.22	0.88	0.00	0.446	0.034	0.212	23.426	6.56	31.61	4.97	6.15

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
39	5	13	21.00	20.75	2.22	0.00	0.00	0.446	0.034	0.212	23.426	6.56	31.61	4.97	6.15
40	6	1	7.00	6.75	0.00	0.00	0.00	0.042	0.360	0.002	25.006	0.08	33.01	0.06	0.01
41	6	2	6.75	6.50	0.00	0.00	0.00	0.042	0.360	0.002	25.006	0.08	33.01	0.06	0.01
42	6	3	6.50	6.25	0.00	0.00	0.00	0.042	0.360	0.002	25.006	0.08	33.01	0.06	0.01
43	6	4	6.25	6.00	0.00	0.00	0.00	0.042	0.360	0.002	25.006	0.08	33.01	0.06	0.01
44	7	1	6.00	5.75	0.00	0.00	0.00	0.042	0.362	0.002	26.006	0.08	34.33	0.06	0.01
45	7	2	5.75	5.50	0.00	0.00	0.00	0.042	0.362	0.002	26.006	0.08	34.33	0.06	0.01
46	7	3	5.50	5.25	0.00	0.00	0.00	0.042	0.362	0.002	26.006	0.08	34.33	0.06	0.01
47	7	4	5.25	5.00	0.00	0.00	0.00	0.042	0.362	0.002	26.006	0.08	34.33	0.06	0.01
48	7	5	5.00	4.75	0.00	0.00	0.00	0.042	0.362	0.002	26.006	0.08	34.33	0.06	0.01
49	7	6	4.75	4.50	0.00	0.00	0.00	0.042	0.362	0.002	26.006	0.08	34.33	0.06	0.01
50	8	1	4.50	4.25	0.00	0.00	0.00	0.040	0.378	0.002	27.006	0.08	35.65	0.06	0.01
51	8	2	4.25	4.00	0.00	0.00	0.00	0.040	0.378	0.002	27.006	0.08	35.65	0.06	0.01
52	8	3	4.00	3.75	0.00	0.00	0.00	0.040	0.378	0.002	27.006	0.08	35.65	0.06	0.01
53	9	1	3.75	3.50	0.00	0.00	0.00	0.031	0.493	0.003	28.006	0.11	36.98	0.08	0.01
54	9	2	3.50	3.25	0.00	0.00	0.00	0.031	0.493	0.003	28.006	0.11	36.98	0.08	0.01
55	9	3	3.25	3.00	0.00	0.00	0.00	0.031	0.493	0.003	28.006	0.11	36.98	0.08	0.01
56	9	4	3.00	2.75	0.00	0.00	0.00	0.031	0.493	0.003	28.006	0.11	36.98	0.08	0.01
57	9	5	2.75	2.50	0.00	0.00	0.00	0.031	0.493	0.003	28.006	0.11	36.98	0.08	0.01
58	9	6	2.50	2.25	0.00	0.00	0.00	0.031	0.493	0.003	28.006	0.11	36.98	0.08	0.01
59	9	7	2.25	2.00	0.00	0.00	0.00	0.031	0.493	0.003	28.006	0.11	36.98	0.08	0.01
60	10	1	2.00	1.75	0.00	0.00	0.00	0.027	0.566	0.003	30.006	0.12	39.62	0.09	0.01
61	10	2	1.75	1.50	0.00	0.00	0.00	0.027	0.566	0.003	30.006	0.12	39.62	0.09	0.01
62	10	3	1.50	1.25	0.00	0.00	0.00	0.027	0.566	0.003	30.006	0.12	39.62	0.09	0.01
63	10	4	1.25	1.00	0.00	0.00	0.00	0.027	0.566	0.003	30.006	0.12	39.62	0.09	0.01
64	10	5	1.00	0.75	0.00	0.00	0.00	0.027	0.566	0.003	30.006	0.12	39.62	0.09	0.01
65	10	6	0.75	0.50	0.00	0.00	0.00	0.027	0.566	0.003	30.006	0.12	39.62	0.09	0.01
66	10	7	0.50	0.25	0.00	0.00	0.00	0.027	0.566	0.003	30.006	0.12	39.62	0.09	0.01
67	10	8	0.25	0.00	0.00	0.00	0.00	0.027	0.566	0.003	30.006	0.12	39.62	0.09	0.01
68	11	1	20.75	20.50	2.22	0.00	0.00	0.404	0.038	0.181	30.369	7.26	40.67	5.50	4.87
69	11	2	20.50	20.25	2.22	0.00	0.00	0.404	0.038	0.181	30.369	7.26	40.67	5.50	4.87
70	11	3	20.25	20.00	3.14	0.92	0.00	0.462	0.033	0.223	30.447	8.95	40.92	6.78	6.64

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
71	12	1	20.00	19.75	3.14	0.00	0.00	0.428	0.036	0.240	30.481	9.66	41.02	7.32	6.55
72	12	2	19.75	19.50	5.28	2.15	0.00	0.525	0.029	0.328	30.656	13.28	41.54	10.06	10.41
73	13	1	19.50	19.25	5.28	0.00	0.00	0.525	0.029	0.328	30.656	13.28	41.54	10.06	10.41
74	13	2	19.25	19.00	5.91	0.62	0.00	0.548	0.028	0.351	30.701	14.21	41.67	10.77	11.49
75	13	3	19.00	18.75	5.91	0.00	0.00	0.548	0.028	0.351	30.701	14.21	41.67	10.77	11.49
76	13	4	18.75	18.50	5.91	0.00	0.00	0.548	0.028	0.351	30.701	14.21	41.67	10.77	11.49
77	13	5	18.50	18.25	5.91	0.00	0.00	0.548	0.028	0.351	30.701	14.21	41.67	10.77	11.49
78	14	1	18.25	18.00	5.91	0.00	0.00	0.492	0.031	0.335	35.837	15.83	48.58	11.99	9.92
79	14	2	18.00	17.75	5.91	0.00	0.00	0.492	0.031	0.335	35.837	15.83	48.58	11.99	9.92
80	14	3	17.75	17.50	5.91	0.00	0.00	0.492	0.031	0.335	35.837	15.83	48.58	11.99	9.92
81	14	4	17.50	17.25	5.91	0.00	0.00	0.492	0.031	0.335	35.837	15.83	48.58	11.99	9.92
82	14	5	17.25	17.00	5.91	0.00	0.00	0.492	0.031	0.335	35.837	15.83	48.58	11.99	9.92
83	14	6	17.00	16.75	5.91	0.00	0.00	0.492	0.031	0.335	35.837	15.83	48.58	11.99	9.92
84	14	7	16.75	16.50	5.91	0.00	0.00	0.492	0.031	0.335	35.837	15.83	48.58	11.99	9.92
85	14	8	16.50	16.25	5.91	0.00	0.00	0.492	0.031	0.335	35.837	15.83	48.58	11.99	9.92
86	14	9	16.25	16.00	5.91	0.00	0.00	0.492	0.031	0.335	35.837	15.83	48.58	11.99	9.92
87	14	10	16.00	15.75	5.91	0.00	0.00	0.492	0.031	0.335	35.837	15.83	48.58	11.99	9.92
88	14	11	15.75	15.50	5.91	0.00	0.00	0.492	0.031	0.335	35.837	15.83	48.58	11.99	9.92
89	14	12	15.50	15.25	6.83	0.92	0.00	0.521	0.029	0.365	35.912	17.30	48.79	13.10	11.28
90	15	1	15.25	15.00	6.83	0.00	0.00	0.521	0.029	0.365	35.912	17.30	48.79	13.10	11.28
91	15	2	15.00	14.75	6.83	0.00	0.00	0.521	0.029	0.365	35.912	17.30	48.79	13.10	11.28
92	15	3	14.75	14.50	6.83	0.00	0.00	0.521	0.029	0.365	35.912	17.30	48.79	13.10	11.28
93	15	4	14.50	14.25	6.83	0.00	0.00	0.521	0.029	0.365	35.912	17.30	48.79	13.10	11.28
94	15	5	14.25	14.00	6.83	0.00	0.00	0.521	0.029	0.365	35.912	17.30	48.79	13.10	11.28
95	15	6	14.00	13.75	6.83	0.00	0.00	0.521	0.029	0.365	35.912	17.30	48.79	13.10	11.28
96	15	7	13.75	13.50	6.83	0.00	0.00	0.521	0.029	0.365	35.912	17.30	48.79	13.10	11.28
97	15	8	13.50	13.25	7.06	0.24	0.00	0.527	0.029	0.372	35.950	17.67	48.85	13.39	11.61
98	15	9	13.25	13.00	7.06	0.00	0.00	0.527	0.029	0.372	35.950	17.67	48.85	13.39	11.61
99	15	10	13.00	12.75	7.06	0.00	0.00	0.527	0.029	0.372	35.950	17.67	48.85	13.39	11.61
100	15	11	12.75	12.50	8.83	1.76	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
101	15	12	12.50	12.25	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
102	15	13	12.25	12.00	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
103	16	1	12.00	11.75	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
104	16	2	11.75	11.50	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
105	16	3	11.50	11.25	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
106	16	4	11.25	11.00	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
107	16	5	11.00	10.75	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
108	16	6	10.75	10.50	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
109	16	7	10.50	10.25	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
110	16	8	10.25	10.00	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
111	16	9	10.00	9.75	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
112	16	10	9.75	9.50	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
113	17	1	9.50	9.25	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
114	17	2	9.25	9.00	8.83	0.00	0.00	0.575	0.027	0.425	36.070	20.25	49.22	15.34	14.15
115	18	1	9.00	8.75	0.00	0.00	0.00	0.081	0.188	0.005	6.012	0.04	7.95	0.03	0.05
116	18	2	8.75	8.50	0.00	0.00	0.00	0.081	0.188	0.005	6.012	0.04	7.95	0.03	0.05
117	18	3	8.50	8.25	0.00	0.00	0.00	0.081	0.188	0.005	6.012	0.04	7.95	0.03	0.05
118	18	4	8.25	8.00	0.00	0.00	0.00	0.081	0.188	0.005	6.012	0.04	7.95	0.03	0.05
119	18	5	8.00	7.75	0.00	0.00	0.00	0.081	0.188	0.005	6.012	0.04	7.95	0.03	0.05
120	18	6	7.75	7.50	0.00	0.00	0.00	0.081	0.188	0.005	6.012	0.04	7.95	0.03	0.05
121	18	7	7.50	7.25	0.00	0.00	0.00	0.081	0.188	0.005	6.012	0.04	7.95	0.03	0.05
122	19	1	7.25	7.00	0.00	0.00	0.00	0.066	0.230	0.005	8.013	0.05	10.59	0.04	0.04
123	19	2	7.00	6.75	0.00	0.00	0.00	0.066	0.230	0.005	8.013	0.05	10.59	0.04	0.04
124	19	3	6.75	6.50	0.00	0.00	0.00	0.066	0.230	0.005	8.013	0.05	10.59	0.04	0.04
125	19	4	6.50	6.25	0.00	0.00	0.00	0.066	0.230	0.005	8.013	0.05	10.59	0.04	0.04
126	20	1	6.25	6.00	0.00	0.00	0.00	0.038	0.398	0.003	20.007	0.09	26.42	0.07	0.02
127	20	2	6.00	5.75	0.00	0.00	0.00	0.038	0.398	0.003	20.007	0.09	26.42	0.07	0.02
128	20	3	5.75	5.50	0.00	0.00	0.00	0.038	0.398	0.003	20.007	0.09	26.42	0.07	0.02
129	20	4	5.50	5.25	0.00	0.00	0.00	0.038	0.398	0.003	20.007	0.09	26.42	0.07	0.02
130	20	5	5.25	5.00	0.00	0.00	0.00	0.038	0.398	0.003	20.007	0.09	26.42	0.07	0.02
131	20	6	5.00	4.75	0.00	0.00	0.00	0.038	0.398	0.003	20.007	0.09	26.42	0.07	0.02
132	20	7	4.75	4.50	0.00	0.00	0.00	0.038	0.398	0.003	20.007	0.09	26.42	0.07	0.02
133	20	8	4.50	4.25	0.00	0.00	0.00	0.038	0.398	0.003	20.007	0.09	26.42	0.07	0.02
134	20	9	4.25	4.00	0.00	0.00	0.00	0.038	0.398	0.003	20.007	0.09	26.42	0.07	0.02
135	20	10	4.00	3.75	0.00	0.00	0.00	0.038	0.398	0.003	20.007	0.09	26.42	0.07	0.02
136	21	1	3.75	3.50	0.00	0.00	0.00	0.045	0.339	0.002	25.005	0.07	33.01	0.06	0.01
137	21	2	3.50	3.25	0.00	0.00	0.00	0.045	0.339	0.002	25.005	0.07	33.01	0.06	0.01
138	22	1	3.25	3.00	0.00	0.00	0.00	0.034	0.452	0.002	30.004	0.10	39.61	0.07	0.01
139	22	2	3.00	2.75	0.00	0.00	0.00	0.034	0.452	0.002	30.004	0.10	39.61	0.07	0.01
140	22	3	2.75	2.50	0.00	0.00	0.00	0.034	0.452	0.002	30.004	0.10	39.61	0.07	0.01
141	22	4	2.50	2.25	0.00	0.00	0.00	0.034	0.452	0.002	30.004	0.10	39.61	0.07	0.01
142	22	5	2.25	2.00	0.00	0.00	0.00	0.034	0.452	0.002	30.004	0.10	39.61	0.07	0.01

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
143	22	6	2.00	1.75	0.00	0.00	0.00	0.034	0.452	0.002	30.004	0.10	39.61	0.07	0.01
144	22	7	1.75	1.50	0.00	0.00	0.00	0.034	0.452	0.002	30.004	0.10	39.61	0.07	0.01
145	22	8	1.50	1.25	0.00	0.00	0.00	0.034	0.452	0.002	30.004	0.10	39.61	0.07	0.01
146	23	1	1.25	1.00	0.00	0.00	0.00	0.031	0.496	0.003	30.004	0.11	39.61	0.08	0.01
147	23	2	1.00	0.75	0.00	0.00	0.00	0.031	0.496	0.003	30.004	0.11	39.61	0.08	0.01
148	23	3	0.75	0.50	0.00	0.00	0.00	0.031	0.496	0.003	30.004	0.11	39.61	0.08	0.01
149	23	4	0.50	0.25	0.00	0.00	0.00	0.031	0.496	0.003	30.004	0.11	39.61	0.08	0.01
150	23	5	0.25	0.00	0.00	0.00	0.00	0.031	0.496	0.003	30.004	0.11	39.61	0.08	0.01
151	24	1	9.00	8.75	8.83	0.00	0.00	0.414	0.037	0.593	35.890	28.11	49.02	21.30	13.45
152	24	2	8.75	8.50	8.83	0.00	0.00	0.414	0.037	0.593	35.890	28.11	49.02	21.30	13.45
153	25	1	8.50	8.25	8.83	0.00	0.00	0.414	0.037	0.593	35.890	28.11	49.02	21.30	13.45
154	25	2	8.25	8.00	8.83	0.00	0.00	0.414	0.037	0.593	35.890	28.11	49.02	21.30	13.45
155	25	3	8.00	7.75	8.83	0.00	0.00	0.414	0.037	0.593	35.890	28.11	49.02	21.30	13.45
156	25	4	7.75	7.50	11.05	2.22	0.00	0.452	0.034	0.679	36.018	32.27	49.43	24.45	16.41
157	26	1	7.50	7.25	11.05	0.00	0.00	0.477	0.032	0.744	31.126	30.57	43.14	23.16	18.70
158	26	2	7.25	7.00	11.05	0.00	0.00	0.477	0.032	0.744	31.126	30.57	43.14	23.16	18.70
159	26	3	7.00	6.75	11.05	0.00	0.00	0.477	0.032	0.744	31.126	30.57	43.14	23.16	18.70
160	26	4	6.75	6.50	11.05	0.00	0.00	0.477	0.032	0.744	31.126	30.57	43.14	23.16	18.70
161	26	5	6.50	6.25	11.05	0.00	0.00	0.477	0.032	0.744	31.126	30.57	43.14	23.16	18.70
162	26	6	6.25	6.00	11.05	0.00	0.00	0.477	0.032	0.744	31.126	30.57	43.14	23.16	18.70
163	26	7	6.00	5.75	11.05	0.00	0.00	0.477	0.032	0.744	31.126	30.57	43.14	23.16	18.70
164	26	8	5.75	5.50	11.05	0.00	0.00	0.477	0.032	0.744	31.126	30.57	43.14	23.16	18.70
165	26	9	5.50	5.25	11.84	0.79	0.00	0.490	0.031	0.775	31.169	31.91	43.29	24.17	19.87
166	26	10	5.25	5.00	11.84	0.00	0.00	0.490	0.031	0.775	31.169	31.91	43.29	24.17	19.87
167	26	11	5.00	4.75	11.84	0.00	0.00	0.490	0.031	0.775	31.169	31.91	43.29	24.17	19.87
168	26	12	4.75	4.50	11.84	0.00	0.00	0.490	0.031	0.775	31.169	31.91	43.29	24.17	19.87
169	26	13	4.50	4.25	11.84	0.00	0.00	0.490	0.031	0.775	31.169	31.91	43.29	24.17	19.87
170	26	14	4.25	4.00	11.84	0.00	0.00	0.490	0.031	0.775	31.169	31.91	43.29	24.17	19.87
171	26	15	4.00	3.75	11.84	0.00	0.00	0.490	0.031	0.775	31.169	31.91	43.29	24.17	19.87
172	27	1	3.75	3.50	11.84	0.00	0.00	0.486	0.031	0.772	31.551	32.16	44.16	24.36	19.64
173	27	2	3.50	3.25	13.16	1.32	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
174	27	3	3.25	3.00	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
175	27	4	3.00	2.75	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
176	27	5	2.75	2.50	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
177	27	6	2.50	2.25	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
178	27	7	2.25	2.00	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
179	27	8	2.00	1.75	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
180	27	9	1.75	1.50	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
181	27	10	1.50	1.25	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
182	27	11	1.25	1.00	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
183	27	12	1.00	0.75	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
184	27	13	0.75	0.50	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
185	27	14	0.50	0.25	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54
186	27	15	0.25	0.00	13.16	0.00	0.00	0.506	0.030	0.822	31.647	34.35	44.46	26.03	21.54

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

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
1	1	6.75	3	*******	2.18	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	3	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	4	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	5	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	6	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	7	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	8	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	9	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	10	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	11	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	12	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	13	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	14	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1	7.20	3	*******	1.82	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	6.90	3	903.68	2.05	0.00	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	3	6.80	3	923.20	2.14	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	4	6.77	3	930.17	2.17	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	1	6.76	3	709.00	2.18	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2	6.75	3	485.74	2.18	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	6.75	3	485.82	2.18	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	4	7.26	3	319.63	1.78	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1	7.04	3	260.79	1.94	0.00	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	2	6.92	3	319.48	2.04	0.00	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	3	6.84	3	324.34	2.10	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	6.80	3	327.15	2.14	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1	6.78	3	258.49	2.16	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	2	6.77	3	188.71	2.17	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	3	6.76	3	189.02	2.18	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	4	6.76	3	189.19	2.18	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	5	6.75	3	189.29	2.18	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6	6.75	3	189.35	2.18	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	7	6.75	3	189.38	2.18	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	8	6.75	3	189.39	2.18	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	9	6.75	3	189.40	2.18	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	10	6.75	3	189.41	2.18	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	11	6.75	3	189.35	2.18	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	12	7.08	3	150.19	1.91	0.00	1.13	0.00	0.00	0.00	0.00	0.00	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/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
5	13	6.97	3	126.59	1.99	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	1	6.75	3	*******	2.18	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	3	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	4	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	1	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	3	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	4	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	5	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	6	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	3	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	1	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	3	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	4	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	5	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	6	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	7	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	1	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	3	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	4	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	5	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	6	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	7	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	8	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	1	6.90	3	4613.27	2.05	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	2	6.84	3	156.84	2.10	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	3	7.05	3	134.10	1.94	0.00	1.16	0.00	0.00	0.00	0.00	0.00	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/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
12	1	6.96	3	111.67	2.01	0.00	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	2	7.26	3	82.29	1.78	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	1	7.15	3	68.79	1.86	0.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	2	7.15	3	66.24	1.86	0.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	3	7.07	3	64.64	1.92	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	4	7.01	3	65.46	1.96	0.00	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	5	6.96	3	66.15	2.00	0.00	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	1	6.92	3	67.31	2.04	0.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	2	6.88	3	68.40	2.07	0.00	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	3	6.85	3	68.81	2.09	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	4	6.83	3	69.14	2.11	0.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	5	6.81	3	69.39	2.13	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	6	6.80	3	69.60	2.14	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	7	6.79	3	69.76	2.15	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	8	6.78	3	69.88	2.16	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	9	6.77	3	69.98	2.16	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	10	6.77	3	70.06	2.17	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	11	6.77	3	70.10	2.17	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	12	6.89	3	64.94	2.06	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	1	6.86	3	62.00	2.08	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	2	6.84	3	62.29	2.10	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	3	6.82	3	62.53	2.12	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	4	6.81	3	62.72	2.13	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	5	6.80	3	62.87	2.14	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	6	6.79	3	63.00	2.15	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	7	6.78	3	63.10	2.16	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	8	6.81	3	62.01	2.13	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	9	6.80	3	61.40	2.14	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	10	6.79	3	61.49	2.15	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	11	6.98	3	54.78	1.99	0.00	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	12	6.94	3	50.89	2.02	0.00	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	13	6.91	3	51.22	2.04	0.00	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	1	6.89	3	51.49	2.06	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	2	6.87	3	51.73	2.08	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	3	6.85	3	51.93	2.10	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	4	6.83	3	52.10	2.11	0.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	5	6.82	3	52.25	2.12	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	6	6.81	3	52.37	2.13	0.00	1.31	0.00	0.00	0.00	0.00	0.00	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/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
16	7	6.80	3	52.47	2.14	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	8	6.79	3	52.56	2.15	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	9	6.79	3	52.63	2.15	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	10	6.78	3	52.70	2.16	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	1	6.78	3	52.75	2.16	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	2	6.77	3	52.79	2.17	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	1	6.76	3	*******	2.18	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	3	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	4	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	5	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	6	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	7	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	1	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	3	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	4	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	1	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	3	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	4	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	5	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	6	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	7	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	8	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	9	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	10	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	1	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	1	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	3	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	4	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	5	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	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/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
22	6	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	7	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	8	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	1	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	2	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	3	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	4	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	5	6.75	3	*******	2.19	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	1	6.77	3	6062.65	2.17	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	2	6.77	3	27.23	2.17	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	1	6.76	3	27.25	2.17	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	2	6.76	3	27.26	2.17	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	3	6.76	3	27.24	2.17	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	4	6.97	3	24.17	2.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	1	6.94	3	21.21	2.02	0.00	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	2	6.92	3	20.13	2.04	0.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	3	6.90	3	20.22	2.05	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	4	6.88	3	20.29	2.07	0.00	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	5	6.87	3	20.35	2.08	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	6	6.85	3	20.41	2.09	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	7	6.84	3	20.46	2.10	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	8	6.83	3	20.50	2.11	0.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	9	6.89	3	19.78	2.06	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	10	6.88	3	19.36	2.07	0.00	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	11	6.86	3	19.41	2.09	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	12	6.85	3	19.46	2.10	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	13	6.84	3	19.50	2.10	0.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	14	6.83	3	19.54	2.11	0.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	15	6.82	3	19.58	2.12	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	1	6.82	3	19.62	2.12	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	2	6.91	3	18.56	2.04	0.00	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	3	6.90	3	17.93	2.06	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	4	6.88	3	17.99	2.07	0.00	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	5	6.87	3	18.04	2.08	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	6	6.86	3	18.08	2.09	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	7	6.85	3	18.12	2.10	0.00	1.28	0.00	0.00	0.00	0.00	0.00	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/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
27	8	6.84	3	18.16	2.11	0.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	9	6.83	3	18.19	2.11	0.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	10	6.82	3	18.22	2.12	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	11	6.81	3	18.25	2.13	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	12	6.81	3	18.27	2.13	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	13	6.80	3	18.29	2.14	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	14	6.80	3	18.31	2.14	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	15	6.79	3	18.33	2.15	0.00	1.32	0.00	0.00	0.00	0.00	0.00	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-F	CM-1 TSS mg/L	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	98.54	30.00	0.00	0.00	6.18	1.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2	98.61	30.00	0.00	0.00	6.18	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	3	98.61	30.00	0.00	0.00	6.18	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	4	98.61	30.00	0.00	0.00	6.18	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	5	98.61	30.00	0.00	0.00	6.18	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	6	98.61	30.00	0.00	0.00	6.18	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	7	98.61	30.00	0.00	0.00	6.18	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	8	98.61	30.00	0.00	0.00	6.18	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	9	98.61	30.00	0.00	0.00	6.18	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	10	98.61	30.00	0.00	0.00	6.18	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	11	98.61	30.00	0.00	0.00	6.18	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	12	98.61	30.00	0.00	0.00	6.18	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	13	98.61	30.00	0.00	0.00	6.18	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	14	98.61	30.11	0.00	0.00	6.18	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1	91.51	382.99	0.00	0.00	7.09	9.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	96.11	382.99	0.00	0.00	6.06	8.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	3	97.73	382.99	0.00	0.00	5.90	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	4	98.30	382.99	0.00	0.00	5.86	7.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	1	98.50	382.99	0.00	0.00	5.69	7.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2	98.57	382.99	0.00	0.00	5.45	6.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	98.59	384.32	0.00	0.00	5.44	5.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	4	90.67	681.06	0.00	0.00	6.10	8.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1	93.93	681.06	0.00	0.00	5.78	7.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	2	95.93	681.06	0.00	0.00	5.72	7.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	3	97.07	681.06	0.00	0.00	5.63	6.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	97.73	681.06	0.00	0.00	5.57	6.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1	98.11	681.06	0.00	0.00	5.39	5.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	2	98.33	681.06	0.00	0.00	5.12	5.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	3	98.45	681.06	0.00	0.00	5.08	4.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	4	98.52	681.06	0.00	0.00	5.07	4.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	5	98.56	681.06	0.00	0.00	5.07	4.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6	98.58	681.06	0.00	0.00	5.08	3.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	7	98.59	681.06	0.00	0.00	5.08	3.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	8	98.60	681.06	0.00	0.00	5.08	3.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	9	98.60	681.06	0.00	0.00	5.08	2.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	10	98.61	681.05	0.00	0.00	5.09	2.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	11	98.58	680.59	0.00	0.00	5.09	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	12	93.30	622.71	0.00	0.00	5.48	5.17	0.00	0.00	0.00	0.00	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-F	CM-1 TSS mg/L	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
5	13	95.01	622.70	0.00	0.00	5.32	4.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	1	98.57	30.00	0.00	0.00	6.18	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	2	98.61	30.00	0.00	0.00	6.17	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	3	98.61	30.00	0.00	0.00	6.17	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	4	98.61	30.00	0.00	0.00	6.17	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	1	98.61	30.00	0.00	0.00	6.17	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	2	98.61	30.00	0.00	0.00	6.18	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	3	98.61	30.00	0.00	0.00	6.18	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	4	98.61	30.00	0.00	0.00	6.18	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	5	98.61	30.00	0.00	0.00	6.18	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	6	98.61	30.00	0.00	0.00	6.18	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1	98.61	30.00	0.00	0.00	6.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	2	98.61	30.00	0.00	0.00	6.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	3	98.61	30.00	0.00	0.00	6.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	1	98.61	30.00	0.00	0.00	6.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	2	98.61	30.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	3	98.61	30.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	4	98.61	30.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	5	98.61	30.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	6	98.61	30.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	7	98.61	30.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	1	98.61	30.00	0.00	0.00	5.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	2	98.61	30.00	0.00	0.00	5.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	3	98.61	30.00	0.00	0.00	5.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	4	98.61	30.00	0.00	0.00	5.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	5	98.61	30.00	0.00	0.00	5.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	6	98.61	30.00	0.00	0.00	5.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	7	98.61	30.00	0.00	0.00	5.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	8	98.61	30.18	0.00	0.00	5.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	1	96.20	622.03	0.00	0.00	6.80	4.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	2	97.09	621.94	0.00	0.00	5.40	4.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	3	93.86	612.07	0.00	0.00	5.42	6.17	0.00	0.00	0.00	0.00	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-F	CM-1 TSS mg/L	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
12	1	95.26	610.41	0.00	0.00	5.22	5.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	2	90.68	459.90	0.00	0.00	5.43	7.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	1	92.25	460.03	0.00	0.00	5.26	7.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	2	92.29	468.64	0.00	0.00	4.34	55.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	3	93.46	468.64	0.00	0.00	3.91	52.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	4	94.42	468.64	0.00	0.00	3.74	50.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	5	95.22	468.64	0.00	0.00	3.67	47.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	1	95.90	468.64	0.00	0.00	3.53	44.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	2	96.48	468.64	0.00	0.00	3.58	42.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	3	96.93	468.64	0.00	0.00	3.62	39.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	4	97.29	468.64	0.00	0.00	3.65	37.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	5	97.57	468.64	0.00	0.00	3.69	34.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	6	97.79	468.64	0.00	0.00	3.73	32.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	7	97.97	468.64	0.00	0.00	3.77	30.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	8	98.10	468.64	0.00	0.00	3.82	28.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	9	98.21	468.64	0.00	0.00	3.86	26.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	10	98.30	468.64	0.00	0.00	3.90	25.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	11	98.34	468.47	0.00	0.00	3.95	23.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	12	96.31	457.10	0.00	0.00	4.19	21.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	1	96.75	457.10	0.00	0.00	4.17	19.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	2	97.10	457.10	0.00	0.00	4.16	18.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	3	97.39	457.10	0.00	0.00	4.16	17.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	4	97.62	457.10	0.00	0.00	4.17	16.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	5	97.81	457.10	0.00	0.00	4.18	15.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	6	97.96	457.10	0.00	0.00	4.19	14.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	7	98.08	457.25	0.00	0.00	4.21	13.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	8	97.67	466.45	0.00	0.00	4.27	12.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	9	97.84	466.46	0.00	0.00	4.28	12.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	10	97.94	467.09	0.00	0.00	4.29	11.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	11	94.89	505.50	0.00	0.00	4.55	11.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	12	95.47	505.50	0.00	0.00	4.50	10.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	13	95.95	505.50	0.00	0.00	4.46	10.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	1	96.37	505.50	0.00	0.00	4.43	9.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	2	96.71	505.50	0.00	0.00	4.41	9.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	3	97.01	505.50	0.00	0.00	4.40	8.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	4	97.26	505.50	0.00	0.00	4.38	8.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	5	97.46	505.50	0.00	0.00	4.38	7.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	6	97.64	505.50	0.00	0.00	4.37	7.32	0.00	0.00	0.00	0.00	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-F	CM-1 TSS mg/L	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	7	97.79	505.50	0.00	0.00	4.37	6.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	8	97.92	505.50	0.00	0.00	4.37	6.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	9	98.02	505.50	0.00	0.00	4.37	6.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	10	98.11	505.50	0.00	0.00	4.38	5.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	1	98.19	505.50	0.00	0.00	4.38	5.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	2	98.26	505.50	0.00	0.00	4.40	5.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	1	98.43	30.00	0.00	0.00	6.15	2.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	2	98.61	30.00	0.00	0.00	6.13	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	3	98.61	30.00	0.00	0.00	6.13	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	4	98.61	30.00	0.00	0.00	6.13	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	5	98.61	30.00	0.00	0.00	6.13	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	6	98.61	30.00	0.00	0.00	6.13	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	7	98.61	30.00	0.00	0.00	6.13	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	1	98.61	30.00	0.00	0.00	6.02	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	2	98.61	30.00	0.00	0.00	6.10	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	3	98.61	30.00	0.00	0.00	6.10	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	4	98.61	30.00	0.00	0.00	6.10	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	1	98.61	30.00	0.00	0.00	5.72	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	2	98.61	30.00	0.00	0.00	6.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	3	98.61	30.00	0.00	0.00	6.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	4	98.61	30.00	0.00	0.00	6.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	5	98.61	30.00	0.00	0.00	6.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	6	98.61	30.00	0.00	0.00	6.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	7	98.61	30.00	0.00	0.00	6.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	8	98.61	30.00	0.00	0.00	6.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	9	98.61	30.00	0.00	0.00	6.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	10	98.61	30.00	0.00	0.00	6.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	1	98.61	30.00	0.00	0.00	6.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	2	98.61	30.00	0.00	0.00	6.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	1	98.61	30.00	0.00	0.00	6.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	2	98.61	30.00	0.00	0.00	6.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	3	98.61	30.00	0.00	0.00	6.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	4	98.61	30.00	0.00	0.00	6.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	5	98.61	30.00	0.00	0.00	6.09	0.00	0.00	0.00	0.00	0.00	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-F	CM-1 TSS mg/L	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
22	6	98.61	30.00	0.00	0.00	6.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	7	98.61	30.00	0.00	0.00	6.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	8	98.61	30.00	0.00	0.00	6.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	1	98.61	30.00	0.00	0.00	6.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	2	98.61	30.00	0.00	0.00	6.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	3	98.61	30.00	0.00	0.00	6.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	4	98.61	30.00	0.00	0.00	6.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	5	98.61	30.13	0.00	0.00	6.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	1	98.30	505.36	0.00	0.00	6.72	5.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	2	98.35	505.36	0.00	0.00	5.06	4.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	1	98.39	505.36	0.00	0.00	4.23	4.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	2	98.42	505.42	0.00	0.00	3.82	3.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	3	98.38	507.65	0.00	0.00	3.64	3.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	4	95.08	600.64	0.00	0.00	3.85	5.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	1	95.51	600.64	0.00	0.00	3.77	5.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	2	95.85	600.64	0.00	0.00	3.62	4.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	3	96.16	600.64	0.00	0.00	3.53	4.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	4	96.44	600.64	0.00	0.00	3.46	4.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	5	96.68	600.64	0.00	0.00	3.43	3.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	6	96.90	600.64	0.00	0.00	3.40	3.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	7	97.09	600.66	0.00	0.00	3.39	3.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	8	97.23	601.37	0.00	0.00	3.38	3.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	9	96.32	625.93	0.00	0.00	3.48	3.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	10	96.56	625.93	0.00	0.00	3.45	3.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	11	96.78	625.93	0.00	0.00	3.43	3.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	12	96.97	625.93	0.00	0.00	3.42	2.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	13	97.14	625.93	0.00	0.00	3.41	2.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	14	97.30	625.93	0.00	0.00	3.40	2.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	15	97.44	625.92	0.00	0.00	3.39	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	1	97.52	625.69	0.00	0.00	3.38	2.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	2	95.99	618.02	0.00	0.00	3.52	3.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	3	96.25	618.02	0.00	0.00	3.46	3.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	4	96.48	618.02	0.00	0.00	3.42	2.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	5	96.68	618.02	0.00	0.00	3.39	2.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	6	96.87	618.02	0.00	0.00	3.37	2.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	7	97.04	618.02	0.00	0.00	3.36	2.44	0.00	0.00	0.00	0.00	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-F	CM-1 TSS mg/L	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
27	8	97.19	618.02	0.00	0.00	3.35	2.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	9	97.33	618.02	0.00	0.00	3.34	2.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	10	97.46	618.02	0.00	0.00	3.34	2.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	11	97.57	618.02	0.00	0.00	3.33	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	12	97.67	618.02	0.00	0.00	3.33	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	13	97.76	618.02	0.00	0.00	3.33	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	14	97.84	618.02	0.00	0.00	3.33	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	15	97.91	618.02	0.00	0.00	3.33	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
									COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)						
1	1	1	98.54	6.75	6.18	0.57	0.00	0.00	19.90	15786.01	-3.95	********	0.00	0.00	0.00
2	1	2	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15818.94	-2.47	********	0.00	0.00	0.00
3	1	3	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15818.17	-1.54	********	0.00	0.00	0.00
4	1	4	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15817.59	-0.96	********	0.00	0.00	0.00
5	1	5	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15817.24	-0.60	********	0.00	0.00	0.00
6	1	6	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15817.02	-0.37	********	0.00	0.00	0.00
7	1	7	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15816.87	-0.23	********	0.00	0.00	0.00
8	1	8	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15816.78	-0.14	********	0.00	0.00	0.00
9	1	9	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15816.74	-0.09	********	0.00	0.00	0.00
10	1	10	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15816.70	-0.06	********	0.00	0.00	0.00
11	1	11	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15816.67	-0.04	********	0.00	0.00	0.00
12	1	12	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15816.66	-0.02	********	0.00	0.00	0.00
13	1	13	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15816.65	-0.01	********	0.00	0.00	0.00
14	1	14	98.61	6.75	6.18	0.57	0.00	0.00	0.00	15816.66	-0.01	********	0.00	0.00	0.00
15	2	1	91.51	7.20	7.09	0.11	0.00	0.00	153.50	1385.27	-17.53	-663.56	0.00	0.00	0.00
16	2	2	96.11	6.90	6.06	0.85	0.00	0.00	0.00	765.77	-18.37	-770.16	0.00	0.00	0.00
17	2	3	97.73	6.80	5.90	0.90	0.00	0.00	0.00	831.93	-17.79	-811.66	0.00	0.00	0.00
18	2	4	98.30	6.77	5.86	0.91	0.00	0.00	0.00	849.20	-16.76	-826.81	0.00	0.00	0.00
19	3	1	98.50	6.76	5.69	1.07	0.00	0.00	0.00	759.24	-15.36	-616.66	0.00	0.00	0.00
20	3	2	98.57	6.75	5.45	1.30	0.00	0.00	0.00	633.51	-13.78	-618.09	0.00	0.00	0.00
21	3	3	98.59	6.75	5.44	1.31	0.00	0.00	0.00	636.61	-12.37	-618.33	0.00	0.00	0.00
22	3	4	90.67	7.26	6.10	1.16	0.00	0.00	106.28	370.79	-14.58	-246.77	0.00	0.00	0.00
23	4	1	93.93	7.04	5.78	1.26	0.00	0.00	0.00	329.08	-14.91	-341.17	0.00	0.00	0.00
24	4	2	95.93	6.92	5.72	1.20	0.00	0.00	0.00	381.88	-14.77	-364.02	0.00	0.00	0.00
25	4	3	97.07	6.84	5.63	1.22	0.00	0.00	0.00	394.31	-14.29	-377.78	0.00	0.00	0.00
26	4	4	97.73	6.80	5.57	1.23	0.00	0.00	0.00	403.09	-13.65	-385.89	0.00	0.00	0.00
27	5	1	98.11	6.78	5.39	1.39	0.00	0.00	0.00	359.40	-12.78	-299.05	0.00	0.00	0.00
28	5	2	98.33	6.77	5.12	1.65	0.00	0.00	0.00	311.54	-11.79	-301.17	0.00	0.00	0.00
29	5	3	98.45	6.76	5.08	1.68	0.00	0.00	0.00	317.55	-10.84	-302.37	0.00	0.00	0.00
30	5	4	98.52	6.76	5.07	1.68	0.00	0.00	0.00	318.09	-9.95	-303.05	0.00	0.00	0.00
31	5	5	98.56	6.75	5.07	1.68	0.00	0.00	0.00	317.80	-9.13	-303.44	0.00	0.00	0.00
32	5	6	98.58	6.75	5.08	1.68	0.00	0.00	0.00	317.29	-8.38	-303.65	0.00	0.00	0.00
33	5	7	98.59	6.75	5.08	1.67	0.00	0.00	0.00	316.74	-7.68	-303.78	0.00	0.00	0.00
34	5	8	98.60	6.75	5.08	1.67	0.00	0.00	0.00	316.18	-7.04	-303.84	0.00	0.00	0.00
35	5	9	98.60	6.75	5.08	1.67	0.00	0.00	0.00	315.63	-6.45	-303.88	0.00	0.00	0.00
36	5	10	98.61	6.75	5.09	1.66	0.00	0.00	0.00	315.11	-5.91	-303.90	0.00	0.00	0.00
37	5	11	98.58	6.75	5.09	1.66	0.00	0.00	0.00	314.41	-5.46	-303.68	0.00	0.00	0.00
38	5	12	93.30	7.08	5.48	1.60	0.00	0.00	63.80	240.52	-9.86	-189.00	0.00	0.00	0.00

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

** DISSOLVED OXYGEN DATA **

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

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
39	5	13	95.01	6.97	5.32	1.65	0.00	0.00	0.00	208.85	-9.64	-199.75	0.00	0.00	0.00
40	6	1	98.57	6.75	6.18	0.58	0.00	0.00	15.29	20221.57	-3.55	********	0.00	0.00	0.00
41	6	2	98.61	6.75	6.17	0.58	0.00	0.00	0.00	20246.55	-1.99	********	0.00	0.00	0.00
42	6	3	98.61	6.75	6.17	0.58	0.00	0.00	0.00	20245.75	-1.11	********	0.00	0.00	0.00
43	6	4	98.61	6.75	6.17	0.58	0.00	0.00	0.00	20245.26	-0.62	********	0.00	0.00	0.00
44	7	1	98.61	6.75	6.17	0.59	0.00	0.00	0.00	20986.15	-0.35	********	0.00	0.00	0.00
45	7	2	98.61	6.75	6.18	0.57	0.00	0.00	0.00	20918.51	-0.19	********	0.00	0.00	0.00
46	7	3	98.61	6.75	6.18	0.57	0.00	0.00	0.00	20918.37	-0.11	********	0.00	0.00	0.00
47	7	4	98.61	6.75	6.18	0.57	0.00	0.00	0.00	20918.31	-0.06	********	0.00	0.00	0.00
48	7	5	98.61	6.75	6.18	0.57	0.00	0.00	0.00	20918.30	-0.03	********	0.00	0.00	0.00
49	7	6	98.61	6.75	6.18	0.57	0.00	0.00	0.00	20918.30	-0.02	********	0.00	0.00	0.00
50	8	1	98.61	6.75	6.16	0.59	0.00	0.00	0.00	21248.18	-0.01	********	0.00	0.00	0.00
51	8	2	98.61	6.75	6.17	0.58	0.00	0.00	0.00	20794.15	-0.01	********	0.00	0.00	0.00
52	8	3	98.61	6.75	6.17	0.58	0.00	0.00	0.00	20794.13	0.00	********	0.00	0.00	0.00
53	9	1	98.61	6.75	6.10	0.65	0.00	0.00	0.00	18720.63	0.00	********	0.00	0.00	0.00
54	9	2	98.61	6.75	6.00	0.75	0.00	0.00	0.00	16538.59	0.00	********	0.00	0.00	0.00
55	9	3	98.61	6.75	6.00	0.75	0.00	0.00	0.00	16538.80	0.00	********	0.00	0.00	0.00
56	9	4	98.61	6.75	6.00	0.75	0.00	0.00	0.00	16538.80	0.00	********	0.00	0.00	0.00
57	9	5	98.61	6.75	6.00	0.75	0.00	0.00	0.00	16538.80	0.00	********	0.00	0.00	0.00
58	9	6	98.61	6.75	6.00	0.75	0.00	0.00	0.00	16538.80	0.00	********	0.00	0.00	0.00
59	9	7	98.61	6.75	6.00	0.75	0.00	0.00	0.00	16538.80	0.00	********	0.00	0.00	0.00
60	10	1	98.61	6.75	5.94	0.81	0.00	0.00	0.00	16500.06	0.00	********	0.00	0.00	0.00
61	10	2	98.61	6.75	5.92	0.83	0.00	0.00	0.00	15437.32	0.00	********	0.00	0.00	0.00
62	10	3	98.61	6.75	5.92	0.83	0.00	0.00	0.00	15437.36	0.00	********	0.00	0.00	0.00
63	10	4	98.61	6.75	5.92	0.83	0.00	0.00	0.00	15437.36	0.00	********	0.00	0.00	0.00
64	10	5	98.61	6.75	5.92	0.83	0.00	0.00	0.00	15437.36	0.00	********	0.00	0.00	0.00
65	10	6	98.61	6.75	5.92	0.83	0.00	0.00	0.00	15437.36	0.00	********	0.00	0.00	0.00
66	10	7	98.61	6.75	5.92	0.83	0.00	0.00	0.00	15437.36	0.00	********	0.00	0.00	0.00
67	10	8	98.61	6.75	5.92	0.83	0.00	0.00	0.00	15437.36	0.00	********	0.00	0.00	0.00
68	11	1	96.20	6.90	6.80	0.10	0.00	0.00	0.00	456.76	-9.46	-243.14	0.00	0.00	0.00
69	11	2	97.09	6.84	5.40	1.44	0.00	0.00	0.00	225.85	-9.00	-250.29	0.00	0.00	0.00
70	11	3	93.86	7.05	5.42	1.62	0.00	0.00	48.69	217.86	-11.94	-183.24	0.00	0.00	0.00

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

** DISSOLVED OXYGEN DATA **

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

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
71	12	1	95.26	6.96	5.22	1.74	0.00	0.00	0.00	193.93	-11.61	-177.82	0.00	0.00	0.00
72	12	2	90.68	7.26	5.43	1.83	0.00	0.00	76.83	150.20	-12.79	-112.17	0.00	0.00	0.00
73	13	1	92.25	7.15	5.26	1.89	0.00	0.00	0.00	129.80	-13.91	-118.04	0.00	0.00	0.00
74	13	2	92.29	7.15	4.34	2.81	0.00	0.00	20.78	186.00	-103.79	-110.59	0.00	0.00	0.00
75	13	3	93.46	7.07	3.91	3.16	0.00	0.00	0.00	204.20	-101.52	-114.86	0.00	0.00	0.00
76	13	4	94.42	7.01	3.74	3.27	0.00	0.00	0.00	214.23	-98.66	-118.50	0.00	0.00	0.00
77	13	5	95.22	6.96	3.67	3.29	0.00	0.00	0.00	217.90	-95.35	-121.58	0.00	0.00	0.00
78	14	1	95.90	6.92	3.53	3.39	0.00	0.00	0.00	227.93	-91.54	-130.29	0.00	0.00	0.00
79	14	2	96.48	6.88	3.58	3.30	0.00	0.00	0.00	225.46	-87.31	-132.76	0.00	0.00	0.00
80	14	3	96.93	6.85	3.62	3.23	0.00	0.00	0.00	222.50	-82.95	-134.73	0.00	0.00	0.00
81	14	4	97.29	6.83	3.65	3.18	0.00	0.00	0.00	219.71	-78.56	-136.30	0.00	0.00	0.00
82	14	5	97.57	6.81	3.69	3.12	0.00	0.00	0.00	216.77	-74.23	-137.55	0.00	0.00	0.00
83	14	6	97.79	6.80	3.73	3.07	0.00	0.00	0.00	213.66	-70.01	-138.54	0.00	0.00	0.00
84	14	7	97.97	6.79	3.77	3.02	0.00	0.00	0.00	210.46	-65.93	-139.33	0.00	0.00	0.00
85	14	8	98.10	6.78	3.82	2.97	0.00	0.00	0.00	207.21	-62.01	-139.94	0.00	0.00	0.00
86	14	9	98.21	6.77	3.86	2.91	0.00	0.00	0.00	203.98	-58.28	-140.43	0.00	0.00	0.00
87	14	10	98.30	6.77	3.90	2.87	0.00	0.00	0.00	200.82	-54.72	-140.81	0.00	0.00	0.00
88	14	11	98.34	6.77	3.95	2.82	0.00	0.00	0.00	197.56	-51.30	-141.01	0.00	0.00	0.00
89	14	12	96.31	6.89	4.19	2.70	0.00	0.00	25.29	175.19	-43.54	-121.08	0.00	0.00	0.00
90	15	1	96.75	6.86	4.17	2.70	0.00	0.00	0.00	167.12	-41.50	-122.81	0.00	0.00	0.00
91	15	2	97.10	6.84	4.16	2.68	0.00	0.00	0.00	167.09	-39.45	-124.24	0.00	0.00	0.00
92	15	3	97.39	6.82	4.16	2.66	0.00	0.00	0.00	166.58	-37.41	-125.40	0.00	0.00	0.00
93	15	4	97.62	6.81	4.17	2.64	0.00	0.00	0.00	165.78	-35.42	-126.35	0.00	0.00	0.00
94	15	5	97.81	6.80	4.18	2.62	0.00	0.00	0.00	164.78	-33.49	-127.12	0.00	0.00	0.00
95	15	6	97.96	6.79	4.19	2.60	0.00	0.00	0.00	163.66	-31.63	-127.74	0.00	0.00	0.00
96	15	7	98.08	6.78	4.21	2.57	0.00	0.00	0.00	162.44	-29.84	-128.23	0.00	0.00	0.00
97	15	8	97.67	6.81	4.27	2.54	0.00	0.00	6.33	157.43	-27.71	-124.00	0.00	0.00	0.00
98	15	9	97.84	6.80	4.28	2.52	0.00	0.00	0.00	154.85	-26.21	-124.70	0.00	0.00	0.00
99	15	10	97.94	6.79	4.29	2.50	0.00	0.00	0.00	153.89	-24.75	-125.10	0.00	0.00	0.00
100	15	11	94.89	6.98	4.55	2.43	0.00	0.00	41.39	133.05	-22.36	-99.20	0.00	0.00	0.00
101	15	12	95.47	6.94	4.50	2.44	0.00	0.00	0.00	124.24	-21.54	-101.07	0.00	0.00	0.00
102	15	13	95.95	6.91	4.46	2.45	0.00	0.00	0.00	125.44	-20.69	-102.67	0.00	0.00	0.00
103	16	1	96.37	6.89	4.43	2.45	0.00	0.00	0.00	126.33	-19.82	-104.05	0.00	0.00	0.00
104	16	2	96.71	6.87	4.41	2.45	0.00	0.00	0.00	126.96	-18.95	-105.23	0.00	0.00	0.00
105	16	3	97.01	6.85	4.40	2.45	0.00	0.00	0.00	127.36	-18.09	-106.23	0.00	0.00	0.00
106	16	4	97.26	6.83	4.38	2.45	0.00	0.00	0.00	127.59	-17.24	-107.09	0.00	0.00	0.00
107	16	5	97.46	6.82	4.38	2.44	0.00	0.00	0.00	127.65	-16.41	-107.82	0.00	0.00	0.00
108	16	6	97.64	6.81	4.37	2.44	0.00	0.00	0.00	127.61	-15.60	-108.44	0.00	0.00	0.00

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
									COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)						
109	16	7	97.79	6.80	4.37	2.43	0.00	0.00	0.00	127.48	-14.82	-108.97	0.00	0.00	0.00
110	16	8	97.92	6.79	4.37	2.42	0.00	0.00	0.00	127.27	-14.06	-109.42	0.00	0.00	0.00
111	16	9	98.02	6.79	4.37	2.41	0.00	0.00	0.00	127.00	-13.34	-109.80	0.00	0.00	0.00
112	16	10	98.11	6.78	4.38	2.40	0.00	0.00	0.00	126.68	-12.65	-110.12	0.00	0.00	0.00
113	17	1	98.19	6.78	4.38	2.39	0.00	0.00	0.00	126.33	-11.98	-110.39	0.00	0.00	0.00
114	17	2	98.26	6.77	4.40	2.37	0.00	0.00	0.00	125.03	-11.35	-110.62	0.00	0.00	0.00
115	18	1	98.43	6.76	6.15	0.61	0.00	0.00	29.32	9299.51	-4.48	-9269.69	0.00	0.00	0.00
116	18	2	98.61	6.75	6.13	0.62	0.00	0.00	0.00	9348.43	-3.19	-9323.29	0.00	0.00	0.00
117	18	3	98.61	6.75	6.13	0.62	0.00	0.00	0.00	9348.07	-2.26	-9323.78	0.00	0.00	0.00
118	18	4	98.61	6.75	6.13	0.62	0.00	0.00	0.00	9347.41	-1.61	-9323.79	0.00	0.00	0.00
119	18	5	98.61	6.75	6.13	0.62	0.00	0.00	0.00	9346.94	-1.14	-9323.79	0.00	0.00	0.00
120	18	6	98.61	6.75	6.13	0.62	0.00	0.00	0.00	9346.61	-0.81	-9323.79	0.00	0.00	0.00
121	18	7	98.61	6.75	6.13	0.62	0.00	0.00	0.00	9346.37	-0.57	-9323.79	0.00	0.00	0.00
122	19	1	98.61	6.75	6.02	0.73	0.00	0.00	0.00	11170.10	-0.39	********	0.00	0.00	0.00
123	19	2	98.61	6.75	6.10	0.65	0.00	0.00	0.00	10131.99	-0.26	********	0.00	0.00	0.00
124	19	3	98.61	6.75	6.10	0.65	0.00	0.00	0.00	10131.59	-0.17	********	0.00	0.00	0.00
125	19	4	98.61	6.75	6.10	0.65	0.00	0.00	0.00	10131.54	-0.12	********	0.00	0.00	0.00
126	20	1	98.61	6.75	5.72	1.03	0.00	0.00	0.00	18549.37	-0.07	********	0.00	0.00	0.00
127	20	2	98.61	6.75	6.04	0.71	0.00	0.00	0.00	14651.24	-0.04	********	0.00	0.00	0.00
128	20	3	98.61	6.75	6.04	0.71	0.00	0.00	0.00	14650.42	-0.02	********	0.00	0.00	0.00
129	20	4	98.61	6.75	6.04	0.71	0.00	0.00	0.00	14650.42	-0.01	********	0.00	0.00	0.00
130	20	5	98.61	6.75	6.04	0.71	0.00	0.00	0.00	14650.41	-0.01	********	0.00	0.00	0.00
131	20	6	98.61	6.75	6.04	0.71	0.00	0.00	0.00	14650.41	0.00	********	0.00	0.00	0.00
132	20	7	98.61	6.75	6.04	0.71	0.00	0.00	0.00	14650.41	0.00	********	0.00	0.00	0.00
133	20	8	98.61	6.75	6.04	0.71	0.00	0.00	0.00	14650.41	0.00	********	0.00	0.00	0.00
134	20	9	98.61	6.75	6.04	0.71	0.00	0.00	0.00	14650.41	0.00	********	0.00	0.00	0.00
135	20	10	98.61	6.75	6.04	0.71	0.00	0.00	0.00	14650.40	0.00	********	0.00	0.00	0.00
136	21	1	98.61	6.75	6.09	0.66	0.00	0.00	0.00	19766.64	0.00	********	0.00	0.00	0.00
137	21	2	98.61	6.75	6.21	0.54	0.00	0.00	0.00	21481.14	0.00	********	0.00	0.00	0.00
138	22	1	98.61	6.75	6.11	0.64	0.00	0.00	0.00	22081.91	0.00	********	0.00	0.00	0.00
139	22	2	98.61	6.75	6.09	0.66	0.00	0.00	0.00	19314.07	0.00	********	0.00	0.00	0.00
140	22	3	98.61	6.75	6.09	0.66	0.00	0.00	0.00	19314.11	0.00	********	0.00	0.00	0.00
141	22	4	98.61	6.75	6.09	0.66	0.00	0.00	0.00	19314.11	0.00	********	0.00	0.00	0.00
142	22	5	98.61	6.75	6.09	0.66	0.00	0.00	0.00	19314.11	0.00	********	0.00	0.00	0.00

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

** DISSOLVED OXYGEN DATA **

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

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
143	22	6	98.61	6.75	6.09	0.66	0.00	0.00	0.00	19314.11	0.00	********	0.00	0.00	0.00
144	22	7	98.61	6.75	6.09	0.66	0.00	0.00	0.00	19314.11	0.00	********	0.00	0.00	0.00
145	22	8	98.61	6.75	6.09	0.66	0.00	0.00	0.00	19314.11	0.00	********	0.00	0.00	0.00
146	23	1	98.61	6.75	6.06	0.69	0.00	0.00	0.00	18430.50	0.00	********	0.00	0.00	0.00
147	23	2	98.61	6.75	6.02	0.73	0.00	0.00	0.00	17623.76	0.00	********	0.00	0.00	0.00
148	23	3	98.61	6.75	6.02	0.73	0.00	0.00	0.00	17623.83	0.00	********	0.00	0.00	0.00
149	23	4	98.61	6.75	6.02	0.73	0.00	0.00	0.00	17623.83	0.00	********	0.00	0.00	0.00
150	23	5	98.61	6.75	6.02	0.73	0.00	0.00	0.00	17623.83	0.00	********	0.00	0.00	0.00
151	24	1	98.30	6.77	6.72	0.04	0.00	0.00	0.00	266.23	-10.86	-79.41	0.00	0.00	0.00
152	24	2	98.35	6.77	5.06	1.71	0.00	0.00	0.00	46.58	-10.07	-79.54	0.00	0.00	0.00
153	25	1	98.39	6.76	4.23	2.54	0.00	0.00	0.00	69.07	-9.33	-79.64	0.00	0.00	0.00
154	25	2	98.42	6.76	3.82	2.94	0.00	0.00	0.00	80.07	-8.65	-79.72	0.00	0.00	0.00
155	25	3	98.38	6.76	3.64	3.13	0.00	0.00	0.00	85.20	-8.10	-79.62	0.00	0.00	0.00
156	25	4	95.08	6.97	3.85	3.12	0.00	0.00	32.70	75.41	-10.80	-62.55	0.00	0.00	0.00
157	26	1	95.51	6.94	3.77	3.17	0.00	0.00	0.00	67.20	-10.23	-57.85	0.00	0.00	0.00
158	26	2	95.85	6.92	3.62	3.30	0.00	0.00	0.00	66.38	-9.69	-58.50	0.00	0.00	0.00
159	26	3	96.16	6.90	3.53	3.37	0.00	0.00	0.00	68.21	-9.17	-59.09	0.00	0.00	0.00
160	26	4	96.44	6.88	3.46	3.42	0.00	0.00	0.00	69.36	-8.66	-59.62	0.00	0.00	0.00
161	26	5	96.68	6.87	3.43	3.44	0.00	0.00	0.00	70.07	-8.17	-60.09	0.00	0.00	0.00
162	26	6	96.90	6.85	3.40	3.45	0.00	0.00	0.00	70.50	-7.70	-60.51	0.00	0.00	0.00
163	26	7	97.09	6.84	3.39	3.46	0.00	0.00	0.00	70.75	-7.25	-60.89	0.00	0.00	0.00
164	26	8	97.23	6.83	3.38	3.45	0.00	0.00	0.00	70.82	-6.84	-61.17	0.00	0.00	0.00
165	26	9	96.32	6.89	3.48	3.41	0.00	0.00	11.76	67.36	-7.14	-56.99	0.00	0.00	0.00
166	26	10	96.56	6.88	3.45	3.42	0.00	0.00	0.00	66.23	-6.75	-57.44	0.00	0.00	0.00
167	26	11	96.78	6.86	3.43	3.43	0.00	0.00	0.00	66.57	-6.37	-57.84	0.00	0.00	0.00
168	26	12	96.97	6.85	3.42	3.43	0.00	0.00	0.00	66.80	-6.01	-58.21	0.00	0.00	0.00
169	26	13	97.14	6.84	3.41	3.43	0.00	0.00	0.00	66.95	-5.67	-58.53	0.00	0.00	0.00
170	26	14	97.30	6.83	3.40	3.43	0.00	0.00	0.00	67.04	-5.34	-58.83	0.00	0.00	0.00
171	26	15	97.44	6.82	3.39	3.43	0.00	0.00	0.00	67.09	-5.03	-59.09	0.00	0.00	0.00
172	27	1	97.52	6.82	3.38	3.44	0.00	0.00	0.00	67.48	-4.79	-59.49	0.00	0.00	0.00
173	27	2	95.99	6.91	3.52	3.39	0.00	0.00	18.26	62.97	-6.75	-53.17	0.00	0.00	0.00
174	27	3	96.25	6.90	3.46	3.43	0.00	0.00	0.00	61.57	-6.39	-53.61	0.00	0.00	0.00
175	27	4	96.48	6.88	3.42	3.46	0.00	0.00	0.00	62.22	-6.05	-54.01	0.00	0.00	0.00
176	27	5	96.68	6.87	3.39	3.48	0.00	0.00	0.00	62.68	-5.73	-54.38	0.00	0.00	0.00
177	27	6	96.87	6.86	3.37	3.48	0.00	0.00	0.00	62.99	-5.41	-54.71	0.00	0.00	0.00
178	27	7	97.04	6.85	3.36	3.49	0.00	0.00	0.00	63.21	-5.11	-55.01	0.00	0.00	0.00

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY) F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
179	27	8	97.19	6.84	3.35	3.49	0.00	0.00	0.00	63.35	-4.83	-55.28	0.00	0.00	0.00
180	27	9	97.33	6.83	3.34	3.49	0.00	0.00	0.00	63.44	-4.55	-55.53	0.00	0.00	0.00
181	27	10	97.46	6.82	3.34	3.48	0.00	0.00	0.00	63.50	-4.29	-55.75	0.00	0.00	0.00
182	27	11	97.57	6.81	3.33	3.48	0.00	0.00	0.00	63.52	-4.04	-55.96	0.00	0.00	0.00
183	27	12	97.67	6.81	3.33	3.48	0.00	0.00	0.00	63.53	-3.81	-56.14	0.00	0.00	0.00
184	27	13	97.76	6.80	3.33	3.47	0.00	0.00	0.00	63.52	-3.59	-56.31	0.00	0.00	0.00
185	27	14	97.84	6.80	3.33	3.47	0.00	0.00	0.00	63.49	-3.38	-56.46	0.00	0.00	0.00
186	27	15	97.91	6.79	3.33	3.46	0.00	0.00	0.00	63.46	-3.19	-56.59	0.00	0.00	0.00

RAYSE CREEK TMDL

APPENDIX D

RESPONSIVENESS SUMMARY

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LLINOIS ENVIRONMENTAL PROTECTION AGENCY
(Illinois EPA)

IN THE MATTER OF:

RAYSE CREEK IN JEFFERSON COUNTY
TOTAL MAXIMUM DAILY LOAD DLC# 698-02

RESPONSIVENESS SUMMARY

This responsiveness summary responds to substantive questions and comments received during the public comment period from December 29, 2002, through February 28, 2003 (postmarked) including those from the January 29 public hearing.

WHAT IS A TMDL?

A Total Maximum Daily Load (TMDL) is the sum of the allowable amount of a single pollutant (nutrients, siltation, etc.) that a water body can receive from all contributing sources and still meet water quality standards or designated uses. The Rayse Creek TMDL report contains a plan detailing the actions necessary to reduce pollutant loads to Rayse Creek 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 the regulations thereunder.

BACKGROUND

The watershed targeted for TMDL development is Rayse Creek (ILNK01). Rayse Creek is located in Jefferson County in a headwater reach of the Big Muddy River Basin. There are two waterbody segments in the 63,581-acre watershed being targeted for TMDL and implementation plan development, NK 01 and NK 02. This watershed includes 29.74 miles of river in the TMDL development area. For NK 01, phosphorus loadings and siltation impair the designated uses (*i.e.* aquatic life support and swimming) of NK 01 to a moderate degree. The source of these pollutants is generally agriculture and non-irrigated crop production. For NK 02, BOD impairs the designated uses (*i.e.* aquatic life support) of NK 02 to a moderate degree. The sources of these loadings are generally agriculture, non-irrigated crop production and animal holding/management areas. Total Maximum Daily Loads (TMDL) for phosphorus and siltation are required for stream segment NK 01 and for dissolved oxygen in segment NK 02, the Illinois EPA contracted Montgomery Watson Harza, Chicago, Illinois, to prepare a TMDL report for Illinois EPA on this waterbody.

PUBLIC MEETINGS/ HEARING

A public meeting was held at the village hall in Woodland on November 13, 2000. Eighty-four persons attended the public meeting. A public hearing on the proposed plan was held on Wednesday, January 29, 2003, at the city hall, 474 West Main Street, Ashley, Illinois. Fifty-one persons attended the public hearing. The hearing record remained open until midnight February 28, 2003. A total of 6 exhibits were received either during the hearing or within the public comment period. A court reporter prepared a transcript of the public hearing. The Illinois EPA provided public notice for the hearing by placing boxed display ads in the *Mount Vernon Register News* and in the *Centralia Morning Sentinel* on December 27, 2002 and on January 3 and 10, 2003. These three notices gave the date, time, location, and purpose of the hearing. The notices also provided references to obtain additional information about this specific site, the TMDL Program, and other related issues, as well as the name, address, and phone number of the IEPA hearing officer. Approximately 75 individuals and organizations were also sent the public notice by first class mail. The mailing list is contained in the Agency file DLC # IEPA/BOW/03-008. The Draft TMDL Report was available for review on the Agency's web page at http://www.epa.state.il.us/water/tmdl/tmdl-reports.html.

QUESTIONS AND COMMENTS

Several questions were asked at the public hearing that were not directly related to the East Fork Kaskaskia TMDL. Illinois EPA has other divisions to handle those concerns. Please contact one of the offices listed below for further details or questions.

For concerns about an air, water, or land problem such as possible illegal dumping, runoff from oil wells and gasoline-saturated land, or discharges anywhere in Jefferson County, please contact the Illinois EPA's Marion Regional Office at 618/993-7200 and they will connect you to a field inspector related to the problem being reported.

For information about contamination from a gas station, please contact our Leaking Underground Storage Tank section in Springfield at 217/782-9851.

1. The southern segment of Rayse Creek is impaired, but the northern end is not. Are the landowners in the northern section going to be asked to participate in any conservation programs? I live in the southern end and know that all their sediment gets washed down to us.

   The Illinois EPA is taking a watershed approach to this TMDL. We are examining the entire watershed and asking everyone to participate in the conservation practices that we have suggested in the TMDL report. Positive results will be much greater if everyone participates.

2. One thing I haven't heard from anybody is about the impact or a comment from a forestry expert. You know, 15, 16% of the area that you are talking about is covered by hardwood, and most of that obviously is in a high slope area, which has a greater impact because of your hard rains you are talking about and siltation. But I haven't heard a word or a comment from the forestry manager about the effects of logging, clear cutting, deforestation, anything on the amount of sediment in that flow. And I find that a little strange because I would think that would have a greater impact. Even though it's 16% of the total area, I can't help but think that 16% has a greater impact on the other 74% or 84%. Do you have any comments on that?

   The forestland was included and considered. However, the impact is small considering that the entire 16% of forest is not being logged all at once. We have not monitored logging operations in the watershed to ensure they are following pertinent laws and guidelines.

3. Are you planning on revising your report? I went through the report and looked at quite a bit of it and a lot of the data is not up to date. You changed your summary of things by eliminating and taking out NK 02 based on new information. Do you plan on updating the entire report with this new information?

This report was first developed before the new data became available to us. Removing NK 02 entirely from the report would involve a substantial re-write. Considering the time and expense involved in writing the original report, and the fact that we have numerous other TMDLs under development, we felt a revision of the summary and not the entire report was sufficient. Comments and questions from this hearing will be addressed in the responsiveness summary. New information obtained at the hearing may be included in the report or may be considered in our adaptive management process.

4. NK 02 is now considered healthy? What did we do to get it that way?

   NK 02 is no longer considered impaired. We are not certain what specifically brought about this improvement. The increase in no till or conservation tillage that occurred between 1995 and 2000 and/or the timing and intensity of weather events may have played an important part in the improvement.

5. Was the model validated with actual storm flow data of sediment concentrations or is that data just from the model itself? Was that collected during storm events? And how did that match up?

   The contractor matched the modeled data as closely as possible against the data provided by the Agency. Yes, there were some high flow events. The data matched up well for solids, less so for phosphorus.

6. I am just curious how the total suspended solids standard of 0.61 mg/L, what is that based on or what data? And how was that number chosen? Is that for all watersheds?

   The guideline for total suspended solids is 116 mg/L. It is a guideline, not a water quality standard. For parameters such as suspended solids that have no water quality standards, a statistical value (i.e., 85^{th} percentile) is used as the threshold for identifying potential causes of impairment. For suspended solids, this percentile value is calculated from all available Ambient Water Quality Monitoring Network (AWQMN) data from Water Years 1978 through 1996 and approximately 30,000 samples. One exceedance of the threshold statistical value at an Intensive Basins Survey (IBS) or Facility Related Stream Survey (FRSS) site, or one exceedance over three years at an AWQMN station, qualifies that parameter as a potential cause of impairment.

   The TSS guideline has been in use for approximately four years. It was developed to address consistency issues in the surface water monitoring program. Before adoption of the guideline, biologists depended on best professional judgment in the field. This guideline ensures that all streams are measured consistently against the same statistically derived guideline.

7. What's the biggest source of the phosphorus or can you identify its source? How would you know how to eliminate it?

We know that phosphorus is discharged from sewage treatment plants, from runoff from livestock facilities, and from row crop agriculture. In this TMDL we do not site specific sources. However, we indicate row crop agriculture as a possible source since a majority of land use in the area is under cultivation with corn and soybeans.

8. I know in your report you identified the possibility of two or three specific locations as being a potential problem for livestock, and further studying needs to be done in those areas. So do you have that plan for those particular three places?

   That information came from an intensive basin survey of the segment. The field biologist that collected that information rated the livestock facilities as low, medium and high-risk facilities based on factors such as proximity to the stream and thus identified it as a potential source. We would suggest that a study be done at the local level prior to adopting management or operational practices to determine the appropriate area(s) to concentrate on, and what the appropriate practice(s) are for implementation.

9. You specifically noted three facilities, I believe, in Section 5 and in Section 8. Now, if you can specify them that closely, I would think that somebody would investigate and arrange a one-on-one conversation with the owners to see if there is something specific they can do to help the situation.

   The Illinois EPA relied on an intensive basin survey to estimate the impact of the three facilities on impairment of the segment. A detailed investigation and interview with individual property owners was not included in the scope of this TMDL. However, the Illinois EPA hopes this TMDL can serve as a blueprint for watershed groups, like the Rayse Creek Watershed Committee, to begin working with local landowners to correct specific problem areas in the watershed.

10. The data in this report is eight years old. Most of it was done in 1995. Obviously, farming practices have changed a lot in the last eight years. You know, when you look at it in that respect, the whole report is outdated.

    Illinois EPA used the best available data to develop this TMDL. The Agency admits those data are now several years old. However, the Agency is required, by federal law, to assess the health of the state's waters and develop TMDLs to address waterbodies considered impaired. The Agency must do this with limited resources and thus, many watersheds are not monitored as often as we would like. However, the Agency must continue with its federal mandate and continue to research, learn, and improve upon the program that is presently in place.

    The Rayse Creek watershed is scheduled for an intensive basin survey in the summer of 2003. In addition, an Ambient Water Quality Monitoring Network (AWQMN) site on NK01 (USGS station number 05595730) is sampled 9 times per year on a cycle of once every 6 weeks. Using data from these assessments we will work with landowners and

the Rayse Creek Watershed Committee to identify additional monitoring and data needs.

11. The report does not show that they have a well-managed, well-organized watershed committee already in place in this area. The committee was put together prior to the TMDL being written.

    The Illinois EPA was not aware of the existence of the Rayse Creek Watershed Committee. We welcome your input and look forward to working with you in the future.

12. We have reviewed the draft TMDL for Rayse Creek and believe that this TMDL, as written, will not ensure the necessary improvements in water quality. The use of statistically derived water quality endpoints for total suspended solids (TSS) and total phosphorus and the application of those endpoints in a once in a three-year period are not scientifically defensible. In addition, the use of this approach is contrary to the Agency's policy that was revised after the public hearing on the Cedar Creek TMDL.

    As the Agency strives to satisfy requirements in Section 303(d) and 305(b) of the Clean Water Act, we must attempt to quantify biological and chemical processes that are not fully understood. The Agency uses several methods of rational in its attempt to analyze the health of our state's waterways and to adopt standards and guidelines protective of designated uses. As mentioned above, the TSS guideline was developed using a large amount of statewide water quality data. The Agency feels the TSS guideline is an acceptable endpoint in determining designated use impairment and stands by this TMDL as an accurate analysis of watershed dynamics and the first step in improving water quality in the East Fork Kaskaskia River watershed.

    Development of the TMDL for the East Fork Kaskaskia River was initiated prior to our policy change for developing TMDLs on only those pollutants with numeric standards. Therefore, since this report was nearly complete at the time we made this policy change, it was finalized under the same program policies that were established at the time it was begun. Given that the proposed implementation plan is dependent on voluntary practices within the watershed, including the gathering of additional information, we do not believe this TMDL mandates unscientific or unsupportable approaches to water quality.

13. The draft TMDL does not show a cause-and-effect relationship between any exceedance of the water quality endpoint of 116 mg/L TSS once in any 3-year period and an impairment of aquatic life. The mean TSS concentration in many streams in western Illinois is greater than 116 mg/L, but the Agency has not determined that those waterbodies are impaired. We also note that the Agency's report on baseline loadings of nitrogen, phosphorus and sediments from Illinois watersheds (Short, 1999) indicates that the statewide mean for TSS is greater than 116 mg/L in May through July and that the 75th percentile exceeds 116 mg/L in June and July (Figure 3-17, p. 41).

The Agency realizes that chemical and biological processes in surface waters vary significantly from region to region. Determining impairment of a stream involves assessing the chemical, biological and physical characteristics. The TSS guideline of 116 mg/L was not used to determine impairment of the stream, but was only used as the guideline for determining the cause of the impairment once the stream is identified as impaired.

Due to the analytical nature of TMDLs, however, an established guideline or numerical limit is necessary as an endpoint or goal for pollutant reduction. The Illinois EPA has made every effort to use sound science in determining an appropriate endpoint. The Agency stands by the current TSS guideline as a general indicator of the cause of impairment throughout the state.

14. The literature indicates that the mean or the median concentration is a more appropriate measure than use of 85th percentile and once in a three-year period as a basis for water quality endpoints. For example: **USEPA Stressor Identification Guidance Document** (page 3-7): "The mean of chemical concentrations over time is often the most relevant (USEPA, 1998a)." Based on information available at the IEPA website, it has been our understanding that the Agency would no longer use the 85th percentile value or the once-in-three years occurrence in developing TMDLs.

    Development of TMDLs for Rayse Creek was initiated prior to this policy change (also see response to question #12). Therefore, since this report was nearly complete at the time we made this policy change, it was finalized under the same program policies that were established at the time it was begun. Future TMDLs will follow the policy you discuss.

15. While we do not have a significant disagreement with the use of arbitrary values for TSS, siltation or nutrients in the 305(b) report for the purpose of identifying potential causes of water quality impairments, we do not believe that those values should be used as de facto water quality standards in determining the maximum allowable load of a constituent for TMDLs. The Department is concerned about the way in which the water quality endpoints are used in the draft TMDL. These values are not justified in terms of impairments to designated uses and result in unrealistic proposals for changing agricultural practices. As a consequence of these unrealistic and, we believe, inappropriate endpoints, the entire TMDL process in Illinois is likely to lose credibility.

    The Illinois EPA makes all recommendations for control of non-point sources of pollution on a voluntary basis. We believe the 116 mg/L TSS guideline in reasonable and appropriate for its function as a water quality endpoint for the purpose of this TMDL (refer to response for question #12).

16. If the draft TMDL for Rayse Creek represents another change in Agency policy, the Department recommends that the Agency immediately address the appropriateness of the water quality endpoints being used in developing TMDLs. While we are aware of the Agency's current efforts to convene the Illinois Nutrient Standards Work Group (INSW) to

develop water quality standards for nutrients in response to USEPA's proposed water quality criteria, we all recognize that completion of that process will take several years at aminimum. We would also recommend that the Agency add sediment-related water quality parameters (TSS, siltation and turbidity; USEPA's nutrient criteria proposal includes turbidity) to the charge to the INSW or form another technical working group to address the development of appropriate water quality endpoints or standards for those parameters.

Your suggestions are noted. We believe the appropriate approach for nutrient standards development is now underway, in part through the INSW. We intend to address TSS and other endpoints as described in the 2002 303(d) List. Thank you for your comments.

17. The Rayse Creek Watershed Planning Committee objects to the use of "old 1995" data to determine an accurate depiction of the Rayse Creek watershed at present. We object to the quality of the stream data assumptions used to formulate the Rayse Creek water model. The Committee also feels that there was not enough stream sampling taken to show an accurate depiction of watershed activities.

    Please see response to comment #10

18. The Rayse Creek Watershed Planning Committee objects to the use of the old livestock operation data used in the modeling process. A number of the sites shown on the EPA maps are no longer in existence.

    This report utilizes the only data made available to us at the time of development for this TMDL. Requests were made to obtain more current information from local contacts within the watershed. These requests either received no response, were told they didn't have the time or staff to assemble this information for us, or we were informed that no other information was available. We recommend that the local planning committee collect new information before determining where and what practices need to be implemented in the watershed.

19. The Rayse Creek Watershed Planning Committee expressed concern about how it was determined how much Best Management Practices (BMP's) impact water quality and how long it would take the BMP's to significantly impact stream quality. The engineering firm stated in the water quality plan, that if all cropland was seeded down to CRP, the watershed would still be impaired.

    Estimates on the effectiveness of BMPs came from a variety of sources. A compendium of BMP effectiveness published by USEPA (Guidance Specifying Management for Sources of Nonpoint Pollution in Coastal Waters, January 1993) indicates significant ranges in nutrient reduction in case studies nationwide.

    Due to lack of data on relative sources and loads, effects of stream bank and stream bed erosion were not included in the modeling scenarios. BMPs recommended in the TMDL will be effective in reducing sheet and rill erosion from agricultural land. The

TMDL feasibility evaluation is meant to identify general practices that allow landowners flexibility in decisions affecting their land. Conservation plans will ultimately need to be prepared at the farm level with soil/nutrient/BOD load reduction estimates evaluated for consistency with this TMDL. The statement referred to stresses the point that addressing upland runoff (sheet and rill erosion) alone will not accomplish the goal of attaining water quality. Additional studies regarding stream bank and stream bed erosion should occur so that the appropriate practices may be installed to address those issues which are probably adding significantly to the stream impairment.

20. One concern about the draft TMDL that causes some concern is the watershed model that was chosen for the Rayse Creek Watershed. We feel it cannot accurately simulate the events of the watershed. According to the USGS's web page called: Surface Water and Water Quality Models Information Clearinghouse found at http://smig.usgs.gove/SMIC/model_pages/qual2e.html, which explains the capabilities and limitations of the QUAL2E model as found in its user's manual, "Hydraulically, QUAL2E is limited to the simulation of time periods during which both the stream flow in river basins and input waste loads are essentially constant." Rayse Creek is **not** a constant flow stream and there are times when the stream is dry in places and also periods when the water is at a stand still. Another source (http://www3.baylor.edu/~Bruce_Byars/brcmod.html) stated, "More significant are the limitations of the model when examining the contribution of nonpoint sources of pollutants to river water quality degradation." Besides for the Richview Sewage Facility, no point sources have been verified in the draft. Is there a better-quality model available that would more closely depict the characteristics of our watershed?

    Model selection is discussed in Chapter 4. QUAL2EU is commonly used to simulate dissolved oxygen concentrations under various point and nonpoint source loads (Brown and Barnwell 1987). Multiple flows are simulated in steady state models (like QUAL2EU) through separate computer runs.

21. The TMDL draft mentions that there are no records of a large hog operation. That information is incorrect. A large hog operation is located in Section 20 of Blissville Township, on the edge of the watershed. It is evident that a good quantity of the manure from the operation ends up in the watershed.

    Thank you for your comment. Please refer to our response to question # 18. Load reduction from livestock operations can be dealt with under the new CAFO regulations along with the other animal facilities in the watershed. These regulations require permits and manure management plans that result in load reductions consistent with approved TMDLs.

22. The data used in the TMDL is very much out of date. Since 1995, the Jefferson Co. SWCD has received more and more conservation money to implement practices in the county as well as the Rayse Creek watershed. This is in addition to practices established from other agencies. From the data that was included in the TMDL draft, a conclusion cannot be distinguished as to how much the additional funding has helped, since the data are out dated.

Another concern that we had is the fact that some of the data do not have dates to show when the samples were taken. If the budget holds up, we hope to continue to be able to provide cost-share for conservation practices.

The objective of the TMDL was not to determine how much past funding for projects in the watershed has helped. To determine this, an intensive monitoring program would have had to have been established prior to the implementation of any practices and continued for numerous years after application. A TMDL is developed to determine the loads a stream may receive and still attain water quality standards/ designated uses. Information establishing the types of practices, the amount of those practices, and their location in the watershed was not available. Developing the TMDL without consideration of existing practices is one of the margin of safety methods used in the TMDL.

23. There are multiple instances in which the report says that there were not enough data, more data needed to be collected, or no data were available. If there is that much data missing or not existing, the TMDL should have been put off until the information could have been provided or collected, in order to provide us with the best possible data and the most accurate description of what is wrong with the creek. When landowners read the TMDL, they are most likely going to dismiss anything that is suggests because all of the data are not there. Accurate conclusions cannot be drawn unless all necessary data are available.

    The amount of data available to develop this or any TMDL will always be an issue. At this time, the Agency does not have the resources to gather additional data. Under the mandates of the federal Clean Water Act, TMDLs must be developed for impaired waters. In many cases, we will have to do so with limited data. Upon completion of any TMDL, the local watershed stakeholders should address the data gaps as they implement the plan.

24. The Sub Impoundment Dam at Waltonville and Rend Lake do create backwater in Rayse Creek. The bearing the backwater has on the NK01 samples has not been taken into consideration anywhere in the report. It could be possible that some of the high levels that are found are from these two areas backing up water. More research needs to be done before all of the blame falls onto the agricultural community.

    It is highly unlikely that backwater from the Sub impoundment dam at Waltonville could reach the sampling station on NK01. If water were to back up that far, it would be a very rare occurrence and would not have an effect on overall sample concentrations.

25. There is an old landfill located in Section 36 of Casner Township. Tests need to be done to determine the impact that it may have on the watershed, especially since a stream runs through the corner of the property. The landfill was not mentioned in the TMDL draft. It is possible that some of the chemicals from the degrading trash could seep into the watershed. We feel this area needs more research done.

The landfill was not identified as a potential source of pollutants and therefore was not addressed in the TMDL.

26. It seems that landowners in the lower part of the watershed are concerned that part of their problem may simply be a watershed-wide problem. With the top half having been recommended for removal from the 303d list, and the bottom half still having poor water quality, there is obviously some sort of point source pollution that is being overlooked. The agricultural practices of the watershed do not differ significantly enough from top to bottom for there to be that much difference in water quality. Numerous landowners feel that when sampling the bottom half, the water that is coming from the top half needs to be taken into consideration as already having some impairment in it. To place blame solely on the bottom half is not practical unless a point source can be found.

    The TMDL is developed on a watershed basis. The source assessment element in the TMDL (Chapter 4) addresses loads in 12 separate sub-watersheds. Rayse Creek is divided into two segments for the purposes of monitoring only. To address the impairments, the whole watershed must be considered and nowhere does the TMDL place blame on the top versus the bottom of the watershed.

27. Something that needs to be noted in the TMDL draft is the involvement of the watershed. A Rayse Creek Watershed Committee has been started in order to address concerns that landowners may have and to assist in improving the water quality in the watershed. The Committee is currently working with Southern Illinois University at Carbondale in getting a 319 Grant (a nonpoint source control grant, issued by the Illinois EPA) to do further testing on the watershed so that they can ascertain the real condition of the watershed's water quality.

    The Agency commends the Rayse Creek Watershed Committee for its commitment to improving water quality in the watershed. We look forward to working with the committee to accomplish the ultimate goal of compliance with water quality standards.

28. We understand that the information used in the draft dates back to 1995. How valid is this information if it is already 8 years old? Livestock operations have decreased in the past 8 years in the watershed. Adjustments need to be made to the draft. We feel that new data should be used in the draft, not old information.

    Please see response to Comment # 10 and # 18.

29. The use of statistically derived water quality endpoints for total suspended solids (TSS) and total phosphorus and the application of those endpoints in a once in a three-year period are not scientifically valid. The draft TMDL does not prove a cause/effect connection between any elevated TSS and impairment to aquatic life. We are concerned with the way in which the statistically based water quality endpoint for TSS is used. We question the connection between this information and impairments to designated uses. We are concerned that this will eventually result in unrealistic proposals for changing agricultural practices in the watershed.

Please see responses to comments #12 and 13.

30. Another concern is that the IEPA had previously indicated that constituents without water quality standards would be listed for causing impairment but that TMDLs would not include numeric reductions and allocations of these constituents. The draft TMDL for the Kaskaskia contains a reduction of potential causes for which there are no water quality standards. This uses a de facto water quality standard to determine an allowable load of constituent for TMDLs. This is a reversal of EPA's previous statement that TMDLs would not be developed for constituents that do not have water quality standards.

    Please see responses to comments #12 and 13.

31. The document should better justify that water quality throughout the watershed is protected by the TMDL, not just at the sampling points. It was not clear whether the models, particularly the EPA Screening Procedures, used to determine appropriate loading from each subwatershed set pollutant concentration constraints at various points along the stream network. If so please specify where those points are. This is particularly important with respect to point source loading. The document states that the contribution from the point source is negligible when compared to total loadings in the watershed, but it likely is a very significant source of pollutants in the waters immediately downstream of the discharge. If it may contribute to standards violations, reductions will be necessary.

    The purpose of developing TMDLs on a watershed basis is for the exact purpose of addressing water quality throughout the watershed rather than at specific points in the watershed. The report divides the watershed into 12 sub-watersheds to help determine where pollutant loads to the stream are coming from. There are no specific points set for pollutant concentration constraints. The lone point source in the watershed was determined to be negligible based on data reviewed, and the results of the modeling effort.

32. It was unclear how the models were calibrated and verified. There is some discussion of the calibration for the TSS model, but it is not clear whether the EPA Screening Procedures model was calibrated to the phosphorus data, how calibration of the QUAL2E is proposed, or what additional data are recommended to perform such a calibration. The calibration discussion should justify the selection of parameters that are adjusted during the calibration. "Conservative" assumptions should not be made prior to calibration because making these assumptions and calibrating the model to existing data can lead to non-conservative calibrated parameters. Instead, uncertain variables should be given values that are the modeler's best estimate for the purpose of the calibration. Conservative values may then be used during model runs if an implicit MOS is desired.

    As described on pages 52 and 53, the phosphorus model predictions closely matched field data and therefore required no calibration.

Very little data were available for calibration of the QUAL2EU model (see pages 60 and 61). With the lack of information on critical factors that influence DO in streams, a sensitivity analysis and professional judgment were relied on.

In the most recent 303(d) listing, DO has not been identified as a cause of impairment in NK02 and DO is now identified as a pollutant in NK01. The QUAL2E model (or another method) will be revised in the future when the Agency develops a TMDL for DO in ILNK01.

33. There is insufficient justification for the allocation decisions. There are no reductions proposed for the new point source because its contribution is judged to be a small portion of the whole impairment. However, each individual farm field and livestock facility in the watershed could make the same claim that it is only a small contributor to the larger problem. The burden of pollution reduction should fall equitably upon each contributor that discharges at levels above background conditions.

    The agricultural sources are linked to wet weather, while the future point source is relatively constant (Chapter 4). This TMDL does restrict the imposition of more stringent discharge limits in future NPDES permits.

34. The margin of safety (MOS) for TSS and phosphorus is inadequate. The document indicates that it is implicit through conservative assumptions including the assumption that no deposition of sediment occurs, the critical season is modeled, recent conservation practices are not included, and pre-BMP water quality data is used for the calibration. However, these do not lead to conservative results with an adequate MOS for the following reasons: (1) In a healthy river system , there is no net deposition of sediment; a healthy river is defined as one that moves sediment such that it neither accumulates nor erodes. (2) Because water quality standards must be met, even during critical conditions, regulations require that the TMDL be based on critical conditions; this should not also be considered a credit in the MOS. (3 and 4) Because recent conservation practices are not included in the model, it is only appropriate that water quality that occurred prior to implementation of such practices be used in the calibration. Calibrating the model using water quality data that did not match practices modeled would lead to a bad calibration. Therefore, the MOS for the TSS and phosphorus TMDLs should be redefined with solid justification that the magnitude of the MOS takes into account all uncertainty in the model.

    We selected a simple model and an implicit approach to MOS because we have insufficient data on the system to use more complex models or to develop scientifically defensible explicit MOS factors. Clearly better data would lead to improved loading estimates, but supplemental data collection was not provided for in this TMDL. Rather, this TMDL includes recommendations for future monitoring and for adaptive management, which provides assurance for eventual success.

35. The Universal Soil Loss Equation was primarily intended to estimate annual soil loss. There is certainly a need to determine daily loads from critical storm events because they are critical to stream health. However, please provide additional justification that this equation

has been properly modified for use estimating individual events. References to scientific literature that includes findings that this use of the USLE is appropriate would be helpful.

The Universal Soil Loss Equation (USLE) predicts the long term average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, crop system and management practices. Five major factors are used to calculate the soil loss for a given site. Each factor is the numerical estimate of a specific condition that affects the severity of soil erosion at a particular location. The erosion values reflected by these factors can vary considerably due to varying weather conditions.

This TMDL used the USEPA's Screening Procedures to develop load estimates. The Screening Procedure, detailed in Mills *et al.* (1985), includes two modifications to adapt the USLE to individual storm events. The erosivity term, E, reflects rainfall intensity, among other things. Expected magnitudes of single-storm erosivity indices are presented in Wischmeier and Smith (1978). Erosivity values for the East Fork Kaskaskia River watershed were interpolated between two stations in Illinois (Cairo and Springfield). For a 1-year storm, the erosivity is 65 (10^2 m-ton-cm/ha-hr) in this area. For the 3-year storm, the erosivity is 118 (10^2 m-ton-cm/ha-hr). For the 10-year storm, the erosivity is 199 (10^2 m-ton-cm/ha-hr). The Screening Procedure also includes estimates of the volume of runoff for specific storm events, which are part of calculating the loads. In this TMDL, runoff volume was estimated for several specific storm events (see Section 5.1 in the report).

36. The phosphorus modeling assumed that phosphorus predominantly enters the stream absorbed onto sediment particles that enter the stream. However, page 51 of the document indicates that while TSS concentration is strongly correlated with flow, total phosphorus is not strongly correlated with flow. Therefore, this assumption may not be appropriate, and additional consideration should be given to dissolved phosphorus and the management strategies necessary to control the component.

    We considered transport of dissolved phosphorus from sources to the waterway and believe that this mechanism is not significant. Dissolved phosphorus has a strong affinity for binding to mineral surfaces (Stumm and Morgan, 1981, *Aquatic Chemistry, 2nd Ed.,* John Wiley, Toronto), and as such, is generally found in the particulate form in natural waters.

37. Because there is a weak correlation between flow and total phosphorus, high flow events should not be used as the only critical condition. Instead, the TMDL developer should identify the flow events during which actual exceedances were observed and use such events to select modeling conditions. It would be best to identify the critical conditions during which ecological impacts may occur due to excess phosphorus. If phosphorus is not likely to cause a problem during a three-year storm, a different event, or set of events, should be modeled. This would also be more clear for modelers, as mentioned above, if IEPA tied listing criteria more closely to predicted impacts.

    Thank you for your comment.

38. The point source load from the new wastewater treatment plant at Richview was considered negligible compared to non-point source (NPS) loads during a 3-yr storm. Because exceedances of the phosphorus target were observed during different events, comparative loads from these sources should be considered for different events. Also, the document indicates that NPS loads were likely overestimated due to "conservative assumptions" which include using only those conservation practices that were in place prior to 1995 for estimating the C factor in the USLE, and assuming no conservation practices at all in estimating the P factor. This suggests that the fraction from the point source load may be more significant. Finally, longer-term loads (weekly, monthly) will need to be considered eventually because such loads may be contributing to impairment of the downstream lake.

    Phosphorus wasteloads from the future Richview plant will be negligible during all rainfall events that lead to runoff.

39. The dissolved oxygen discussion does not constitute an adequate TMDL analysis. As described in the document, insufficient information was available to develop a defensible TMDL. Please explain the new timetable for completing this TMDL.

    This segment no longer requires a TMDL for DO based on new data collected by the Illinois EPA indicating this segment is currently meeting the DO standard.

40. The downstream reach of Rayse Creek (NK01) should receive TMDL analysis for dissolved oxygen (DO), although it is not identified in the document as requiring such analysis. This reach clearly fails to meet the current DO criteria. Exhibit 14 indicates that 19 of 71 samples collected between 1991 and 1998 exceeded the standards due to dissolved oxygen. If all of these measurements are taken during daylight hours, it is likely that the lowest dissolved oxygen concentrations, which typically occur just before dawn, have not been detected. Examination of the data listed shows that DO criteria are reliably violated during the summer months. It is unclear why this segment was not listed due to low DO in the 1998 list, but it certainly requires a TMDL. This analysis would most efficiently be conducted in conjunction with the NK02 TMDL.

    This was an oversight on the part of the Agency. We will re-evaluate this segment for DO impairment the next time this area is targeted for TMDL development.

41. Lack of data are certainly a problem in the DO TMDL for NK02. However, before IEPA collects additional data, a sampling plan should be prepared that ensures that the most useful data for the modeling purposes will be collected. Merely collecting additional data at station NK02 will not provide helpful information in identifying the sources responsible for the violations and will not provide necessary data for the QUAL2E model. Relatively few days worth of data spread spatially over the watershed during selected flow events would be more helpful for these purposes than many days of single samples at station NK02 spread over several months and years.

    Thank you for your comment.

42. The document convincingly suggests that the DO violations are likely point source problems, but the sources are not identified. Please describe IEPA's plan for identifying these sources as part of the ongoing TMDL development.

    The report does not identify point sources as the source of the DO violations.

43. The new wastewater treatment plant at Richview certainly must be part of the QUAL2E model, though it is not clear whether or not this has already been incorporated. Model output for the stream reach downstream of the facility should be scrutinized to ensure that the Richview point source does not cause DO sags that violate standards. Output should also be analyzed to determine whether or not the point source contributes to the DO deficit in Rayse Creek at the confluence of Rayse and the tributary to which Richview discharges.

    In the most recent 303(b) listing, DO has not been identified as a cause of impairment in NK02 and DO is now identified as a pollutant in NK01. The QUAL2E model (or another method) will be revised in the future when the Agency develops a TMDL for DO in ILNK01.

44. The document notes early on that sediment oxygen demand is negligible and low flow is the most critical condition. Therefore, the pollutant reduction options described in section 6.3 should not exclusively discuss storm runoff from agriculture. It is not convincing that such reductions would adequately improve dissolved oxygen conditions during low flows.

    Neither BOD nor SOD have been measured, but could be as part of the development of a more rigorous TMDL for DO in Rayse Creek. We believe this is not necessary if adequate watershed planning, BMP selection and adaptive management is conducted.

45. The results of the QUAL2E modeling are unclear. There seems to be a recommendation that instream BOD not exceed 10 mg/L. Does this mean that if instream BOD concentrations do not exceed 10 mg/L anywhere in the watershed, standards will be met everywhere in the watershed? Does this recommendation refer to ultimate BOD or 5-day BOD? On what is this recommendation based?

    The QUAL2E model (or another method) will be revised in the future when the Agency develops a TMDL for DO in ILNK01. Additional field data are recommended to reduce uncertainty.

46. Please clarify what the output file in Appendix C represents. The model output shows violations of the criterion, so this is apparently not the TMDL loading. Graphs showing the longitudinal profiles of DO along the tributaries and main stem of Rayse Creek would be very helpful in displaying calibrated current conditions and an estimate of conditions following TMDL implementation.

Appendix C includes model output and boundary conditions for baseflow conditions. Under these conditions, DO levels are less than the standard. Future output for a revised model that address DO deficits in NK01 can include the requested graphs.

47. P. 27 indicates that the QUAL2E model allows simulation of diurnal variation. However, there is no discussion of such variation and how it is incorporated into model. Were diurnal variations modeled? If diurnal variations were not simulated, how will these variations be considered in the TMDL?

    Diurnal conditions were not simulated. A DO TMDL is no longer required for NK02. The DO model will be revised in the future when the Agency develops a TMDL for DO in NK01.

48. The document indicates that the watershed contains 28 livestock facilities. Are any of these facilities subject to regulation under CAFO regulations? A few of the facilities are categorized as "high risk" facilities. What constitutes a "high risk" facility? What specific changes may ensure that these facilities do not contribute to the impairments?

    This TMDL was written before the new federal CAFO regulations were made public, and thus does not address the facilities in that context. The livestock facilities were rated during an intensive basin survey as low, medium and high risk based on factors such as proximity to the stream and manure management practices. The Agency believes that the information in the TMDL used in conjunction with continued communication and support of local watershed groups, can produce a dialogue with the facilities in question. Once these facilities have been identified and approached about the problem by local stakeholders, the Agency can act in a supporting role to ensure compliance.

49. As mentioned above, the determination that the City of Richview WWTP is an insignificant contributor to the water quality impairments, and therefore is not responsible for pollutant reductions is unjustified. Particularly in the tributary to which it discharges, this source may be very significant. Furthermore, even if reductions are not imposed at this time, a numeric allowable load must be allocated to the facility. A waste load allocation must be specifically defined, rather than merely described as a negligible component in the TMDL equation. If no allocation is specified, presumably the allocation is zero, and the point source should cease discharging.

    The assumption on the significance of the Richview wastewater treatment plant applies to wet weather conditions. That assumption should not have been applied to periods of DO deficits. The DO model will be revised in the future when the Agency develops a TMDL for DO in NK01.

50. We appreciate that future growth was considered in the TMDL allocation, and the conclusion that growth in the area will not significantly increase loading to the creek may be sound. However, the justification indicates only that no increased loading will occur because no land use changes are projected. The justification should also include evidence that no increases

will occur from other discharges including permitted discharges, such as those from sewage treatment facilities, or from individual private wastewater systems.

The Growth Projections from the Regional Planning Commissions are the only sources of information available for us to verify or predict future increases in municipal sewage treatment facilities or individual septic systems. From the growth data supplied to us, it is reasonable to assume that a prediction of zero growth will lead to no increase in discharges or installation of septic systems.

51. TMDLs for waters impaired largely due to nonpoint sources are only useful if they include implementation plans that provide useful information for addressing those non-regulated sources. Therefore, we are very pleased to see the level of detail that went into the pollutant reduction options and the implementation plan for Rayse Creek. The plan offered a good summary of incentive programs, and an interesting exploration of different alternatives.

    Thank you for the comment.

52. The prioritization of watersheds for incentive program investments is very helpful; however, it should be based on overall impact in addition to soil loss. For example, watershed RC-8 is estimated to have extremely high BOD loading, but lower soil loss rates. If incentive programs are appropriate in that watershed, projects that might reduce BOD loading should receive significant priority.

    Thank you for your comment. These are issues and decisions the local stakeholders in the watershed and resource agencies need to make.

53. Finally, the discussion on costs should include a restatement that the costs may be overestimated, because the USLE was based on the assumption that fewer conservation practices are in place than currently exist. In other words, some of the costs have already been covered for some of the changes that are recommended by the TMDL, and in fact some of the changes have been implemented.

    Thank you for your comment.

GLOSSARY AND ACRONYMS

ALUS	Aquatic Life Use Support.
AWQMN	Ambient Water Quality Network
BMPs	Best Management Practices. These are practices that have been determined to be effective and practical means of preventing or reducing pollution from nonpoint sources.
BOD	Biological Oxygen Demand
CAFO	Concentrated Animal Feeding Operations
CPP	Conservation Practices Program
CRP	Conservation Reserve Program
FY2000	Fiscal Year 2000
IBI	Index of Biological Integrity. Primary purpose is to assess the biological integrity of a habitat using samples of living organisms and to evaluate the consequences of human actions on biological systems. Developed for use in managing aquatic resources (e.g., to establish use designations for water bodies, biological water quality standards, or goals for restoration).
IBS	Intensive Basin Survey
IEPA	The Illinois Environmental Protection Agency (also referred to as the Agency or Illinois EPA)
NRCS	Natural Resources Conservation Service
NVSS	Non-volatile suspended solids
RUSLE	Revised Universal Soil Loss Equation
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids. Solids in water that can be trapped by a filter. TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life.
USEPA	United States Environmental Protection Agency
USLE	Universal Soil Loss Equation. A method of estimating the average soil loss from sheet and rill erosion that might be expected to occur over an extended period under specified conditions of soils, vegetation, climate, cultural operation, and conservation measures.

DISTRIBUTION OF RESPONSIVENESS SUMMARY

Copies of this responsiveness summary were mailed in March 2003, to all who registered at the hearing, to all who sent in written comments and to anyone who requested a copy. Additional copies of this responsiveness summary are available from Bill Hammel, Illinois EPA Office of Community Relations, phone 217-524-7342 or e-mail Bill.Hammel@epa.state.il.us.

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The public hearing notice, the hearing transcript and the responsiveness summary are available on the Illinois EPA website: www.epa.state.il.us

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