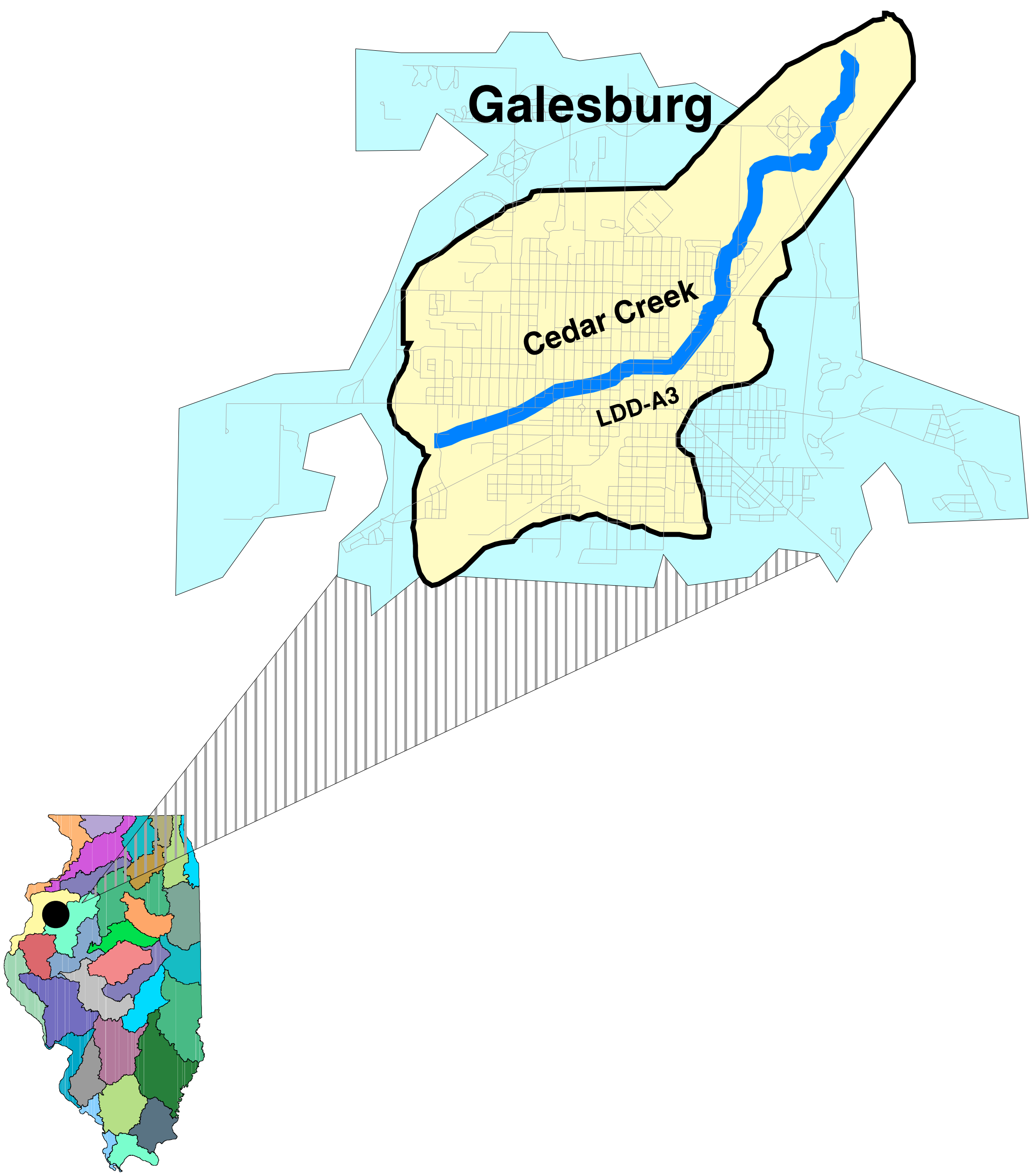
Illinois
Environmental
Protection Agency

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

August 2002

IEPA/BOW/02-014

CEDAR CREEK TMDL REPORT



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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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AUG 01 2002

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

Dear Ms. Willhite:

The United States Environmental Protection Agency (U. S. EPA) has conducted a complete review of the final Total Maximum Daily Load (TMDL) submittal for siltation and excess nutrients in Cedar Creek, which is located in Knox County, Illinois, including supporting documentation and information. Based on this review, U.S. EPA has determined that Illinois' TMDLs for siltation and excess nutrients meet 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, by this order, U.S. EPA hereby APPROVES Illinois' TMDLs for siltation and excess nutrients in segment ILLDDOI-LDD-A3 of Cedar 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 appreciate your hard work in this area and the submittal of the TMDL as required. If you have any questions, please contact Mr. Kevin Pierard, Chief of the Watersheds and Wetlands Branch at 312-886-4448.

Jo Lynn Traub,
Director, Water Division

Enclosure

CEDAR CREEK
GALESBURG, ILLINOIS
TOTAL MAXIMUM DAILY LOADS

Prepared for

Illinois Environmental Protection Agency

CONTENTS

CONTENTS (Continued)

FIGURES

TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

Ammonia-N	Ammonia-nitrogen
BMP	Best management practice
BOD_5	Five day biochemical oxygen demand
CFR	Code of Federal Regulations
CSO	Combined sewer overflow
CWA	Clean Water Act
CWP	Center for Watershed Protection
DO	Dissolved oxygen
EMC	Event mean concentration
EPA	U.S. Environmental Protection Agency
ft^3/s	Cubic foot per second
GSD	Galesburg Sanitary District
IAC	Illinois Administrative Code
IDOT	Illinois Department of Transportation
IEPA	Illinois Environmental Protection Agency
ISWS	Illinois State Water Survey
MBI	Macroinvertebrate biotic index
mg/L	Milligram per liter
mi^2	Square mile
MRCC	Midwest Regional Climate Center
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
SOD	Sediment oxygen demand
SWMM	Storm Water Management Model
Tetra Tech	Tetra Tech EM Inc.
TMDL	Total maximum daily load
TSS	Total suspended solids
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WS	Watershed
WWTP	Wastewater treatment plant
7Q10	7-day, 10-year low flow

EXECUTIVE SUMMARY

A 5.95-mile segment of Cedar Creek (Watershed Identification No. ILLDD01-LDD-A3) in and near Galesburg, Illinois, is on Illinois' 303(d) list for biological impairments resulting from nutrient, siltation, and other habitat alterations and has a priority ranking of 68. This total maximum daily load (TMDL) document addresses two of the three reductions, the nutrient and silt load reductions, that are needed for the listed segment of Cedar Creek to comply with Illinois guidelines. These reductions and other corrective measures described in this document will also result in habitat improvements in the Cedar Creek segment. The specific problems and control action plans associated with nutrient and silt loads are highlighted below.

Problem No. 1: Siltation

Silt loads along the listed segment of Cedar Creek have led to biological degradation. Silt loads have been a problem in both the agricultural and urban areas. In the upstream agricultural area, silt loads are caused by farming activities and natural processes that result in erosion. In the urban area, urban runoff picks up silt loads from various construction and transportation activities and discharges the loads to the listed segment of the creek. Silt loads have resulted in elevated instream concentrations of total suspended solid (TSS) and elevated silt/mud percentages, which are surrogate measures for siltation. Combined sewer overflows (CSOs) have also historically contributed to silt loads in the creek; however, the Galesburg Sanitary District (GSD) has made several improvements that have reduced the number and impact of CSOs. Best management practices (BMP), including re-establishing or enhancing existing wetlands, installing buffer strips, using swales, and continuing with GSD efforts to reduce CSOs and improve the storm sewer system, will reduce silt loads and improve aquatic life along the listed segment of the creek.

Problem No. 2: Nutrient Loads

Nutrient loads along the listed segment of Cedar Creek have also led to biological degradation. Nutrient loads are primarily a concern in the upstream agricultural area where ammonia-based fertilizers such as anhydrous ammonia and urea are applied. During first-flush storm events, runoff with elevated nutrient concentrations discharges to the listed segment of Cedar Creek. The listed segment of Cedar Creek addressed in this TMDL is shallow and has a low flow. Consequently, the nutrient concentrations in the upstream portion of Cedar Creek are impacted by the storm events. Excess nutrient loads have resulted in elevated instream concentrations of ammonia-nitrogen (ammonia-N), which is the surrogate measure for nutrients considered in this analysis. Nitrate concentrations are also a surrogate measure for nutrients but are not a focus of this analysis because observed nitrate concentrations have not exceeded state guidelines in the listed segment. Elevated nutrient loads and sediment oxygen demand have also resulted in low dissolved oxygen (DO) concentrations. As a result, the Illinois Water Quality Standard for DO was also used as an endpoint for this analysis. In the urban area, nutrient loads have resulted in periodic elevated ammonia-N concentrations and are a result of human activities such as lawn fertilizer applications, inappropriate disposal of wastes, and inappropriate connections to the storm sewer system. Several BMPs, including re-establishing or enhancing existing wetlands, installing buffer strips, using swales, continuing with GSD efforts to reduce CSOs and improve the storm sewer system, and increasing creek reaeration by modifying the concrete channel and restoring the natural channel, will result in compliance with the ammonia-N guideline and the DO water quality standard, except in the headwater portion, and improved aquatic life within the listed segment of the creek.

1.0 INTRODUCTION

The state of Illinois is required to develop total maximum daily loads (TMDLs) for water bodies not meeting their designated uses in accordance with Section 303(d) of the Clean Water Act (CWA). Water quality in Illinois is monitored by the Illinois Environmental Protection Agency (IEPA) and a variety of other partners to determine whether water quality standards and guidelines are being met and whether the designated uses of the waters are being maintained. If a water body is not maintaining its beneficial uses as defined by state guidelines, the water body is listed on Illinois' 303(d) list and TMDLs must be developed for the water body following a schedule established by the state. If biological data needed to determine whether the designated uses of a water body are being maintained are not available, a water body can be listed if water chemistry data show that state guidelines and standards are being exceeded. Section 303(d) of the CWA and the U.S. Environmental Protection Agency's (EPA) implementing regulations in Title 40 of the *Code of Federal Regulations* (CFR), Section 130, describe the statutory and regulatory requirements for approvable TMDLs.

In general, TMDLs are developed in accordance with the following relationship:

$$TMDL = WLA + LA + MOS$$

where:

TMDL	=	Total maximum daily load
WLA	=	Waste load allocation (point source)
LA	=	Load allocation (nonpoint source)
MOS	=	Margin of safety (scientific uncertainty)

This document provides the information used to develop TMDLs for a 5.95-mile segment of Cedar Creek in Galesburg, IL. This segment of Cedar Creek is on Illinois' 303(d) list under Watershed (WS) Identification No. ILLDD01-LDD-A3. This segment is listed for degradation of biology resulting from nutrient, siltation, and other habitat alterations and has a priority ranking of 68. This TMDL document addresses the nutrient and silt load reductions needed for the listed segment of Cedar Creek to comply with Illinois guidelines for aquatic life use in rivers and streams. These reductions and other corrective measures described in this document will also result in habitat improvements in the Cedar Creek segment.

Following this introduction, this TMDL document is organized in the following sections:

- Section 2.0, Background Information
- Section 3.0, Applicable Water Quality Standards and Numeric Water Quality Targets
- Section 4.0, Pollutant Load Modeling
- Section 5.0, Load Allocations
- Section 6.0, Load Allocation Uncertainties and Margins of Safety
- Section 7.0, Seasonal Variations
- Section 8.0, Monitoring Plan
- Section 9.0, Implementation Activities
- Section 10.0, Reasonable Assurances
- Section 11.0, Public Participation

References used to prepare this document are presented at the end of the text. Appendix A to this document includes a separately bound report that discusses the hydrologic and water quality modeling of the listed segment of Cedar Creek. Appendix B lists federal funding sources available to support the measures discussed in this TMDL document for improving the aquatic life of Cedar Creek.

2.0 BACKGROUND INFORMATION

This section describes general background information for the 303(d)-listed segment of Cedar Creek, including general characteristics, setting and land use, macroinvertebrate communities and habitat characteristics, present and future growth trends in the area, point and nonpoint sources, pollutants of concern and background concentrations, and surrogate measures.

2.1 GENERAL CHARACTERISTICS OF CEDAR CREEK

Cedar Creek extends 47.8 river miles from its headwaters located northeast of the City of Galesburg, Knox County, Illinois, to the confluence of Cedar and Henderson Creeks west of Little York. Segment WS Identification No. ILLDD01-LDD-A3 begins at the headwaters and runs 5.95 miles downstream through the city to McClure Street (see Figure 1). The creek is channelized upstream of Galesburg. Within the city, 1.8 miles of the creek are concrete lined.

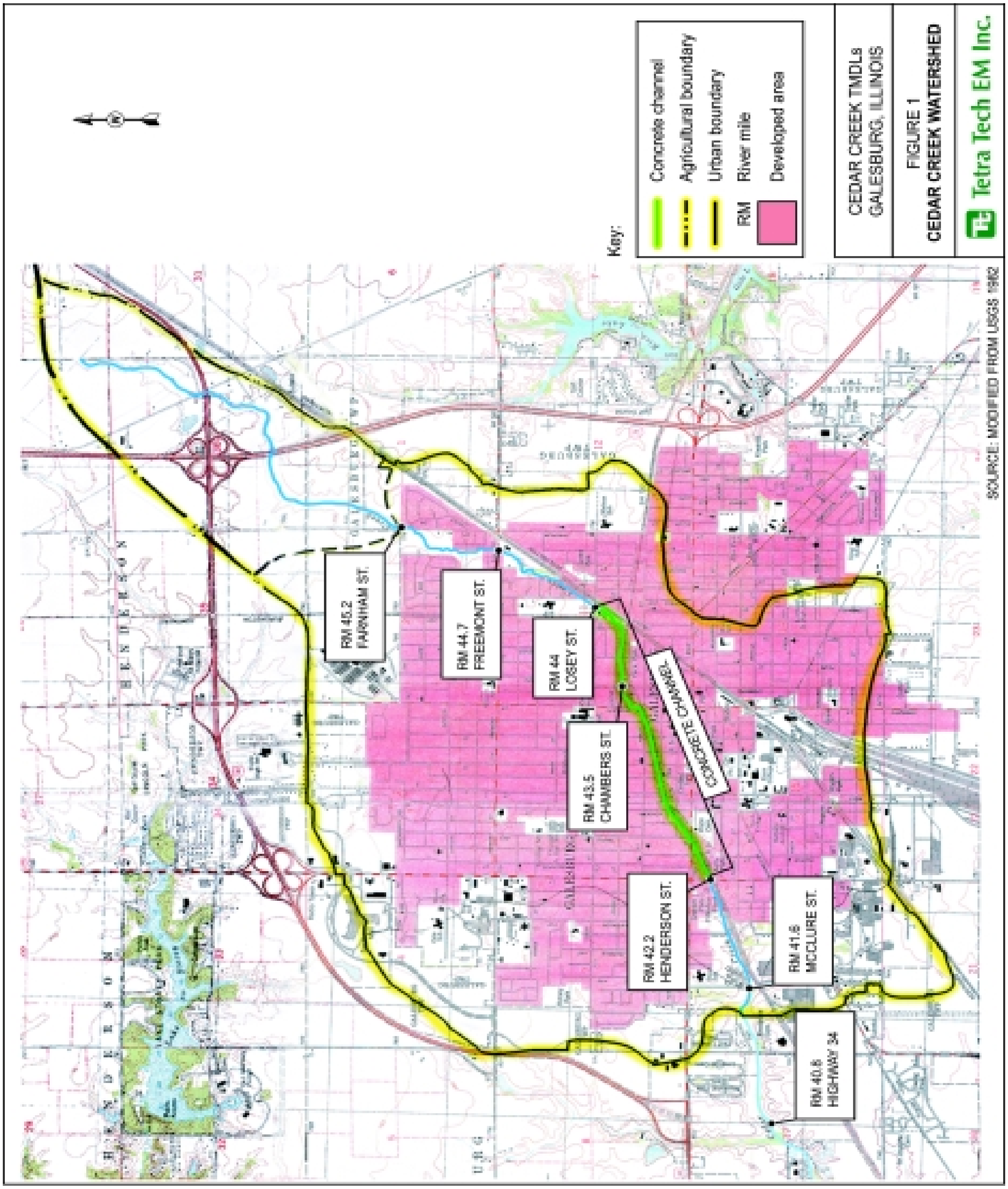
2.2 SETTING AND LAND USE

The listed segment of Cedar Creek is located within a watershed partially defined by the Galesburg sanitary and storm sewer network. The boundaries of this watershed were manually delineated on the USGS topographic maps for the east and west Galesburg quadrangle (see Figure 1). The area, land uses, and other features were then obtained by scaling a digitized image of the watershed. According to the delineation, the land use in this watershed consists of approximately 9.8 square miles (mi^2) of urbanized area, including the city of Galesburg, and 1.8 mi^2 of agricultural area that includes the creek's headwaters. Within the corporate limits of the city of Galesburg, land use is approximately 60 percent residential, 30 percent commercial, and 10 percent agricultural. In the urbanized area of the watershed, storm water is collected by a storm sewer network that discharges through outfalls located along the creek. According to the GSD, about 21 acres of the watershed are still served by a combined sewer system (Tetra Tech 2000a and 2000c). The locations of these remaining combined sewer areas are identified in Table 3-1 in Appendix A. In addition to the storm sewer system, residential foundation drains in the areas previously served by a combined sewer system are still connected to the sanitary system (Huff 2000).

The Cedar Creek watershed near Galesburg consists mostly of soil types in the Ipava-Sable and the Tama-Ipava Associations. These associations consist of soils that are poorly or somewhat poorly drained. The soils in the agricultural area have been modified by installation of drainage tiles. The surface layer consists of black, friable silt loam and silty clay loam. Subsoil consists of brownish, yellowish, and dark gray, friable silt loam and silty clay loam. The percent of clay ranges from 20 to 43 percent, and soil permeability ranges from 0.6 to 2.0 inches per hour. In addition to its moderately low permeability, the area has a seasonal high water table ranging from 1 to 6 feet below ground surface. Slopes in the creek area range from 0 to 15 percent (USDA 1986).

The climate in Knox County is temperate continental. The average annual precipitation is approximately 36.6 inches. The maximum and minimum annual precipitations are 54 inches (1941) and 23.8 inches (1940). On average, 102.3 days have precipitation of at least 0.01 inch, 24.2 days have at least 0.5 inch, and 8.9 days have at least 1 inch. The average annual temperature for Knox County is approximately 50.1° F. The maximum and minimum average temperatures are 59.9 and 40.3 F. The maximum and minimum temperatures are 102° F (1983) and -25° F (1982) (MRCC 2000).

FIGURE 1
CEDAR CREEK WATERSHED



2.3 MACROINVERTEBRATE COMMUNITIES AND HABITAT CHARACTERISTICS

On August 18 and 19, 1999, IEPA collected biological samples and calculated the macroinvertebrate biotic index (MBI) at 10 stations on Cedar Creek to determine conditions upstream and downstream from the GSD WWTP outfall. An MBI reflects the degree of tolerance of the macroinvertebrate community to oxygen-demanding and other contaminants. MBI values reflect aquatic community impairment as follows:

- Less than or equal to 5.9: Good
- 6.0 through 8.9: Fair
- Greater than or equal to 9.0: Poor

An MBI of 6.0 and a taxa of 10 were observed at a station located at the intersection of Farnham Road and Cedar Creek. This station is located in the northeastern corner of Galesburg immediately downstream from the agricultural area and within the creek segment addressed in this TMDL. Based on the MBI, general water quality conditions here are fair. An MBI of 7.5 and a taxa of 7 were observed at a station located at the intersection of Henderson Street and Cedar Creek, also within the creek segment. This station is located at the most downstream point of the concrete segment of the creek. Based on the MBI, general water quality conditions here are fair (IEPA 2000).

Habitat characteristics measured by IEPA in 1999 in Cedar Creek at Farnham Road and Henderson Street are summarized in Table 1.

2.4 PRESENT AND FUTURE GROWTH TRENDS IN AREA

Historically, the population of Galesburg has been steadily decreasing since its peak in 1960. However, according to the U.S. Census 2000, the population has increased from 33,530 in 1990 to 33,706 in 2000. Apparently, the population in Galesburg has stabilized (City of Galesburg 2000; U.S. Census Bureau 2000). For the purposes of this study, the population in Galesburg is assumed to remain relatively constant in the near future.

Table 1. Summary of Habitat Characteristics Measured by IEPA in August 1999

Habitat Parameter	Farnham Road	Henderson Street
Hydraulic Features		
Average Stream Width (ft)	2	7
Average Stream Depth (ft)	0.2	0.3
Average Velocity (ft/s)	0	0.39
Discharge (ft^3/s)	0	0.60
Pool (%)	0	0
Riffle (%)	0	0
Run (%)	100	100
Substrate		
Silt to Mud Ratio (%)	65	0
Sand (%)	0	6
Fine Gravel (%)	0	1
Medium Gravel (%)	0	1
Coarse Gravel (%)	0	1
Plant Detritus (%)	5	2
Vegetation (%)	10	0
Other (%)	20	89

Notes:

% Percent
ft Foot
ft/s Foot per second
ft^3/s Cubic foot per second

2.5 POINT AND NONPOINT SOURCES

Point sources located along the listed segment of Cedar Creek include GSD's combined sewer overflows (CSO). Reportedly, GSD has upgraded the system, resulting in the separation of 99 percent of the CSOs. Several CSOs were eliminated, and a larger capacity, 60-inch-diameter interceptor was installed to route wastewater to the WWTP (IEPA 1994). Historically, one of the biggest contributors to overflow events is building foundation drains connected directly to the combined sewers. Although these foundation drains have not been disconnected, external roof drains previously connected to the combined sewers have been disconnected. In addition to these changes, the city has constructed four wet-weather, primary treatment facilities that can handle 12 million gallons per day, greatly reducing flow in the combined sewers during wet weather periods (Huff 2000).

Since these changes have been made, the number of overflow events have greatly reduced. In 1999, 78 overflows occurred at the 39 CSO locations, 384 less than in 1987. The duration of overflow events has also declined. Since 1987, the average duration of an overflow event has dropped from 58.9 hours per year to just over 15 hours per year in 1999 (GSD 2000).

Nonpoint sources of pollutants along the listed segment of Cedar Creek include agricultural and urban runoff, with the majority of the total suspended solids (TSS) and ammonia-nitrogen (ammonia-N) load coming from urban land. Agricultural runoff flows into the creek from the headwaters to about two miles downstream. Urban runoff flows into the creek directly and indirectly through storm sewers along the remaining four miles of the listed segment.

In the agricultural area of the watershed, silt loads that result in elevated TSS concentrations are caused by farming activities and natural processes that result in erosion. Nutrient loads are caused by use of ammonia-based fertilizers that result in elevated ammonia-N concentrations in the runoff. Ammonia-based fertilizers that are used in the study area include anhydrous ammonia, which is the preferred choice, and urea (Tetra Tech 2001). Anhydrous ammonia is applied as gas and rapidly converts to nitrate in soil, however, small amounts can be carried in surface water runoff from row crops, especially if fertilizers are not applied appropriately. Nitrate, which anhydrous ammonia converts to and can be carried in surface water runoff, has been detected in the listed segment of Cedar Creek but not at levels above its IEPA guideline of 7.8 mg/L. Urea, which is a direct source of ammonia-N, can be transported by overland flow if rainfall occurs immediately after application. In the urban area of the watershed, silt loads are caused by construction and transportation activities. Ammonia-N loads are caused by human activities such as lawn fertilizer applications, inappropriate disposal of wastes, and inappropriate connections to the storm sewer system.

2.6 POLLUTANTS OF CONCERN AND BACKGROUND CONCENTRATIONS

Ammonia-N, a surrogate measure for nutrients, and TSS and silt/mud percentages, surrogate measures of siltation, are the primary concerns along the listed segment of Cedar Creek in (1) the agricultural areas where ammonia-based fertilizers such as anhydrous-ammonia and urea are used and farming activities and natural processes result in erosion and (2) the urban areas where activities such as lawn fertilizer applications, inappropriate waste disposal, and construction and transportation activities take place. Nitrate, also a surrogate measure for nutrients, was not detected in Cedar Creek above its IEPA guideline of 7.8 milligram per liter (mg/L) and therefore is not a focus of this study. In addition, dissolved oxygen (DO) concentrations have been identified as a concern because elevated nutrient loads are often linked to drops in DO concentration. During a small storm in August 1994 that had precipitation of 0.8 inch and precipitation intensity of 0.14 inch per hour (NCDC 1989 through 1999) ammonia-N was detected at concentrations as high as 1 mg/L in the upstream segment of the creek. As demonstrated by Cedar Creek monitoring data, ammonia-N concentrations near the upstream agricultural area are most critical and require the greatest reduction (see Tables 2-2 and 2-3 in Appendix A). TSS has been detected at concentrations of up to 1,460 mg/L during four major storm events with precipitation levels of up to 4.2 inches in 1986 (see Tables 2-3 and 3-4 of Appendix A). The listed segment of the creek contained up to 65 percent silt/mud during studies conducted by IEPA in 1994 and 1999 (see Table 2-2 of Appendix A). DO was detected at concentrations as low as 1.1 mg/L during low-flow conditions in 1985 and as low as 4.6 mg/L during a small storm in 1999 with a precipitation level of 0.3 inch and an intensity of 0.1 inch per hour (NCDC 1988 through 1999) (see Table 2-2 of Appendix A). Although CSOs, which increase sediment oxygen demand (SOD) load and decrease DO, were more prevalent in 1985 than now, SOD loads from CSO events continue to contribute to the low DO concentrations observed in the creek segment. Ammonia-N loads and the current level of reaeration are other key factors contributing to low DO concentrations in the creek segment. (USGS 1987, pages 98 through 108, 128 through 131, and 148, 149, 158 and 159; IEPA 1991, page 11; IEPA 1994, page 12; IEPA 2000, Table 2; GSD 1996 through 2000).

During low-flow conditions in 1985, ammonia-N and TSS were detected at concentrations of about 0.1 and 50 mg/L, respectively. These concentrations are assumed to be equivalent to natural background concentrations. Extreme diurnal variation of DO concentrations in Cedar Creek was observed during low-flow conditions in 1985; consequently, the natural background DO concentration was assumed to be 2 mg/L. This concentration is typical of groundwater, which is the source of base-flow into the listed segment of the creek.

2.7 SURROGATE MEASURES

A TSS concentration of 116 mg/L, a less than 34 percent silt/mud content, and an ammonia-N concentration of 0.41 mg/L have been identified by IEPA as the water quality guidelines for assessing siltation and nutrients; therefore, use of TSS and silt/mud content as surrogate measures for siltation and use of ammonia-N as a surrogate measure for nutrients is appropriate. In addition, TSS and ammonia-N concentrations have exceeded applicable IEPA water quality guidelines according to historical data presented in Tables 2-2 and 2-3 in Appendix A. The use of DO as an indicator for nutrient loading is also appropriate because low DO concentrations are known to be linked to elevated nutrient loads. Furthermore, DO water quality standard violations have been observed in the Cedar Creek segment and are summarized in Tables 2-2 and 2-3 in Appendix A.

3.0 APPLICABLE WATER QUALITY STANDARDS AND NUMERIC WATER QUALITY TARGETS

All waters of Illinois are assigned one of the following four designations: general use waters, public and food processing water supplies, Lake Michigan, and secondary contact and indigenous aquatic life waters. Illinois waters must meet general use water quality standards unless they are subject to another specific designation (Title 35 of the *Illinois Administrative Code* [IAC], Section 302.201).

Although the segment of Cedar Creek addressed by this document is designated solely as general use, it was found to only partially support overall uses (1998 Illinois 303[d] list). According to the Illinois 305 (b) Report, partial support is defined as conditions under which water quality has been impaired but only to a minor degree. The general use standards (1) protect the state's water for aquatic life (except as provided in 35 IAC Section 302.213), wildlife, agricultural use, and most industrial uses, and (2) ensure the aesthetic quality of the state's aquatic environment. Primary contact uses are protected for all general use waters whose physical configuration permits such use. Impairment of the listed segment of Cedar Creek was assessed based on MBI values as described in Section 2.3. The Cedar Creek segment is impaired as a result of nutrients, siltation, and other habitat alterations that exceed water quality guidelines for general use waters (1998 Illinois 303[d] list). Illinois' general use designation supports swimming and fishing; however; this Cedar Creek TMDL document does not address swimming and fishing uses because of the physical limitations of the stream (shallow depth, intermittent flow, and the concrete channel).

As specified under 35 IAC, Subtitle C, Section 302.203, the applicable siltation standard is as follows:

> <u>Siltation</u>: Water of the State shall be free from sludge or bottom deposits. . .of other than natural origin. Illinois EPA has guidelines it uses to evaluate sediment quality with respect to selected parameters. Refer to: "Evaluation of Illinois Stream Sediment Data 1974-1980."

Illinois has also established guidelines for allowable concentrations of ammonia-N and TSS under its CWA Section 305(b) program. These guidelines serve as the TMDL endpoints for this analysis and represent the instream numeric targets for the identified pollutants. Because Cedar Creek is listed based on biological information, the endpoints are proposed to guide the selection of pollutant load reduction allocations. Once these endpoints are achieved, the biological status of the listed segment of Cedar Creek should improve.

Parameter	**TMDL Endpoint**
Ammonia-N	**0.41 mg/L**
TSS	**116 mg/L and less than 34 percent silt/ mud**

In addition, DO is being used as an indicator of stream conditions impacted by excess nutrient loading. As a result, the Illinois Water Quality Standard for DO is used as the TMDL endpoint for this analysis. This standard requires that the DO concentration shall not fall below 6.0 mg/L over a 16-hour period and never fall below 5.0 mg/L.

4.0 POLLUTANT LOAD MODELING

This section provides a general description of the modeling approach used to predict pollutant loads entering the listed segment of Cedar Creek. A more detailed description of the models and modeling approach is provided in Appendix A. Estimates of pollutant load contributions from nonpoint sources in the watershed were derived by applying the Storm Water Management Model (SWMM), Version 4.4. The steady-state water quality model QUAL2E was used to predict instream water quality parameters. Both models were calibrated with data collected by the U.S. Geological Survey (USGS) in 1985 and 1986.

Evaluation of sources of nonpoint pollutant loads entering the Cedar Creek segment identified agricultural and urban areas of the watershed as the main sources of loading. The SWMM and QUAL2E model determined that pollutant loads from point sources, which in this case include the 39 CSOs discharging to the Cedar Creek segment, were not a major factor impacting water quality during critical wet-weather flow conditions in the study area. This determination was made based on comparison of the relative magnitude of storm water volumes, sanitary flow volumes, and CSO volumes. These flow components were estimated using SWMM and are shown in Figures 3-11a through c in Appendix A. Although CSO events do contribute to the SOD load in the creek, according to modeling results, the CSO contribution to TSS and ammonia-N loads to the segment, compared to the contribution of storm water during large storm events to TSS and ammonia-N loads, was found to be small. Based on the SWMM results, TMDL allocation was therefore linked to nonpoint sources in the watershed, and loading rates were determined using the calibrated SWMM.

SWMM and QUAL2E model simulations identified two critical conditions of the listed creek segment: base-flow and first-flush events. Base flow is defined as the residual flow observed in the creek during periods between storm events and is contributed by groundwater. First-flush events are storm events that follow 2 or more dry-weather days or low-flow periods when runoff concentrations are expected to be elevated. Typically, the low-flow condition in the listed creek segment is characterized by the 7Q10 flow parameter, which is defined as the 7-day, 10-year low flow. This parameter could not be used for this analysis because an Illinois State Water Survey (ISWS) 1995 study estimated the 7Q10 in the studied segment of Cedar Creek to be zero (ISWS 1995). As a result, the SWMM analysis used first-flush storms with precipitation in the range of 0.2 to four inches and precipitation intensity of about one inch per hour as the critical flow condition. Precipitation of 0.2 to 1.0 inch did not result in CSOs; however, the resulting surface runoff tended to have elevated pollutant concentrations caused by the small runoff volumes. Monitoring data, precipitation data, and simulations of the SWMM and QUAL2E model showed that critical conditions occur from May through October. This time period was therefore the focus of the modeling effort.

Periodic water quality monitoring conducted along the listed segment of the creek from 1985 to 2000 and QUAL2E model simulations indicated that DO is the primary concern during base-flow conditions. TSS and ammonia-N are not of concern because groundwater, which is the source of water in the creek during base-flow conditions, contains low TSS and ammonia-N concentrations. The reason observed DO concentrations in the listed creek segment are below water quality standards is that the current level of reaeration rates are not sufficient to compensate for SOD. SOD is made up of sediment TSS loads, and residual effects from CSO events; however, the contribution of TSS loads and the residual effects from CSOs to SOD was not modeled. Low flows and shallow depths also cause extreme diurnal variations in the creek, which makes maintaining a DO above 6.0 mg/L difficult (USGS 1987, pages 98 through 108, 128 through 131, and 148, 149, 158 and 159; IEPA 1991, page 11; IEPA 1994, page 12; IEPA 2000, Table 2; GSD 1996 through 2000).

During first-flush events, TSS, ammonia-N, and DO are each of concern. TSS was detected at concentrations up to 1,420 mg/L during various storms in 1986, and the listed segment of the creek contained 65 percent silt/mud during a small storm in August 1999 with a precipitation of 0.3 inch and an intensity of 0.1 inch per hour (NCDC 1988 through 1999). According to Cedar Creek monitoring data, ammonia-N concentrations near the upstream agricultural area are most critical and require the greatest reduction. During a small August 1994 storm that had precipitation of 0.7 inch and precipitation intensity of 0.14 inch per hour, ammonia-N was detected at concentrations as high as 1 mg/L in the upstream segment of the creek (NCDC 1989 through 1999; USGS 1987; IEPA 2000).

5.0 LOAD ALLOCATIONS

After SWMM and the QUAL2E model were calibrated and validated as predictive tools, they were used to determine load allocations based on estimates of seasonal pollutant loads entering the listed segment of Cedar Creek. SWMM was used to determine seasonal loads of ammonia-N and TSS from May through October (the critical period) using 10 years of precipitation data, and the QUAL2E model was used to determine key factors causing impairment and adjustments needed to ensure compliance in the creek segment. Percent load reductions needed for compliance were calculated by comparing the typical loads during first-flush and base-flow events with the loads needed to ensure that the water quality guidelines for ammonia-N (0.41 mg/L), TSS (116 mg/L), silt/mud content (less than 34 percent) and water quality standards for DO would be met.

SWMM was used to predict the loads of ammonia-N and TSS, and the QUAL2E model was then used to determine the instream concentrations of ammonia-N and DO. QUAL2E does not have the capability to predict changes in SOD rates caused by TSS or CSO loads. QUAL2E, however, uses SOD rates as a model parameter to calculate DO concentrations. QUAL2E was not used to model instream TSS concentrations. For the purposes of this study, TSS concentrations predicted by SWMM are assumed to be average instream concentrations.

To calculate the typical seasonal loads during the critical season, the calibrated SWMM was used in “continuous mode.” The minimum data required for continuous simulation include continuous records of precipitation, temperature, and evaporation rates at hourly intervals. In the case of Cedar Creek, such data were not available in the Cedar Creek watershed. The National Oceanic and Atmospheric Administration (NOAA) gage at Galesburg reports only daily precipitation totals and has long periods of missing records. The nearest station with continuous hourly precipitation and temperature records is the NOAA gage at Alexis, which is located approximately 20 miles west of Galesburg. This gage contains hourly precipitation and temperature data from May 1989 through June 1999. Although storm patterns in Galesburg and Alexis may differ, the two locations were assumed to be similar climatically for the purposes of estimating and planning level pollutant loads. Based on experience, water quality violations are likely to occur during the summer dry period between May and October. To develop TMDLs, model results for 10 years of simulation were used to establish average seasonal loads. The SWMM was run using data for May 1 to October 31 of each year for 10 consecutive years. Maximum pollutant concentrations and total seasonal loads for ammonia-N and TSS were computed. Reductions needed to achieve TMDLs and the rationale for load allocation are discussed below.

5.1 REDUCTIONS NEEDED TO ACHIEVE TMDLs

The assimilative capacity of the listed segment of the creek was established by determining inflow concentrations that will not result in violations of the applicable standards or concentrations exceeding applicable guidelines during the critical period. These concentrations were determined using the calibrated QUAL2E model. The percent load reductions from each source necessary to meet the target were used because concentrations were assumed to be the same as the percentage reduction in concentrations and loads are proportional to flow. The difference between the computed maximum seasonal concentrations of ammonia-N and TSS in agricultural and urban runoff and the target concentrations was expressed as a percentage of the target concentration. Details on the use of SWMM and the QUAL2E model for predicting reductions needed to achieve TMDL endpoints are provided in Appendix A.

DO is the primary concern during base-flow conditions. Ammonia-N concentrations measured in the creek segment during low-flow conditions ranged from about 0.1 to 0.2 mg/L, which is below the guideline for ammonia-N. TSS concentrations measured in the creek during low-flow conditions were typically less than 50 mg/L, which is also below its guideline. However, DO has been measured at levels as low as 1.1 mg/L at various locations along the creek during low-flow conditions. Elevated SOD rates and low reaeration rates are the primary causes of DO violations in the creek. The low flow rates and low turbulence of the creek contribute to low reaeration rates. SOD rates also are increased from residual effects of TSS loads during CSO events; however, the residual contribution of CSOs was not explicitly modeled. Low flows and shallow depths also cause extreme diurnal variations in the creek, which makes maintaining a DO concentration above 6.0 mg/L difficult. In addition, DO concentrations above 6 mg/L cannot be maintained because flow is contributed by groundwater, which typically has DO concentrations of about 2 mg/L. The headwater portion of the creek therefore will remain in violation of the DO standard of 6 mg/L. To determine the adjustments in SOD and reaeration rate needed to ensure that Cedar Creek will meet DO standards, QUAL2E model simulations were run using decreasing SOD rates and increasing reaeration coefficients until the modeled DO concentration did not fall below 6.0 mg/L. A reaeration coefficient is a QUAL2E model input parameter with units of "per day"that directly corresponds to the reaeration rate. The reaeration coefficients that correspond to the creek's current reaeration rates are eight per day (base e) in the concrete portion and 10 per day (base e) in the unlined portion. The creek's current reaeration coefficients are summarized in Table 4-1 in Appendix A. Table 2 shows the percent decrease in SOD rates and target reaeration coefficients needed to ensure that no violations of DO water quality standards occur along the creek segment below the headwaters during low flow. The adjustments do not ensure compliance with DO standards in the headwaters during base flow because groundwater, which is the sole source of base flow in the headwater, typically has concentrations around 2.0 mg/L.

Table 2. Possible Combinations of Reaeration and SOD Adjustments In Cedar Creek to Ensure Compliance with DO Water Quality Standards During Low Flow[a,b]

Decrease in SOD Rate (percent)	Target Reaeration Coefficient for Natural Channel (per day, base e)	Target Reaeration Coefficient for Concrete Channel (per day, base e)
0	22	20
50	20	18
100	16	14

Notes:

SOD Sediment oxygen demand
[a] DO endpoint is 6.0 mg/L
[b] These adjustments do not ensure compliance with DO water quality standards in the headwaters during base flow because groundwater, which is the sole source of base flow in the headwaters, typically has DO concentrations as low as 2.0 mg/L.

Table 3. Daily Load Reductions

Source	Modeled Current Seasonal Load[a] (lb/day)	Percent Load Reduction	Load Reduction to Meet Water Quality Guidelines (lb/day)	Maximum Allowable Load[b] (lb/day)
Ammonia-N				
Agricultural area (1.8 mi^2)	0.15	50	0.075	0.075
Urban area (9.8 mi^2)	1.52	22	0.34	1.18
TSS				
Agricultural area (1.8 mi^2)	368[c]	93	341	27
Urban area (9.8 mi^2)	4,489[c]	83	3,725	764

Notes:

Ammonia-N	Ammonia-nitrogen
lb/day	Pound per day
mi^2	Square mile
TSS	Total suspended solids

[a] Total loads computed by SWMM for summer season were divided by 184 to calculate daily loads.

[b] See Table 4 for final TMDL allocations, including margins of safety.

[c] The load allocations do not represent 'sediment yields,' they refer specifically to TSS. TSS and 'sediment yields' may be correlated but are not equivalent. Total sediment loads carried by a stream can be many times TSS loads, and may be composed of sediment loads from both land erosion and stream channel erosion, depending on hydraulic and geomorphic factors. The rationale for TSS as a surrogate for siltation is that low TSS indicates reduction of siltation.

The daily reductions in TSS and ammonia-N loads needed to meet state guidelines are listed in Table 3. The total loads computed by SWMM for May through October were converted to daily loads by dividing them by 184. Because seasonal loads are proportional to the average seasonal flow, the load reductions needed to achieve compliance were determined by proportionate reductions in predicted event mean concentrations (EMC) to the target concentrations. For example, if the predicted maximum seasonal EMC for ammonia-N is C_{NH3}, the percent load reduction needed was calculated as (C_{NH3}-Target C_{NH3})/Target C_{NH3}. The reduction in TSS is assumed to directly relate to a reduction in silt/mud concentration. Therefore, a 83 to 93 percent reduction in TSS is assumed to yield a 83 to 93 percent reduction in silt/mud content. Because a silt/mud content of 65 percent was the maximum content observed along the listed segment of the creek, a 83 to 93 percent reduction would yield a silt/mud content less than 34 percent.

5.2 SOURCES OF POLLUTANT LOAD

The sources of pollutant loads to Cedar Creek considered in the modeling effort include nonpoint source runoff from the agricultural and urban portions of the watershed.

5.3 RATIONALE FOR LOAD ALLOCATION

The load allocation is based on the evaluation of the sources of pollutant loads entering the stream from the watershed. The pollutant loads, namely ammonia-N and TSS, have been linked to impairment of the listed stream segment. The magnitudes of the loads were determined using a quantitative procedure based on instream measurements for the critical period from May through October and use of the calibrated SWMM and QUAL2E model. The needed load reductions are based on target concentrations that Illinois has established as allowable under its CWA Section 305(b) Program. Therefore, implementation of proposed load reductions by means of best management practices is expected to bring the listed stream segment into compliance. Specific BMPs are recommended in Section 9.0.

6.0 LOAD ALLOCATION UNCERTAINTIES AND MARGINS OF SAFETY

Pollutant loads from nonpoint sources were determined using the calibrated SWMM and the QUAL2E model. The development of these models involved making assumptions and simplifications that introduce uncertainty in the predicted loads. The main assumptions and simplifications are summarized below.

- Model calibration and validation was based on data from May through October 1986 only. This data set was sufficient to establish critical conditions for creek impairment and to link the causes of impairment to the sources. The validity of the calibration and the resulting simulation is therefore based on the assumption that the 1986 season data set represented typical yearly water quality trends in the stream. This assumption is reasonable because monthly precipitation and temperature records for 1986 are within the expected range of monthly precipitation and temperature records from 1961 through 1990 (MRCC 2000). By using the minimum values of predicted constituent concentrations, a margin of error is included in the predicted loads.

- Calibration of flow and pollutant concentrations was based on single-point observations that may not be representative of the complete flow hydrographs or pollutographs from the watershed. The load predictions reflect the uncertainty of the concentration values.

- Modeling of TSS loads by the SWMM is simplified. SWMM ignores the detailed mechanisms of erosion, transport, and deposition of sediment. No attempt was made to quantify the TSS loads attributed to stream bank or stream bed erosion because the detailed input data (such as soil data, stream geometry, and flow rates) and monitoring data needed to perform such detailed analyses were not available. The above simplifications thus introduce uncertainty in the predicted TSS loads that must be considered in assessing the overall margin of safety of the load allocations.

- The load allocations are based on maximum concentrations predicted from May through October. Such concentrations rarely occur throughout the year. This procedure is expected to result in conservative load predictions.

- The residual contribution of CSOs to SOD was not modeled. CSOs that occur during storms contribute to TSS loads, and TSS loads from CSOs have higher SOD compared to TSS loads from agricultural areas; however, CSOs do not occur during the low-flow critical time period and their residual effects were not modeled. The above simplification introduces uncertainty in TSS loads and SOD that must be considered in assessing the overall margin of safety.

Because of the lack of sufficient water quality data for calibrating the models and the potential for additional TSS and ammonia-N loads not accounted for in the analysis, a margin of safety of 20 percent is assigned to account for these uncertainties. This figure should be reasonable because a 20 percent margin of safety is consistent with other TMDLs approved by EPA that have similar data limitations and model calibration uncertainties. The resulting required load reductions are summarized in Table 4.

Table 4. Load Allocations with Margins of Safety

Source	Load Allocation (lb/day)	Margin of Safety (lb/day)	Maximum Allowable Load (lb/day)
Ammonia-N			
Agricultural area (1.8 mi^2)	0.06	0.015	0.075
Urban area (9.8 mi^2)	0.94	0.24	1.18
TSS			
Agricultural area (1.8 mi^2)	21.6	5.4	27
Urban area (9.8 mi^2)	611	153	764

Note:

Ammonia-N	Ammonia-nitrogen
lb/day	Pound per day
mi^2	Square mile
TSS	Total suspended solids

The waste load allocation is zero because point loads from CSOs along the listed segment were determined to be negligible compared to the nonpoint sources.

7.0 SEASONAL VARIATIONS

The critical period for compliance with water quality standards and guidelines is created by a combination of high temperatures and low-flow conditions in the listed segment. An analysis of low-flow conditions for the listed segment of Cedar Creek established that the critical period for meeting the established target DO and ammonia-N levels is from May through October. The 7Q10 is estimated to be 0 to 1 ft^3/s. Low-flow conditions consist of base flow associated with DO levels below 5.0 mg/L and “first-flush” events that tend to be accompanied by ammonia-N concentrations in runoff that exceed the target concentrations. The period also includes spring storms responsible for siltation (ISWS 1995; USGS 1987).

In November to April, the listed segment generally has low temperatures and higher flows than observed during May through October. These conditions are unlikely to result in low DO concentrations or ammonia-N concentrations that exceed the guidelines. Because the seasonal loads were predicted using precipitation data from storms over a 10-year period from 1989 through 1999, yearly variations are most likely to have been taken into account so that the results reflect reliable yearly patterns of loads entering the Cedar Creek segment.

8.0 MONITORING PLAN

IEPA will continue to monitor ammonia-N, TSS, and DO levels in the listed segment of Cedar Creek. Water samples will be collected at least once every five years or at an interval determined to be sufficient by IEPA to evaluate possible threats to public health and aquatic life and to determine progress in meeting the TMDLs. The water body will remain listed until the water quality standards and guidelines are achieved and further load reductions are no longer needed.

9.0 IMPLEMENTATION ACTIVITIES

The implementation activities recommended below will reduce nonpoint source loads identified during the modeling effort. These BMPs were selected based on criteria such as effectiveness, feasibility, and cost. The discussion focuses on the effectiveness or "technical merits"of each BMP. Implementation approaches are also discussed in Section 9.2.

9.1 BEST MANAGEMENT PRACTICES

A variety of BMPs were considered to increase DO concentrations and reduce ammonia-N and TSS loads. These BMPs are described below, and the proposed locations of these BMPs are shown in Figure 2. Note that these BMPs do not explicitly address SOD reduction; however, reductions in TSS loads and CSOs will result in reductions in SOD rates. All of the BMPs described below would, in combination, achieve the required load reductions. The following three groups of BMPs are described below:

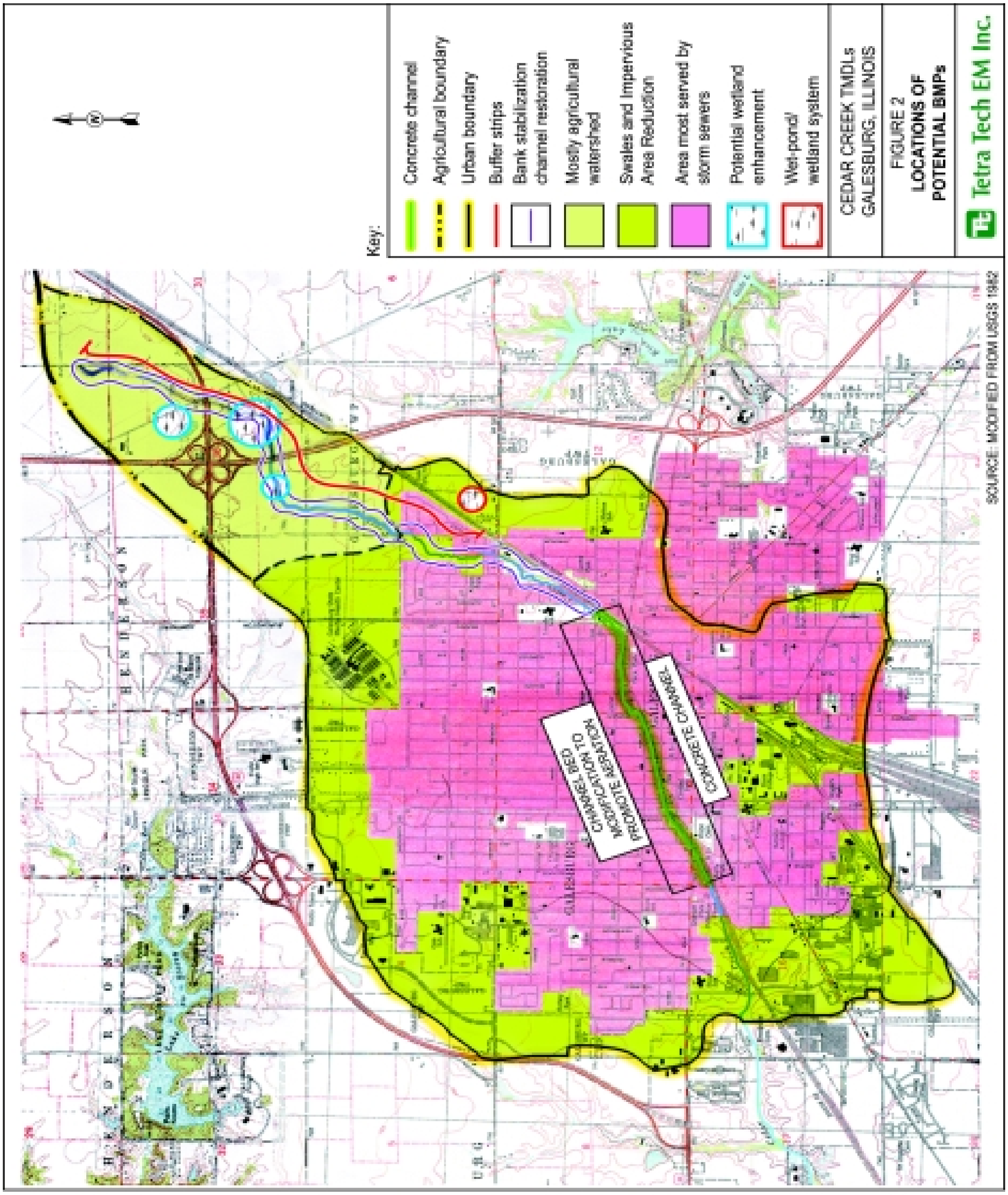
- Channel modification to increase DO
- Agricultural BMPs
- Urban BMPs

CHANNEL MODIFICATION TO INCREASE DO

The QUAL2E water quality model demonstrated that the current level of natural reaeration coefficients ranging from eight to 10 per day (base e) observed in the creek segment in addition to high SOD rates are one of the key factors contributing to low DO concentrations in Cedar Creek (USGS 1989a). In order to comply with the state minimum limits for DO, reaeration in the stream channel will need to be increased to correspond to a target reaeration coefficient of about 22 per day (base e) in the unlined portion and 20 per day (base e) in the concrete-lined portion of the segment. The headwater portion of the creek will not achieve the state water quality standard of 6 mg/L for DO because flow is contributed by groundwater, which has typically low DO concentrations below 6 mg/L and there is no known cost effective method of increasing DO concentrations at this location (Table 2). The unpaved reaches of the Cedar Creek segment are one to two feet wide without any flood plain. The channel banks are steep (side-slope greater than 1:1) and are apparently susceptible to erosion, especially during moderate to large runoff events (storms with at least 1 inch of precipitation and with an intensity of at least one inch per hour). The channel bed slopes range from 11 feet per mile to 26 feet per mile and do not have significant pool and riffle sequences, which are known to promote reaeration. The existing reaeration coefficients are about 10 per day (base e) in the unlined channel and eight per day (base e) in the concrete-lined channel based on reaeration measurements in the creek and reaeration coefficients cited in the literature (see Table 4-1 in Appendix A).

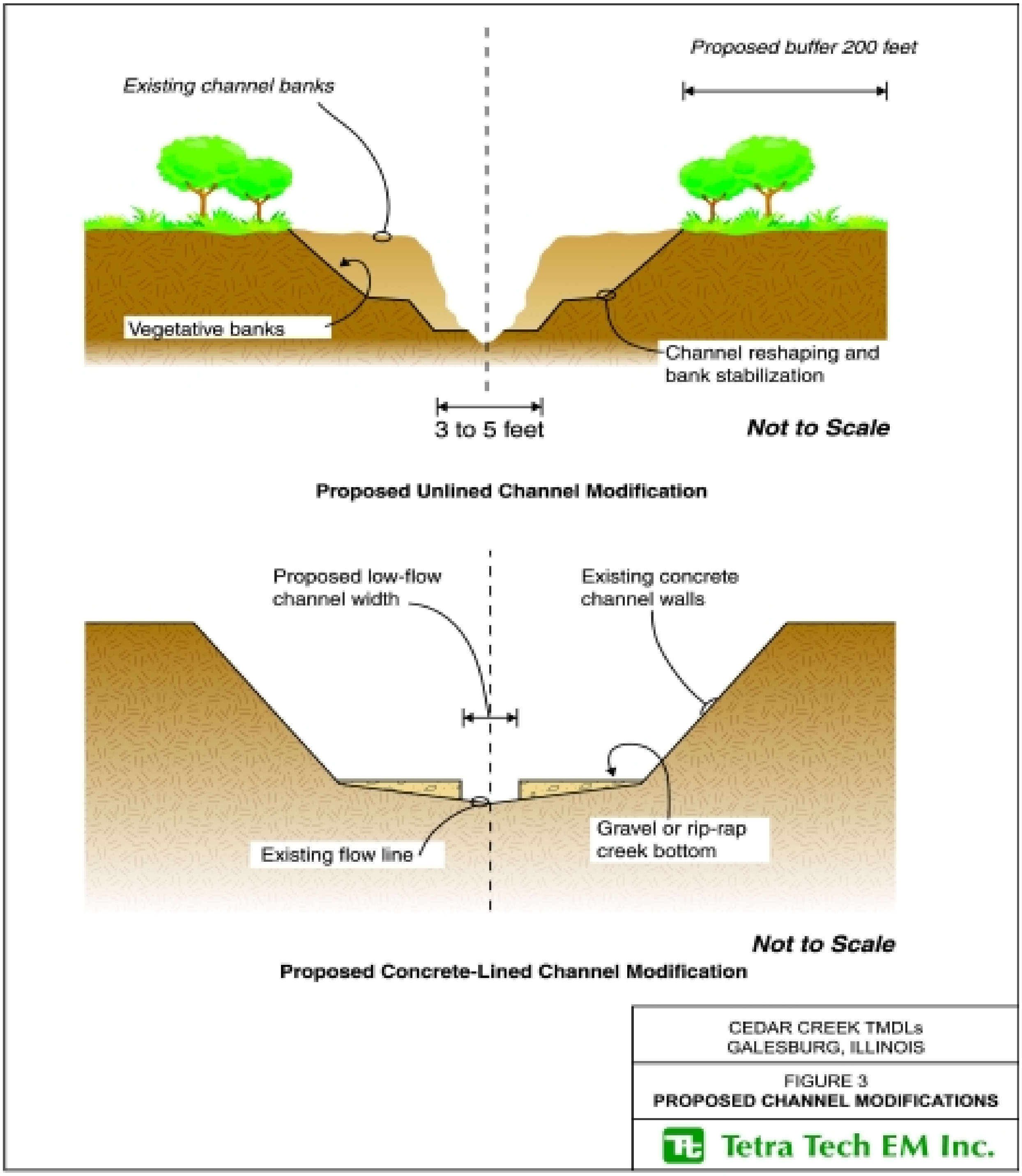
Channel modifications that are known to improve natural reaeration include (1) reshaping channel banks to improve stability and restore native vegetation such as woody species, (2) reshaping the channel cross section to provide a wider bottom and a flood plain, and (3) creating some type of pool and riffle sequence to increase turbulence. In addition, instream restorative measures are typically implemented in conjunction with the creation of buffer strips along the channels to promote channel bank stability and to reduce erosion (see Figure 3).

FIGURE 2
LOCATIONS OF POTENTIAL BMPs



20

FIGURE 3
PROPOSED CHANNEL MODIFICATIONS



21

The reshaping of channel banks and cross sections can be implemented along the 3.4-mile unlined portion of the creek upstream from Losey Street and the 0.8-mile unlined segment downstream of the concrete segment. According to USGS, the length of the unlined segment upstream from Losey Street is 4.5 miles (USGS 1989b); however, the exact location of the start of the creek is not well defined. Determination of the length of the upstream, unlined portion for this study was based on USGS topographic maps and knowledge of the total length of the segment and the length of the concrete channel. The total segment length is 5.95 miles and the length of the concrete channel is 1.8 miles, leaving only 4.15 miles of natural channel (USGS 1982 and 1987). Although reshaping channel banks and cross sections is known to improve reaeration, the level of its effectiveness will need to be verified through monitoring. In addition, an evaluation of impacts of proposed modifications on creek conveyance would be included in the final design since the creek is mapped as a regulatory floodway.

The third option, creating a pool and riffle sequence, is the only option that can be implemented in the concrete-lined portion of the listed segment. Three types of pool and riffle sequences can be created to increase turbulence and improve reaeration in the 1.8-mile concrete-lined portion of the listed segment. The first pool and riffle sequence involves altering the existing flow line located at the centerline of the concrete bottom. The existing V-shape flow line is formed by the gently sloping channel bottom as shown in Figure 3. During low-flow periods, low velocity shallow-depth flow in the lined portion result in laminar flow conditions associated with low DO. Modifying the flow line to create a narrow, well-defined, low-flow channel at the channel centerline would increase DO levels by creating higher velocity turbulent conditions. Such flow conditions will tend to reduce silt deposition in the channel and therefore also reduce SOD rates. Available empirical formulas can be used as a guide for estimating the proper depth-to-width ratios that would result in higher reaeration coefficients. For example, the Parkhurst and Pomeroy formula (EPA 1985) that was derived from measurements in natural small streams can be used. According to this formula, a flow rate of 2 cubic feet per second in a channel that is 1.6 feet wide and 0.5 feet deep is expected to result in a reaeration coefficient of about 33/day (base e). In addition, turbulent conditions will result from such a channel configuration. The second type of pool and riffle sequence involves installing alternating baffle blocks across the middle third of the channel bottom along the entire concrete-lined portion. The baffle blocks will enhance reaeration by promoting turbulent conditions. The third type of pool and riffle sequence involves increasing the channel bed roughness (Manning’s coefficient) to promote turbulent mixing. Channel bed roughness can be increased by relining the bed with coarse gravel. The effectiveness of the proposed channel configurations to increase turbulence and promote aeration will need to be verified by field measurements. Sediment accumulation is a key factor that will need to be monitored when verifying the effectiveness of the proposed channel configurations. However, sediment accumulation should not be a problem because the proposed measures would increase velocities, decreasing sediment deposition. An evaluation of the impacts of proposed modifications on the creek conveyance should also be verified.

Although the effectiveness of the proposed channel configurations will need to be verified by field measurements, a comparison of the existing aeration conditions in the listed segment of creek with unaltered, natural streams of similar size suggest that such restorative measures may improve the reaeration and corresponding reaeration coefficients to the degree needed. No empirical relations have been developed that can be used to estimate the reaeration coefficients after improvements to channels have been made; however, a literature review indicated that reaeration coefficients of stream with hydraulic conditions comparable to the Cedar Creek segment can be as high as 40 per day (base e) (Wilcock and others 1998 and Smoot 1989). In addition, BMPs for reducing TSS loads and CSO events will reduce SOD rates, which were identified as key factors contributing to DO concentrations below the water quality standards during low-flow conditions. Therefore, achieving a reaeration coefficient of 22 per day (base e) should be feasible, but must be verified with field measurements.

AGRICULTURAL BMPs

Agricultural BMPs include restoration and improvement of wetland systems, construction of buffer strips, and nutrient management plans. Each option is discussed below.

Restoration and Improvement of Wetland Systems

The National Wetlands Inventory map for the Galesburg East quadrangle shows wetland sites at several locations contiguous to the listed segment of Cedar Creek (National Wetlands Inventory 1988). The most prominent location is near the intersection of Interstate 74 and Northern Burlington Railroad. Three potential wetland enhancement sites are identified in Figure 2. Initial planning efforts to improve these wetlands are underway, involving the National Resource Conservation Service (NRCS) and the property owners. Restoration and enhancement of these wetlands can present an opportunity to improve the quality of runoff from the agricultural area by reducing ammonia-N and TSS loads provided the drainage system in the vicinity of the wetlands is modified to direct and detain the runoff in the wetland complex. Figure 2 indicates that Cedar Creek at the location of the wetlands serves about a third of the agricultural area. It is anticipated that the reduction of TSS loads will also reduce sediment deposition in the listed segment, which in turn will result in reduction of SOD rates.

Nutrient removal in wetland systems occurs through settling and by biological uptake. Most aquatic and wetland plants uptake nutrients from sediment through root systems rather than from the water column. Removal rates can be quite variable throughout the year, with high removal rates in the growing season. Removal rates, however, are sometimes low in the fall and winter because of floating, dead plant material released from the basin and complex nutrient cycling patterns often associated with wetlands. Healthy wetland detention systems can have sediment removal rates of 60 to 100 percent and nutrient removal rates of 20 to 60 percent. A discussion of the use of wetlands to control nonpoint sources is presented in Denison and Tilton 1993 (see references listed at the end of this document). Detailed procedures for re-establishing wetlands or enhancing existing wetlands are not presented here because these procedures are site-specific.

The feasibility of implementing this BMP will depend to a great extent on the cooperation of the Illinois Department of Transportation (IDOT) and agreement from the property owners. Highway culvert crossings, roadside ditches, and storm sewers within IDOT's right-of-way modify the drainage pattern in the vicinity of the proposed wetland sites. IDOT approval for proposed construction activity within the IDOT right-of-way is needed. In addition, re-established wetlands survive best when native vegetation is used.

Buffer Strips to Improve Water Quality

Buffer strips, which are areas of grass or other permanent vegetation, can maintain or improve water quality by reducing sediment, organics, nutrients, pesticides, and other contaminants in runoff. Buffer strips are recommended because of their effectiveness in reducing dissolved contaminants such as ammonia-N in areas between croplands and water bodies. Buffer strips have been found to be one of the most effective BMPs to reduce nitrogen loads, including ammonia-N. Based on laboratory data and field studies, buffer strips remove approximately 79 percent of ammonia when used in conjunction with nutrient management (EPA 1999). The case studies summarized below illustrate the effectiveness of buffer strips (USDA 1999).

- In Arkansas, two studies concluded that sediment and nutrients in runoff (including nitrogen and phosphorus) from poultry- and swine-manured fields were significantly reduced in the first 10 feet of an area where a tall fescue grass buffer was grown on Captina silt loam soil. Further lengthening of the buffer strip beyond 30 feet did not significantly reduce the contaminant load of the runoff water.

- In Montana, the trapping efficiency and nutrient uptake of four grasses in a buffer strip were measured to treat dairy manure in runoff. Orchard grass and meadow bromegrass were effective at both entrapping the nutrients in the runoff and absorbing the nitrogen into the plant biomass within the upper 20 feet of the buffer.

In addition to reducing the amount of ammonia-N, buffer strips provide additional benefits:

- Buffer strips can contribute to landscape aesthetics by providing contrasting colors and textures.

- Wildlife habitat is enhanced when some part of the cropland area is converted to permanent vegetation. Besides providing shelter, nesting sites, and a food source, buffer strips also create corridors for wildlife movement.

- Permanent vegetation along watercourses and drainageways helps stabilize the adjacent area. The width of buffer strips provides distance from the edge of the watercourse so that equipment does not damage the area.

- Companion legumes in buffer strips have value and can be harvested. Alfalfa is a companion legume that can have different uses such as commercial hay, various types of livestock operations, and other uses.

The effectiveness of buffer strips depends on many parameters. The key parameters include overland flow velocity and depth, vegetation, and width. Based on field experience, ideal slopes for buffer strips range from 2 to 6 percent. For preliminary design purposes, the required widths of buffer strips can be estimated from Table 5. In the case of Cedar Creek, a minimum application setback width of 66 feet is required as a restriction associated with the use of atrazine, an herbicide used on farmlands in the watershed (Tetra Tech 2000b).

In Cedar Creek, buffer strips can be used in the agricultural area upstream from Farnham Road. Initial buffer strip installation is being conducted along Cedar Creek between Interstate 74 and Farnham Road. The NRCS has provided technical assistance to the property owner who is currently installing buffer strips about 200 feet wide on each side of the creek channel. In addition to the above location, NRCS has been working with the other property owners to install buffer strips along the remaining segment of Cedar Creek in the agricultural area.

Ongoing studies at the University of Illinois Urbana-Champaign involve the use of buffer strips to filter outflow from drain tiles in agricultural areas. No results are available to date regarding the effectiveness of this technique. If successful, the technique can be applied to the tiled area contiguous to Cedar Creek. The choice of vegetation should be based on climate conditions, intended functions of the buffer, desired by-products, and soil characteristics. Soil characteristics for the agricultural area of the Cedar Creek watershed needed to determine buffer strip vegetation are summarized in Table 6.

Table 5. Buffer Strip Width Based on Land Slopes[a]

Percent Slope	Buffer Strip Width (feet)					
	0.5	1.0	2.0	3.0	4.0	5.0 or greater
Minimum	36	54	72	90	108	117
Maximum	72	108	144	180	216	234

Source: NRCS 1999

Notes:

[a] Proposed buffer strip widths will achieve a minimum water flowthrough time of 15 and 30 minutes at a 0.5-inch flow depth.

Table 6. Soil Data For Agricultural Area in Cedar Creek Watershed Needed to Determine Buffer Strip Vegetation

Parameter	Tama Series	Ipava Series	Sable Series
Slope (%)	1 to 5 (up to 10 in a few areas)	0 to 3	0 to 2
Drainage	Moderate	Poor	Poor
Surface Soil	Black to dark grayish brown, friable silty clay loam 4 to 8 inches thick	Black, friable silt loam (top 10 inches); very dark grayish brown, friable silty clay loam (lower 8 inches)	Black, friable silty clay loam (top 6 inches); black and very dark gray, friable silty clay loam (lower 15 inches)
Subsurface Soil	Friable silty clay loam 34 to 38 inches thick	Mottled and friable silty clay loam	Dark grayish brown and gray, mottled, friable, and firm silty clay loam 23 inches thick
Organic Matter (%)	3 to 4	4 to 5	5 to 6
High Water Table (feet)	4 to 6	1 to 3	Less than 2
Permeability (inches per hour)	0.6 to 2	0.6 to 2 (surface) 0.2 to 0.6 (subsurface and subsoil)	0.6 to 2

Nutrient Management Plans

In addition to the BMPs recommended above, nutrient management plans can also reduce loads to the listed segment of Cedar Creek. Nutrient management can be applied to most of the watershed and therefore is not shown in Figure 2. Nutrient management involves managing the source, rate, form, timing, and placement of nutrients. Nutrient management can be a component of a conservation management system used in conjunction with conservation buffer strips to reduce the amount of ammonia-N in the listed segment.

The objectives of nutrient management are to effectively and efficiently use scarce nutrient resources to adequately supply soils and plants to produce food, forage, fiber, and cover while achieving environmental goals. Nutrient management is applicable to all lands where plant nutrients and soil amendments are applied.

Typical nutrient management components of conservation plans may include the following information:

- Field and soil maps
- Crop rotation or sequence
- Results of soil, water, plant, and organic material samples analyses
- Expected yield
- Sources of nutrients to be applied
- Nutrient budget, including credits of nutrients available
- Recommended nutrient rates, form, timing, and method of application
- Locations of designated sensitive areas
- Guidelines for operation and maintenance

General nutrient management considerations may include the following:

- Testing of soils, plants, water, and organic material for nutrient content
- Realistic yield goals
- Nutrient application in accordance with soil test recommendations
- Nutrient credits from all sources
- Effects of drought or excess moisture on quantities of available nutrients
- Water budgeting to guide timing of nutrient applications
- Use of cover crops and green manure whenever possible to recover and retain residual nitrogen and other nutrients between cropping periods
- Use of split applications of nitrogen fertilizer for greater nutrient efficiency

Guidelines for plan operation and maintenance are summarized below.

- Review the nutrient management component of the conservation plan annually, and make adjustments when needed.
- Calibrate application equipment to ensure uniform distribution and accurate application rates.
- Protect nutrient storage areas from weather to minimize runoff and leakage.
- Avoid unnecessary exposure to fertilizer and organic wastes, and wear protective clothing when necessary.

- Observe setback distances required for nutrient applications adjacent to water bodies, drainageways, and other sensitive areas.
- Maintain records of nutrient application.
- Clean up residual material from equipment and dispose of properly.

A nutrient management plan also includes an assessment of site-specific potential environmental risks. For example, a nutrient management plan should include an assessment of the potential risk for nitrogen and phosphorus to impact water quality. Areas that may have high levels of nutrients (produced or applied) and thus may contribute to environmental degradation must be considered, and appropriate conservation practices and management techniques must be implemented to mitigate any unacceptable risks.

URBAN BMPs

The GSD is presently operating under National Pollutant Discharge Elimination System (NPDES) Permit No. IL 0023141, which requires special conditions for addressing CSOs and treatment plant bypasses. To comply with NPDES permit requirements, the GSD and the city of Galesburg currently implement BMPs that collectively will result in TSS and ammonia-N load reductions to the listed segment of Cedar Creek. Additional BMP implementation will be required to achieve the TMDL load allocations. A list of currently implemented and recommended BMPs is presented below. A detailed description of these measures is presented in GSD 2000 (see references listed at end of document). The table below summarizes urban BMPs.

BMP	Structural or Nonstructural	Status
Use of swales and impervious area reduction	Structural	Proposed for implementation
CSO reduction (construction of a new interceptor and raising of overflow weir elevation)	Structural	Currently being implemented
Sanitary sewer replacement	Structural	Currently being implemented
Roof drain disconnection	Structural	Currently being implemented
Use of wet-pond/wetland system	Structural	Proposed for implementation
Elimination of illicit connections	Structural	Currently being implemented
Street sweeping program	Nonstructural	Currently being implemented
Hazardous waste collection program	Nonstructural	Currently being implemented
Storm drain stenciling	Nonstructural	Proposed for implementation
Lawn management practices	Nonstructural	Proposed for implementation

Structural BMPs are discussed below, followed by nonstructural BMPs.

Structural BMPs

Use of Swales and Impervious Area Reduction in Urbanized Areas -- Current land-use maps of the watershed indicate that the urbanized watershed that includes the city of Galesburg contains 10 to 15 percent undeveloped land. The undeveloped portion within the urban area is shown as the unshaded area in Figure 1. Appropriate BMPs for new developments in these undeveloped areas are the use of grassed swales to minimize impervious areas by providing grassed medians and broad, vegetated roadside ditches. Swales are an effective and low-cost means of conveying storm water. For new developments, swales can be a cost-effective alternative to curb-and-gutter and storm sewer drainage structures. Typically, vegetated swales cost $7 to $10 per linear foot compared to $14 to $20 per linear foot for curb-and-gutter systems. For older developments, swales can provide runoff pretreatment before runoff is discharged into existing storm sewers. Swales remove heavier solids in runoff through settling. Infiltration in swales can also remove dissolved solids in runoff during smaller storm events. TSS removal rates of 20 to 40 percent in swales are reported (Denison and Tilton 1993).

In addition to water quality benefits, swales reduce runoff volumes by infiltration, which can be augmented through the use of deep-rooted native vegetation such as prairie grasses. Maintenance is needed to ensure an adequate, water-absorbing sod layer. Periodic mowing of grasses and inspections to correct for erosion and channel scour are generally sufficient to maintain the swale's beneficial functions.

CSO Reduction -- A new, 60-inch-diameter Cedar Creek interceptor that feeds into the WWTP has been constructed, replacing the old 48-inch-diameter interceptor beginning from the WWTP to Arthur Avenue (see Figure 3-3 in Appendix A). From Arthur Avenue, approximately 745 feet of new, 36-inch-diameter pipe replaces the old interceptor. By increasing the capacity of the interceptor, pollutant loads to the listed segment are reduced because of the reduced frequency and severity of CSO events. The new interceptor provides an additional storage of about 0.6 acre-foot over the original storage of 2.6 acre-foot provided by the old interceptor. CSOs occur when water levels in the overflow manholes exceed the outfall weir elevations or outfall pipe inverts. The increased capacity of the interceptor reduces CSO events by lowering the high water elevations in the conduit systems at the overflow locations during storms.

Further reduction of CSOs has been accomplished by raising overflow weir elevations to allow additional storage in the conveyance system during wet-weather flows. A monitoring plan that includes visual inspections and timers to record CSO events has been in place since the 1980s. Water samples are collected during CSO events for ultimate carbonaceous biochemical oxygen demand (BOD) and TSS monitoring.

According to the GSD, the above measures have been very effective in reducing both the frequency and duration of CSO events. GSD data indicate that overflow durations have been reduced by about 74 percent from 1987 to 1999, and the frequency of CSOs has been reduced by 85 percent during the same period (GSD 2000). SWMM simulations of the upgraded sewer system seem to support the observations that significant reductions in CSO events have occurred. Because an uncalibrated SWMM model was used in these simulations, quantitative estimates of the overflow volumes could not be made. Reducing CSO events also reduces TSS and ammonia-N loads conveyed by sanitary flow.

Sanitary Sewer Replacement -- Old sanitary sewers are being replaced by new sewers with water-tight joints that prevent infiltration. Also, new storm sewers are now constructed with tighter joints. Presently, infiltration into the sanitary system accounts for more than three times the average dry (nonstorm) weather flows. Reducing infiltration into the sanitary system would benefit the listed segment by further reducing CSOs.

Roof Drain Disconnection -- All downspouts from the sanitary sewer system have been disconnected. The roof drains are now directed to pervious areas to promote infiltration. This measure will need further evaluation because infiltration in the vicinity of resident basements may promote illicit installation of sump pumps. Disconnection of roof drains into the sanitary system would benefit the listed segment by reducing wet-weather sanitary flows, which in turn would reduce CSOs. The benefit of disconnecting the roof drain is compromised in situations where the topography slopes towards the foundation because the rain water will have an easy path to the foundation drains, which are still connected to the sanitary system. Such infiltration to the foundation drains can be minimized if a positive grade away from the building is provided. Alternatively, such flows can be directed to the storm sewer system or sufficiently far from the structure if space allows. The City or District can give guidelines to assist residents to choose the most effective ways of placing disconnected roof drains.

Use of Wet-Pond/Wetland System -- The city of Galesburg is planning to use a wet-pond/wetland system at a site located east of Lincoln Street and north of Freemont as shown in Figure 2. Conceptually, the wet-pond would cover approximately six acres and be used primarily as a storm water storage site. This storage is intended to alleviate flooding problems in nearby subdivisions. In addition to the wet-pond, an additional six acres would be constructed along the perimeter of the pond to function as a buffer and wetland system. Because inflow to this wet-pond/wetland system would be storm water, TSS loads and other storm water pollutants would be substantially reduced. Successful implementation of this project would require land acquisition and funding for the construction work. The city has earmarked some initial funds for the feasibility study of this option.

Elimination of Illicit Connections -- Illicit connections to the storm sewer system have been eliminated, including sump-pump discharges, nonstorm water discharges, and sanitary flows. Eliminating illicit connections benefits the listed segment by eliminating potential sources of pollutant loads to the listed segment.

Nonstructural BMPs

Street Sweeping Program -- The city of Galesburg has a street sweeping program from mid-March through December 1 that uses the following schedule based on recommendations discussed in Metropolitan Council 1994 (see reference listed at the end of this document):

- Downtown: Three times per week
- Main thoroughfare: Two times per week
- Residential side streets: Once a week

Street sweeping benefits the listed segment by reducing solids such as sand, debris, and litter that would otherwise be transported to the stream during rain events. The effectiveness of street sweeping for removing dissolved pollutants (such as ammonia) is questionable. Detailed studies on the effectiveness of street sweeping indicate that pollutants carried by the fine sediment fractions are not removed by existing street-cleaning equipment (Walker and Wong 1999).

Hazardous Waste Collection Program -- The city of Galesburg, in conjunction with IEPA, periodically conducts household hazardous material collection days under a materials storage and recycling program. This measure reduces the amount of hazardous materials disposed of through sanitary and storm sewer systems.

Storm Drain Stenciling -- To complement the urban BMPs currently practiced by the city of Galesburg, storm drain inlet stenciling is recommended. Storm drains frequently discharge runoff directly to water bodies without treatment; therefore, storm drain stenciling programs that educate residents not to dump materials into storm drain inlets or onto sidewalks, streets, parking lots, and gutters could be effective in reducing nonpoint source pollution associated with illegal dumping. Residents are frequently unaware that materials dumped down storm drains may be discharged to a local water body.

Lawn Management Practices -- Incorrect application of pesticides and fertilizer in an urban environment may contribute to storm water pollution. The University of Idaho Cooperative Extension System has developed BMPs for lawn care that are applicable to the urban area in Galesburg. These BMPs consist of the pesticide and fertilizer management components below.

Pesticide management practices require knowledge of lawn species, diseases, and problems. When a problem is identified, the following environmentally sound solutions are recommended:

- Hand-pulling weeds
- Changing water management as an alternative to fungicide use to control lawn disease
- Living with a low level of plant damage from insects
- Using nontoxic solutions to hinder pests such as integrated pest management

Correct pesticides use is also stressed, such as following label directions, matching pesticides with pests, using the correct application rate, and buying only the amount needed. In addition, lawn owners are advised to store and dispose of pesticides properly, buy only small quantities, and store them in secure areas. Finally, lawn owners should use water wisely and never overwater lawns.

Fertilizer management practices require knowledge of the nutrients used in fertilizers. Generally, lawns need addition of only four nutrients: nitrogen, phosphorus, potassium, and sulfur. Improper use of nitrogen and phosphorus fertilizers on lawns can negatively impact water quality. Proper fertilizer management BMPs for lawns are summarized below.

1. Base fertilizer application rates on a sound scientific strategy such as the following:

    - Determine length of lawn growing season in months.
    - Base nitrogen application on lawn growing season.
    - Base phosphorus, potassium, and sulfur applications on ratio to nitrogen, 1,000 square feet of lawn requires 0.5 pound of nitrogen per month of active growth
    - The ratio by weight is 3 nitrogen to 1 phosphorus to 2 potassium to 1 sulfur. Buy fertilizer with as close to a 3:1:2:1 ratio as possible or mix different fertilizers together to achieve the desired ratio.

2. Correctly time fertilizer applications.

   Apply fertilizer when lawn needs it. Use split applications (divide the total nutrient application by four) as follows:

   · 1/4 in early spring (Easter)
   · 1/4 in late spring (Memorial Day)
   · 1/4 in late summer (Labor Day)
   · 1/4 in fall (Halloween)

3. Use slow-release nitrogen fertilizers to improve nitrogen use efficiency and reduce leaching. Look for fertilizers with the word "WIN" on the bag. "WIN" stands for "water insoluble nitrogen," a slow-release fertilizer.

4. Use water wisely on lawns. Water at optimal times and deeply (six inches) a couple of times a week instead of shallowly every day or every other day.

According to the Center for Watershed Protection (CWP), in Prince William County, Virginia, most residents were at least aware and concerned about the link between lawn care and water quality, but most did not have much time to learn about lawn care BMPs. The idea of "neighborhood demonstration lawns" provided a practical public education program. When this idea was implemented, surveys indicated that homeowners significantly changed both their attitudes and actual lawn practices as a result of participating in the demonstration program (CWP 1994). A similar approach in Galesburg would most likely result in effective lawn management practices.

9.2 IMPLEMENTATION APPROACHES

Section 9.1 above describes various BMPs and their potential for achieving the proposed target ammonia-N and TSS load reductions. This section describes the manner in which the proposed BMPs could be implemented. This section does not constitute a plan for implementing BMPs. Rather, this section simply documents that institutional structures are in place to support BMP implementation. The implementation approaches of the three groups of BMPs are discussed below.

CHANNEL MODIFICATIONS TO INCREASE DO

The recommended channel modifications to the portion of the creek in the agricultural area can be accomplished by individuals or collectively. Collective implementation is recommended to take advantage of the economy of scale. NRCS can assist property owners who intend to implement this BMP by assisting with design details such as defining cross-sectional geometry, implementing bank stabilization measures, and using suitable vegetation along the modified banks. Stream restoration is closely tied to the success of the buffer strip program (NRCS 2001) and may be carried out gradually as funding becomes available and land accessibility issues are resolved.

The recommended approach to implement channel modifications in the concrete-lined portion of the creek is to first modify a small portion of the channel (about 500 feet). Based on the effectiveness of increasing DO concentrations in the small portion of the channel, modifications can be extended to the entire length of the concrete-lined channel. The GSD, city of Galesburg, or other entity can implement the proposed modifications to the concrete-lined portion of the creek.

AGRICULTURAL BMPs

Agricultural BMPs that can be implemented in the Cedar Creek Watershed in Galesburg include wetland restoration and improvement, buffer strip installation, and nutrient management plans. According to NRCS, wetland restoration is an ongoing effort in the upper reaches of the watershed. Specifically, NRCS has entered into discussions with landowners to promote restoration efforts. The wetland restoration activities are within the scope of planned NRCS activities (NRCS 2001).

The key component required to implement buffer strip installation is the availability of an adequate buffer width on each side of the creek. This requirement is already met in areas where up to 200-foot-wide buffer strips have been installed. In the areas where buffer strips have not been implemented, allowance for the additional width necessary for the proposed channel modifications should be considered. According to the NRCS, initial efforts have been made to establish buffer strip areas along the listed segment of Cedar Creek. NRCS has been providing technical assistance to private property owners along the creek as well as educating them on the benefits of using buffer strips to reduce pollutants. Because of the initial success of these efforts, this program may be expanded to include all suitable locations along the creek. Experience gained from the current effort will be instrumental in implementing this BMP for the remaining portions of the creek (NRCS 2001).

Nutrient management plans can be introduced to individuals as part of the overall pollution prevention program in the same way buffer strips were introduced. Farmers already have basic knowledge about nutrient types, techniques for their application, and associated costs. The NRCS and the University of Illinois Agricultural Extension service can provide assistance in educating farmers about advanced techniques of nutrient application and management needed under a successful nutrient management plan.

URBAN BMPs

Several urban BMPs, including CSO reduction, sanitary sewer replacement, roof drain disconnection, street sweeping program, elimination of illicit connections, and hazardous waste collection programs, are ongoing activities being implemented in the urban part of the Cedar Creek watershed in Galesburg. Continuation and expansion of these activities are recommended and needed because these BMPs are acceptable to the stakeholders and because the resources, expertise, and equipment necessary for their implementation are available. Because they are currently being implemented, no initial phase-in period is needed to establish the programs.

In addition to the urban BMPs that are being implemented, the use of swales and impervious area reduction, the use of a wet-pond/wetland system, storm drain stenciling, and lawn management practices can be implemented in the city of Galesburg. Implementation of these measures begins by educating the Galesburg community. Promotion of the use of swales and impervious area reduction involves cooperation between the city of Galesburg , land developers, and individual builders. The city of Galesburg can encourage the application of these measures in undeveloped or newly annexed areas of the municipality during the initial planning stages or during zoning application for new developments.

The city of Galesburg has begun initial planning to implement the use of a wet-pond/wetland system. Construction of wet-pond/wetland systems requires land acquisition, design and preparation of engineering plans, and construction. This BMP can be implemented in two phases. The first phase would include construction of the wet-pond, and the second phase would include creation of a wetland buffer system surrounding the wet-pond. Community involvement is recommended to provide input and support from the community during the planning and design process and to provide educational benefits for the community regarding the purpose of the project.

Storm drain stenciling and education has been effectively implemented in primary education programs in various Illinois communities, including Lake Villa, Lindenhurst, and Lake County. Storm sewer stenciling can be introduced to grade schools as an activity that creates pollution prevention awareness. In Lake Villa, the program was managed and implemented by grade school teachers and students. Therefore, this program can also be implemented in Galesburg using the Lake Villa model.

Implementation of lawn management may be combined with an ongoing hazardous waste disposal program in the urban areas. Lawn management can be implemented through education on correct application of pesticides and fertilizers. The University of Illinois Cooperative Extension System has developed BMPs for lawn care that are applicable to the urban area of Galesburg.

10.0 REASONABLE ASSURANCES

Evidence of BMP implementability and regulatory, nonregulatory, or incentive-based approaches consistent with applicable laws and programs are discussed below.

10.1 EVIDENCE OF BMP IMPLEMENTABILITY

Available evidence (see Section 9) indicates that the proposed BMPs are acceptable to watershed stakeholders for implementation. The GSD, in cooperation with the city of Galesburg, is already implementing some of the proposed urban BMPs, including sanitary sewer replacement, elimination of remaining combined sewer areas, street sweeping, and an education program for city residents for better methods to dispose of domestic hazardous waste (City of Galesburg 2001). Implementation of these activities is part of the requirement for compliance with the GSD's NPDES permit. The expertise to continue this program is currently in place. The city and GSD can build on past experience to expand these programs.

NRCS reviewed and concurred with the proposed BMPs for the agricultural areas with regard to effectiveness and feasibility. According to NRCS, buffer strip installation and wetlands restoration work is already being implemented at some locations along the listed segment, and there are plans to expand these activities. These activities demonstrate the willingness of property owners to install buffer strips along the listed segment of Cedar Creek. Evidence of acceptability of these BMPs is also provided by an ongoing study on private land by the University of Illinois/Urbana-Champaign to reduce nitrogen in agricultural tile flow. Recently, the city of Galesburg considered plans to construct a wet-pond/wetland complex at a location within the urban areas. The city has allocated some funding toward initial implementation of this project (City of Galesburg 2001). The recommendation to consider swales as an initial pretreatment of storm water is cost effective and technically feasible, especially in the undeveloped parcels in urban areas. Wherever sufficient right-of-way or drainage easement is available, construction of swales is always the cheaper alternative compared to curb-and-gutter installation. The proposal to improve aeration within the concrete-lined channel is also feasible and reasonable from both technical and cost standpoints. The BMP for lawn management can be included as a part of the domestic waste disposal program that has been implemented in the city of Galesburg. The experience the city has gained thus far is applicable to expanding the program to include lawn management.

10.2 REGULATORY, NONREGULATORY, OR INCENTIVE-BASED APPROACHES CONSISTENT WITH APPLICABLE LAWS AND PROGRAMS

The CWA, the Illinois Environmental Protection Act, and regulations and guidance implementing these statutes do not provide authority for the direct regulation of nonpoint sources of pollution to surface waters. As a result, control of nonpoint sources of pollutants and silt/mud must be addressed through nonregulatory measures such as economic assistance and public education. Section 9.1 describes BMPs that will result in reductions of nutrient and silt/mud load to the listed segment of Cedar Creek. Many of these BMPs are being implemented through voluntary and incentive-based approaches. Furthermore, Appendix B describes funding sources that could be used to further expand the BMP applications.

11.0 PUBLIC PARTICIPATION

Illinois provides public participation consistent with requirements in 40 CFR Section 130.7 (c) (1) (ii). Furthermore, Illinois provides for meaningful public involvement in the TMDL development process through a series of two public meetings and one public hearing that allow for public comment.

The Cedar Creek TMDL development process included two public meetings and one public hearing held in Galesburg, Illinois. The first meeting was held on October 24, 2000, and included a general description of the TMDL process and reasons for listing Cedar Creek on the 303(d) list. The second meeting, held on January 18, 2001, presented the modeling approach. IEPA published notice of the commencement of its solicitation of comment from the public hearing that was held in Galesburg on August 7, 2001. The hearing record opened on July 6, 2001, and closed on September 6, 2001. Written comments postmarked by midnight September 6, 2001, were included in the hearing record. The responsiveness summary responds to questions and comments received from July 6, 2001, through September 6, 2001 (postmarked) and comments from the August 7 public hearing. Prior to the public hearing, a draft TMDL document was placed at the Galesburg Public Library for public review and comment. IEPA responses to the comments will be addressed in a separate document that will be attached to the final TMDL. (See Appendix C.)

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APPENDIX A

HYDROLOGIC AND WATER QUALITY MODELING OF CEDAR CREEK

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CONTENTS

CONTENTS (Continued)

Attachments

FIGURES

Figure **Page**

FIGURES (Continued)

Figure **Page**

FIGURES (Continued)

TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

Ammonia-N	Ammonia-nitrogen
BOD	Ultimate carbonaceous biochemical oxygen demand
CSO	Combined sewer overflow
DO	Dissolved oxygen
EMC	Event mean concentration
EPA	U.S. Environmental Protection Agency
ft^3	Cubic foot
ft^3/s	Cubic foot per second
GSD	Galesburg Sanitary District
Huff & Huff	Huff & Huff, Inc.
IEPA	Illinois Environmental Protection Agency
ISWS	Illinois State Water Survey
MGD	Million gallons per day
mg/L	Milligram per liter
mi^2	Square mile
MRCC	Midwest Regional Climate Center
NCASI	National Council of the Paper Industry for Air and Stream Improvement
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
RM	River mile
SOD	Sediment oxygen demand
STORET	Storage and Retrieval Database
SWMM	Storm Water Management Model
Tetra Tech	Tetra Tech EM Inc.
TMDL	Total maximum daily load
TSS	Total suspended solids
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WWTP	Wastewater treatment plant

1.0 INTRODUCTION

Segment ILLDD01-LDD-A3 of Cedar Creek is listed under Section 303(d) of the Clean Water Act for nutrient, siltation, and other habitat alteration impairments. This report discusses the development of a water quality model to simulate conditions along the listed segment of Cedar Creek to determine the load reductions necessary to support designated uses in the creek. The report is intended to be a part of the documentation required to support development of total maximum daily loads (TMDL) for Cedar Creek. Ammonia-Nitrogen (ammonia-N) and total suspended solids (TSS) are the primary constituents modeled to represent nutrient loads and siltation in the listed segment of Cedar Creek. Dissolved oxygen (DO) was also modeled because DO is often linked to elevated nutrient concentrations and DO violations have been observed in the creek segment. Specific endpoints used as modeling goals when determining load allocations include (1) an increase in DO concentration to above 6.0 milligrams per liter (mg/L), (2) a decrease in TSS loading to ensure that TSS concentrations in the creek segment do not exceed 116 mg/L, and (3) a decrease in ammonia-N loads to ensure that ammonia-N concentrations in the creek segment do not exceed 0.41 mg/L. The water quality standard for DO requires that DO concentrations remain above 5.0 mg/L at all times and above 6.0 mg/L during any consecutive 16-hour period; therefore, use of a modeling goal of 6.0 mg/L will ensure that the water quality standard for DO is not violated. The TMDL endpoints and Illinois water quality guidelines for siltation require that TSS concentrations do not exceed 116 mg/L and that the silt or mud content does not exceed 34 percent in the listed segment of Cedar Creek; however, because of model limitations, only TSS concentrations were used as a modeling goal. It is anticipated that reducing TSS concentrations in the creek segment to below 116 mg/L should result in a silt/mud content of less than 34 percent.

The water quality model consists of two well established, public domain programs: the Storm Water Management Model (SWMM) and the steady-state water quality program QUAL2E. SWMM was used to predict the quantity and quality of runoff into the listed segment of Cedar Creek. The results of the SWMM were used in the instream water quality model QUAL2E to predict water quality in the listed segment of the creek. The model results were then used to determine the loads necessary to achieve compliance along the listed segment.

This report documents the data and model parameters used and discusses the assumptions, calibration procedures, and application of the models to predict nonpoint source pollutant loads entering the Cedar Creek segment from the watershed. Specifically, Section 2.0 discusses background information used in the modeling effort, the water quality of the Cedar Creek segment, and presents an assessment of the critical conditions in the listed segment of Cedar Creek determined to be the focus of the modeling effort. Section 3.0 discusses the development of SWMM to simulate the quantity and quality of runoff from the watershed. Section 4.0 discusses the development of a QUAL2E model to simulate the critical conditions, and Section 5.0 discusses the method for determining load allocations. Section 6.0 presents conclusions based on model results. References used to prepare the report are listed at the end of text.

2.0 STUDY AREA BACKGROUND

Cedar Creek extends 47.8 river miles from its headwaters located northeast of the city of Galesburg, Knox County, Illinois, to the confluence of Cedar and Henderson Creek west of Little York. This study focused on the 5.95-mile reach of Cedar Creek that was listed on Illinois' 303(d) list beginning near McClure Street (river mile [RM] 41.6) to its headwaters. Figure 2-1 shows the part of Cedar Creek watershed studied. The watershed delineation was performed manually using the U.S. Geological Survey (USGS) quadrangle maps for Knox County (USGS 1982). This section describes the hydrologic and hydraulic characteristics of the watershed, the water quality of the listed segment of Cedar Creek, and the critical conditions used to develop the SWMM and the QUAL2E models.

2.1 HYDROLOGIC AND HYDRAULIC CHARACTERISTICS

Based on Figure 2-1, land use in the Cedar Creek watershed near Galesburg comprises 9.8 square miles (mi^2) of urbanized area that includes the city of Galesburg (approximate population 36,000 [City of Galesburg 2000]) and 1.8 mi^2 of agricultural area that includes the headwaters of the creek. The area, land use, and other features were obtained by scaling a digitized image of the watershed. Within the corporate limits of the city of Galesburg, residential land use covers 60 percent, commercial land use covers 30 percent, and agricultural land use covers 10 percent. In the urbanized area of the watershed, storm water is collected by a storm sewer network that discharges along outfalls located along the creek. Presently, about 21 acres are still served by a combined sewer system (Tetra Tech 2000). These remaining combined sewer areas are located in several sub-basins comprising the sanitary sewer network presented in Table 3-1. In addition to the storm sewer system, the house drains in areas previously served by combined sewers are still connected to the sanitary system (Huff & Huff 2000). The house drains contribute to significant inflow into the sanitary system.

The most important physiographic watershed variables that determine the watershed precipitation-runoff relationships are summarized in Table 2-1. The predominant soil groups in the watershed are the Ipava and Tama Series associations, both of which are classified as hydrologic soil group B. These soils are generally composed of silt loams with permeabilities ranging from 0.6 to 2.0 inches per hour (USDA 1986). The data in Table 2-1 were used as basic inputs in the development of the SWMM described in Section 3.0.

FIGURE 2-1
CEDAR CREEK WATERSHED AND USGS SAMPLING SITES

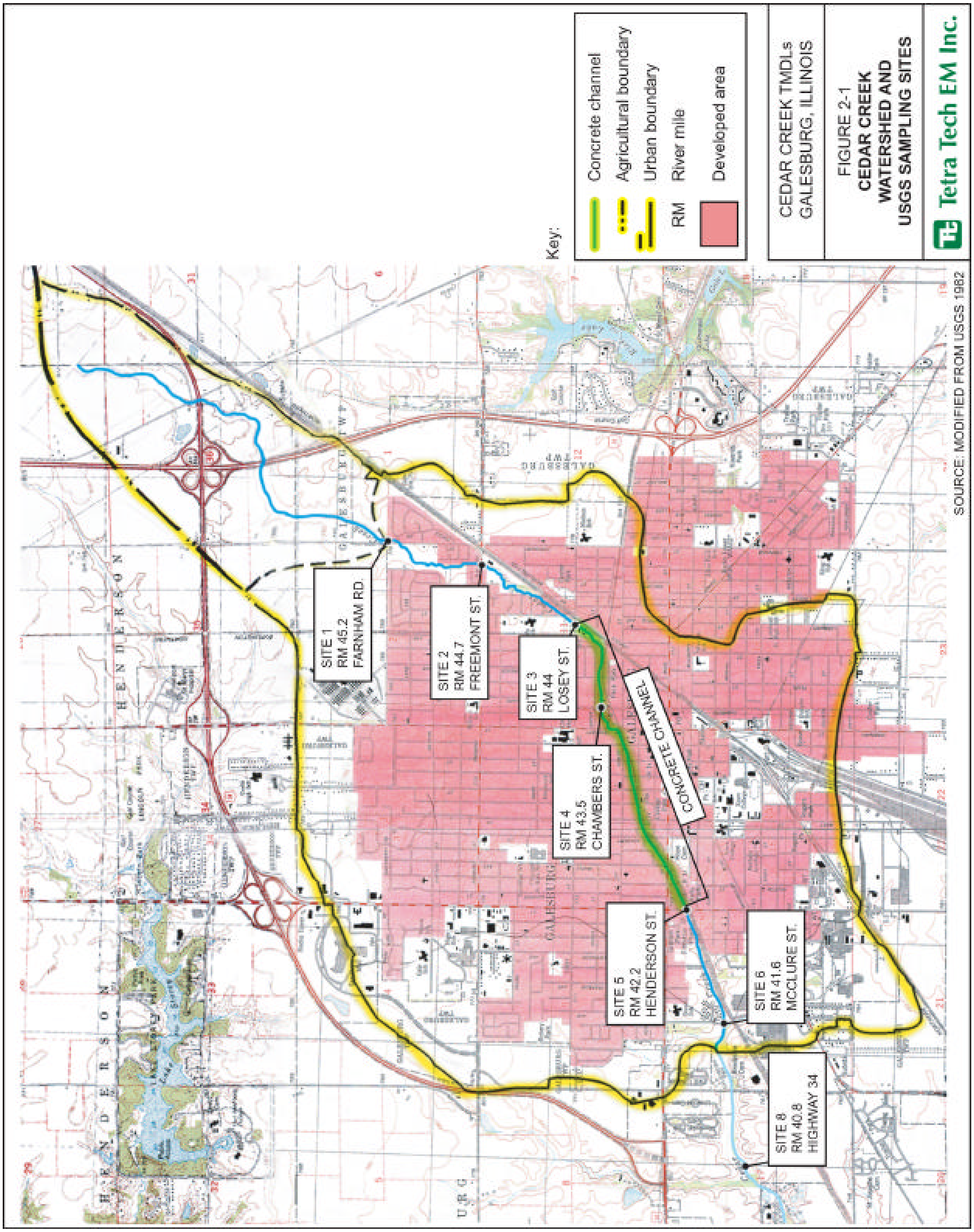


TABLE 2-1

HYDROLOGIC AND HYDRAULIC CHARACTERISTICS OF THE CEDAR CREEK WATERSHED

Parameter	Agricultural Area	Urban Area
Area (mi^2)	1.8	9.8
Imperviousness (%)	5	90
Perviousness (%)	95	10
Soil Types	Hydrologic Group B Tama and Ipava Series silty loams	Hydrologic Group B Tama and Ipava Series silty loams
Infiltration (inches per hour)	0.6 to 2.0	0.6 to 2.0
Average Basin Slope (%)	0 to 10	0 to 10
Depression Storage (inches)	0.1 to 0.25	0.1 to 0.20

Note:

mi^2 Square mile

2.2 WATER QUALITY OF CEDAR CREEK

Storm water runoff and the processes affecting water quality in the listed segment of Cedar Creek have been the subject of previous studies conducted by USGS, the Illinois Environmental Protection Agency (IEPA), and the Galesburg Sanitary District (GSD) from 1985 to the present (USGS 1987, 1989a, and 1989b; IEPA 1991, 1994, and 2000a; GSD 1996 through 2000; EPA 2000). USGS conducted 24-hour water quality sampling at various locations, including those identified in Figure 2-1, during low-flow periods in 1985 and five major storm events in 1986. The water quality parameters measured along the listed segment during the low-flow daily sampling effort included ammonia-N, TSS, and DO, which are the focus of the TMDL document. In addition to these key parameters, the following parameters were also measured and modeled using the QUAL2E model to better simulate the processes affecting ammonia-N and DO: ultimate carbonaceous biochemical oxygen demand (BOD), dissolved phosphorus, nitrite plus nitrate, sediment oxygen demand (SOD), specific conductance, algal biomass (Chlorophyll-a), water temperature, and stream discharge. Key parameters measured by USGS along the listed segment of Cedar Creek during low-flow conditions are summarized in Table 2-2 (USGS 1987, pages 98 through 108 and 128 through 131). Except for DO and Chlorophyll-a, parameters were measured by USGS during the major storm events in 1986. A summary of the daily sampling conducted along the listed segment during the storm events is presented in Table 2-3. USGS conducted sampling along the listed segment of the creek during only four of the five storm events monitored (USGS 1987, pages 148, 149, 158, and 159; EPA 2000).

USGS used the sampling data to prepare a QUALII water quality model of the creek from RM 19 to 41.6; however, the model did not extend sufficiently upstream to include the listed segment, which extends from RM 41.4 to about 47.3. Although the model did not extend sufficiently upstream, model inputs that USGS used in developing the QUALII model were considered when developing the QUAL2E model for RM 41.4 to 47.3 as appropriate. More recent sampling efforts conducted as part of facility-related studies and GSD wastewater treatment plant (WWTP) monitoring results are also summarized in Table 2-2 and were critical in assessing when to use USGS's QUAL2E model inputs as inputs in this modeling effort (GSD 1996 through 2000; IEPA 1991, page 11; IEPA 1994, page 12; IEPA 2000a, Table 2). Tetra Tech received data collected by GSD along multiple segments of the creek, from May 3 through July 26, 2001. The data were received after submittal of the draft TMDL report dated July 7, 2001 and did not include flow measurements needed for modeling. However, these data were reviewed and determined to be consistent with all other monitoring conducted along the creek from 1985 through 1999. These data are presented in Attachment C.

TABLE 2-2

SUMMARY OF WATER QUALITY PARAMETERS IN CEDAR CREEK DURING LOW-FLOW CONDITIONS FROM 1985 TO 2000[a]

	1985 USGS July-August	1991 IEPA September 17	1994 IEPA August 30	1999 IEPA August 18	2000 GSD June- July
Measured Concentrations at Farnham Rd.					
DO	**4**-12.2/7.4[b]	NA	5.8	5.7	5.3-8.7/7.5[b]
Ammonia	< 0.1-**0.97**/0.23[b]	NA	**1**	**0.5**	NA
TSS	22-27/24.5[b]	NA	112	35	NA
Percent silt or mud	NA	NA	**40**	**65**	NA
Measured Concentrations at Freemont St.					
DO	**3.7**-10.5/6[b]	NA	NA	NA	NA
Ammonia	< 0.1	NA	NA	NA	NA
TSS	12-**270**/59.8[b]	NA	NA	NA	NA
Percent silt or mud	NA	NA	NA	NA	NA
Measured Concentrations at Losey St.					
DO	**3.2**-13.8/7[b]	NA	NA	NA	NA
Ammonia	< 0.1	NA	NA	NA	NA
TSS	5-**190**/50.7[b]	NA	NA	NA	NA
Percent silt or mud	NA	NA	NA	NA	NA
Measured Concentrations at Chambers St. (concrete section)					
DO	**4.4**-19.9/11[b]	NA	NA	NA	NA
Ammonia	< 0.1	NA	NA	NA	NA
TSS	2-11/4.8[b]	NA	NA	NA	NA
Percent silt or mud	NA	NA	NA	NA	NA
Measured Concentrations at Henderson St.					
DO	**2.9**-18.8/7.6[b]	17.3	8.1	**4.6**	NA
Ammonia	< 0.1-0.36/0.2[b]	0.15	0.11	**0.9**	NA
TSS	2-68/14.4[b]	7	70	14	NA
Percent silt or mud	NA	0	0	0	NA
Measured Concentrations at McClure St.					
DO	**1.1**-23.0/10.2[b]	NA	NA	NA	NA
Ammonia	< 0.1-**0.42**/0.19[b]	NA	NA	NA	NA
TSS	5-35/9.6[b]	NA	NA	NA	NA
Percent silt or mud	NA	NA	NA	NA	NA

Notes:

DO Dissolved oxygen
GSD Galesburg Sanitary District
IEPA Illinois Environmental Protection Agency
NA Not analyzed
TSS Total suspended solids
USGS U.S. Geological Survey

a All concentrations are in milligrams per liter, and exceedances of Illinois Water Quality Guidelines or standards are in bold text.

b Range of concentrations/average concentration

TABLE 2-3

SUMMARY OF WATER QUALITY PARAMETERS IN CEDAR CREEK AT FARNHAM ROAD AFTER FOUR MAJOR STORM EVENTS[a]

Storm Event	Date	Time	Total Ammonia-N (mg/L)	TSS (mg/L)
Storm 1[b] (May 16 and 17, 1986)	5/17/86	1200	1.5	600
	5/17/86	1355	0.41	950
	5/17/86	1525	0.23	685
	5/17/86	1645	0.23	1,420
	5/17/86	1805	0.17	910
	5/17/86	1925	0.15	1,070
	5/19/86	1045	<0.1	82
	5/19/86	2235	<0.1	70
	5/20/86	1315	<0.1	57
	5/21/86	1430	<0.1	61
Storm 2[b] (July 7 through 10, 1986)	7/8/86	2240	<0.1	566
Storm 3[b] (July 31 through August 1, 1986)	7/31/86	0150	0.25	1,020
	7/31/86	0220	0.24	1,150
	7/31/86	0325	0.29	652
	7/31/86	0340	0.27	596
	7/31/86	0400	0.41	1,160
	7/31/86	0420	0.37	1,080
	7/31/86	1237	0.15	174
	8/1/86	0040	<0.1	206
	8/1/86	1240	<0.1	63
	8/2/86	0040	<0.1	169
	8/2/86	1240	<0.1	43
	8/3/86	0400	<0.1	56
	8/3/86	1240	<0.1	27
	8/4/86	0040	<0.1	165
	8/4/86	1240	<0.1	117
	8/9/11	0450	<0.1	556
Storm 4[b] (August 26 through 27, 1986)	9/11/86	1215	0.12	324
	9/12/86	0815	<0.1	197

Notes:

mg/L **Milligram per liter**
TSS **Total suspended solids**

[a] **Exceedances of Illinois Water Quality Guidelines are presented in bold text.**
[b] See Table 3-4 for precipitation data.

2.3 CRITICAL CONDITIONS

Critical conditions in a stream are periods when water quality impairments are most likely to occur. For the listed segment of Cedar Creek, water quality impairments were presumed to occur either during low-flow periods when pollutant concentrations tend to be elevated or during episodes of combined sewer overflows (CSO). The Illinois State Water Survey (ISWS) studied low-flow conditions in Cedar Creek by developing the set of low-flow parameters defined below.

- 7Q10 by month (January through December): 7Q10 is defined as the 7-day, 10-year low flow.
- 7Q2 flows by month (January through December): 7Q2 is defined as the 7-day, 2-year low flow.
- Seasonal 7Q10 and 90 percent flow duration: 7Q10 is defined above, and 90 percent flow deviation is flow that is exceeded or equaled 90 percent of the time.

ISWS found that 7Q10 was zero in January, February, and June through December and that 7Q2 was zero in August, September, and October. The ISWS study led to the conclusion that the listed segment of Cedar Creek is an ephemeral stream that can have several dry periods in a year (ISWS 1995). No flow is diverted from the creek segment, and anecdotal evidence from residents along the creek segment and flow measurements performed by USGS in 1985 and 1986 are consistent with ISWS's findings. The presence of agricultural drain tiles probably diminishes groundwater contribution to low flow. USGS flow data indicate periods of low flow during July, August, and September. USGS collected water quality data between July and September 1985 and May through September 1986. The data are summarized in Tables 2-2 and 2-3 and show ammonia-N and DO concentrations that exceeded guidelines during low flow conditions and ammonia-N and TSS concentrations that exceeded guidelines during storm events. On the basis of these data, the SWMM and QUAL2E model were therefore developed to simulate low-flow conditions, including base flows and first-flush events. Base flow is defined as residual flow contributed by groundwater observed in the creek following storm events. A first-flush event is defined as a storm event that occurs after a dry period exceeding two to three days during low flow when concentrations of ammonia-N and TSS in runoff are expected to be elevated.

Evaluation of wet-weather sanitary flows to the GSD WWTP indicates that CSO events occur during large storm events (2 to 4 inches of precipitation) associated with high intensities or medium storm events (0.5 to 2 inches of precipitation) when the ground is saturated. A comparison of wet-weather and dry-weather sanitary flows to the WWTP from 1994 to 1998 showed that rain-induced infiltration to the sanitary system results in a flow of 20 to 32 million gallons per day (MGD) and an average dry weather sanitary flow of about 5.2 MGD. Rainfall infiltration into the sanitary sewer network therefore contributes three to four times the average dry weather sanitary flow. Apparently, improvements to the sanitary sewer network since 1985, which consisted of upgrading the main sewer interceptor to the WWTP from 48- to 60-inch-diameter pipe, reduction of the combined sewer areas from 256 to 21 acres, and raising of CSO elevations, have resulted in significant reductions in the frequency and severity of CSO events. Based on the above considerations and the fact that available water quality data do not show violations of DO or ammonia-N standards during high flows in the creek bed, CSO events are unlikely to result in critical conditions in the creek upstream of the WWTP. The SWMM and QUAL2E model therefore did not consider CSOs as an important factor in determining critical conditions in Cedar Creek upstream of the WWTP. Results of CSO simulation of the sanitary network by the SWMM appear to support this conclusion. High SOD rates that lead to low DO concentrations may result from the residual effects of CSOs because TSS loads from CSOs have higher SOD compared to TSS loads from agricultural areas. However, residual effects of CSOs on SOD were not modeled. A detailed presentation of the CSO simulation is presented in Section 3.0. It should be noted that the assessment of critical conditions and subsequent analyses presented in this report are based on flow measurements conducted over one season in 1986. Although the data were sufficient to identify critical conditions, the conclusions based on these data should be regarded as preliminary until more comprehensive monitoring data are available for verification purposes.

3.0 SWMM MODEL DEVELOPMENT

The SWMM program is capable of modeling both the quantity and quality of runoff produced during a storm event over a wide range of hydrologic conditions if adequate data are available. The program consists of four main modules: RUNOFF, TRANSPORT, EXTRAN, and STORAGE/TREATMENT. These modules can be executed individually or in groups. The functional relationships between each of these modules is summarized in Figure 3-1. For purposes of this study, only the RUNOFF, TRANSPORT, and EXTRAN modules were used. The program can be executed in the "single-event" mode, in which the runoff from a particular storm is simulated, or in the "continuous" mode, in which a series of storm events are simulated sequentially. Generally, continuous simulation has the merit of automatically accounting for antecedent conditions; in single-event simulation, antecedent conditions are input as data. The decision to use single-event or continuous-event simulation depends on the purpose of the study and the quality of available data. Single-event simulation was used for calibration and verification in this study because only single-storm data were available. After calibration, continuous simulation was used to generate pollutant loads from nonpoint sources in the watershed.

Details of the procedures for data input and processing are not discussed here but can be found in the U.S. Environmental Protection Agency's (EPA) SWMM Version 3.0 or 4.0 user's manual (EPA 1988; James and James 2000a and 2000b). The discussion below focuses on modeling of direct runoff, modeling of water quality parameters, hydrologic calibration and verification, water quality calibration and verification, SWMM results, and CSO simulation. Attachment A to this report presents example SWMM input and output data files used for calibration and verification. RUNOFF, TRANSPORT, and EXTRAN input/output files are all represented.

3.1 MODELING OF DIRECT RUNOFF USING SWMM

For modeling purposes, runoff generated from the watershed can be broken down into the following three components as illustrated schematically in Figure 3-2:

- Direct storm water runoff
- Base flow or groundwater flow into the listed segment of Cedar Creek
- Combined sewer flows and CSOs

The modeling approach and assumptions used are discussed in the following sections.

FIGURE 3-1
FUNCTIONAL RELATIONSHIP AMONG SWMM MODULES

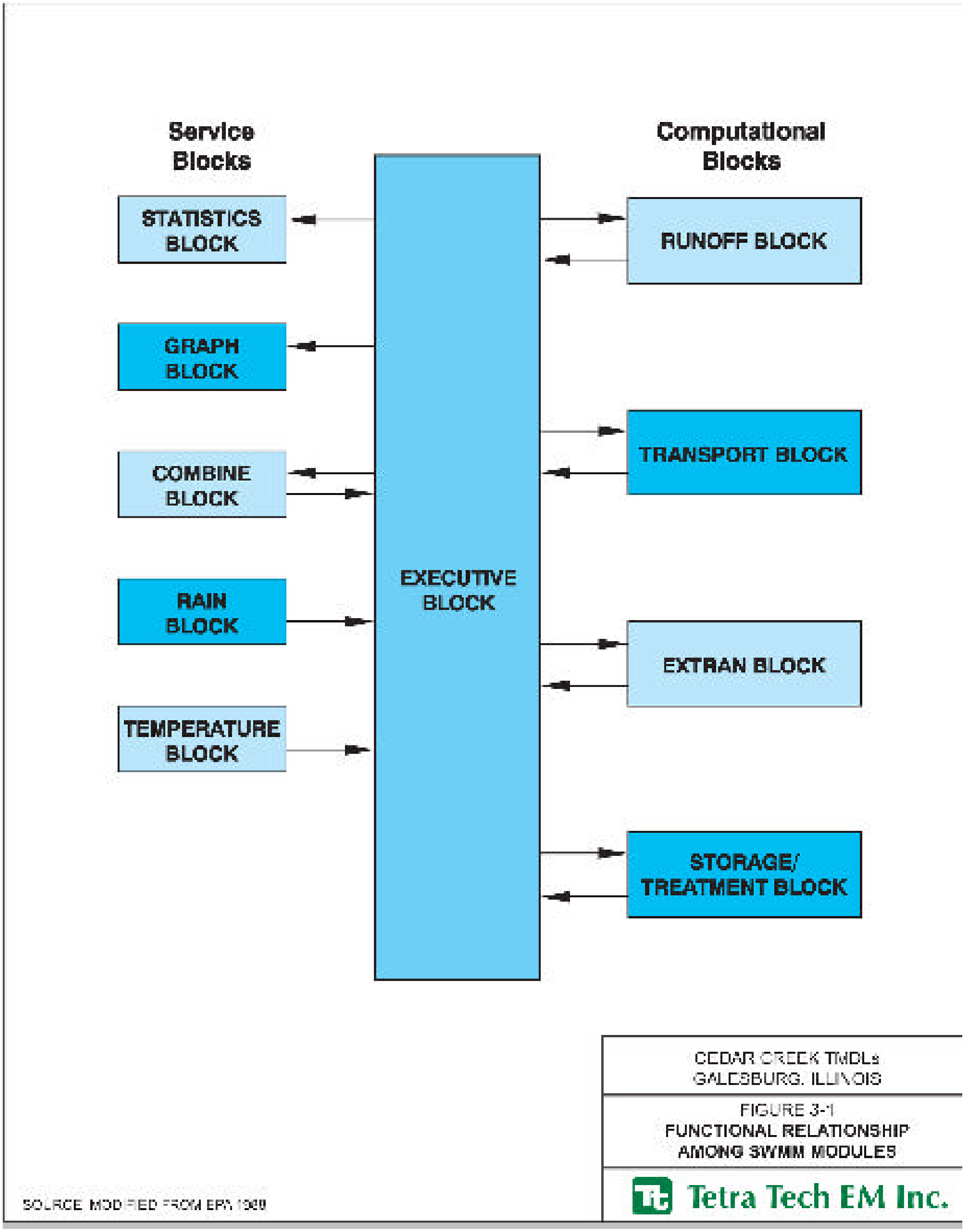
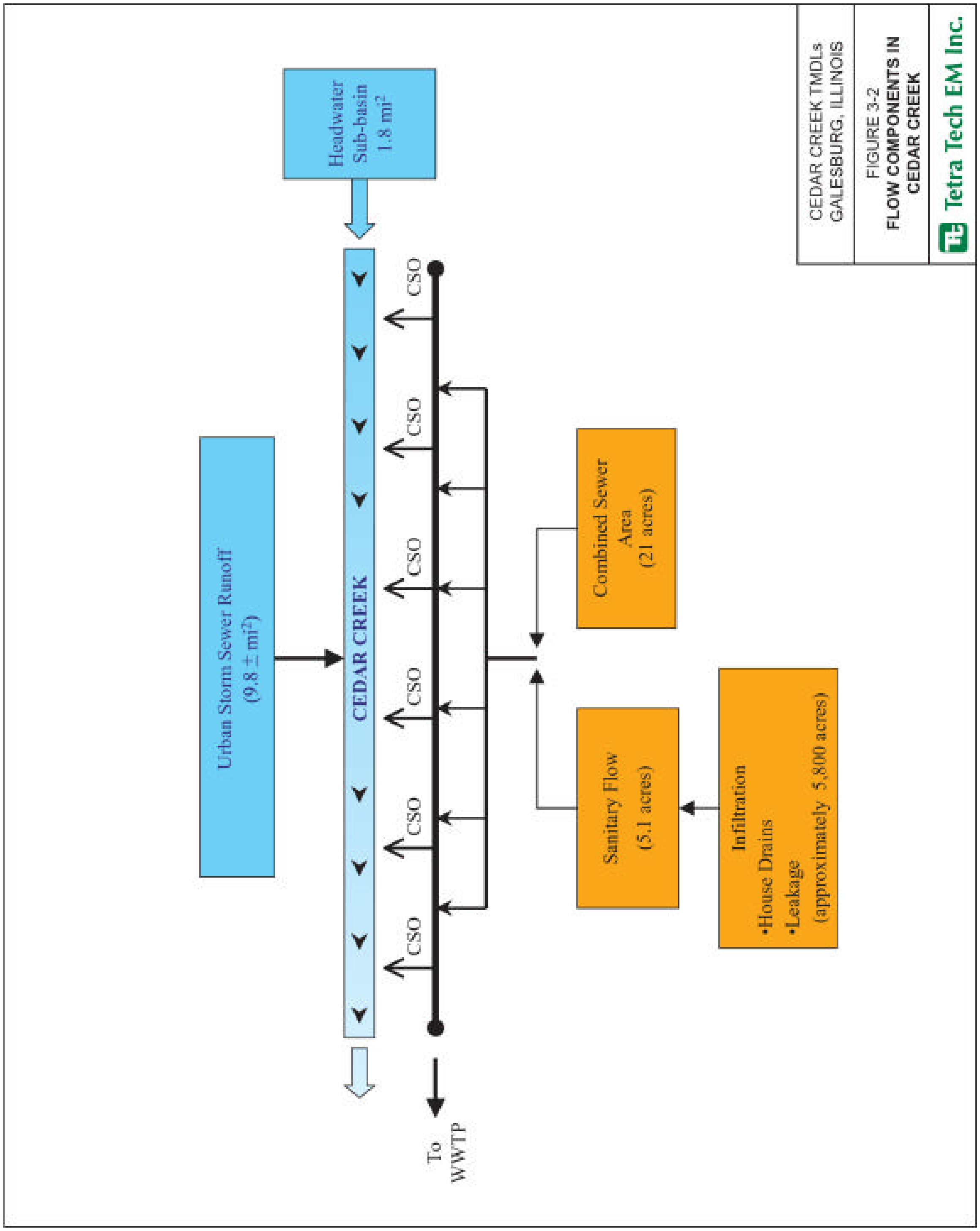


FIGURE 3-2
FLOW COMPONENTS IN CEDAR CREEK



3.1.1 Direct Storm Water Runoff

Direct runoff from the agricultural and urbanized areas was calculated using the SWMM RUNOFF module. The Cedar Creek watershed near Galesburg was represented in this module by two homogenous sub-basins that represent the mostly agricultural area and the urbanized area that includes the city of Galesburg as shown in Table 2-1. The hydrologic parameters that characterize the runoff from these two sub-basins are also summarized in Table 2-1. The downstream collection point of the runoff from the agricultural area is located approximately at Farnham Road. The downstream collection point for runoff from the urban area is located just upstream from Linwood Avenue. Runoff is routed downstream and combined with the urban runoff at the downstream limit of the study reach near Linwood Avenue. During model calibration, the hydrologic parameters initially obtained and listed in Table 2-1 were adjusted to match observed flows at Farnham Road and Linwood Avenue. The infiltration value used was 1.6 inches per hour, which is within the expected ranges for the soils in the watershed as presented in Table 2-1. The depression storage values used were 0.25 inch and 0.20 inch for the agricultural and urban areas, respectively. The higher value in the agricultural area may be attributed to the presence of wetlands and low ground. Modeling of water quality parameters using the RUNOFF module is discussed in Section 3.2.

3.1.2 Base Flow or Groundwater Flow into Cedar Creek

Cedar Creek receives groundwater or base flow from the upstream agricultural area and the urban area in and around Galesburg. Modeling groundwater contribution from the agricultural area using SWMM is problematic first because of insufficient data to characterize the subsurface zone and second because the subsurface flow zone is believed to be artificially modified by agricultural drain tiles. Research efforts geared toward finding reliable procedures for modeling tiled areas is ongoing, but at this point, no practical and reliable method is available. SWMM was therefore not used to estimate base flow into the listed segment of Cedar Creek. Instead, base flow was estimated from hydrographs of individual storm events recorded by USGS from 1985 through 1986. Further discussion of the base-flow hydrograph separation procedure is presented in Section 4.1 of this report in connection with low-flow conditions in the listed segment of the creek. The contribution of the urban area to base flow is diminished in part by the storm sewer network and mainly by the extensive sanitary sewer system that is still connected to house drains. The sanitary sewer network tends to function like drain tile systems, draining part of the infiltration that would have flowed to the creek segment as base flow.

The large Cedar Creek interceptor that runs along the creek collecting sanitary flow is more than 10 feet deep and located below the creek bed; therefore, the groundwater table in the vicinity of the creek segment is expected to be drawn down too low to contribute any significant flow.

The existing sanitary network consists of conduits constructed between 1897 and 1927 (GSD 2000). Tight construction joints were not used in sewer construction until the 1960s; therefore, the sanitary sewer system is expected to have much higher infiltration rates than modern sewers constructed with water-tight joints.

3.1.3 Combined Sewer Flows and CSOs

The listed segment of Cedar Creek receives CSOs during periods of high precipitation in the watershed. Presently, 39 CSOs are located in the Cedar Creek drainage basin in Galesburg according to the GSD (Huff & Huff 2000). Sanitary flow is collected by a main interceptor that runs east to west across the center of the city along the creek adjacent to and beneath the concrete portion of the Cedar Creek segment. The CSO points are located at the junctions between north and south laterals and the main interceptor. Figure 3-3 shows the existing sanitary sewer system and the locations of CSO points, and Figure 3-4 illustrates key features of a typical CSO structure. The service area of the GSD system encompasses approximately 7,836 acres, of which 5,116 acres were originally served by combined sewers. Since 1967, the city has been undertaking a sewer separation program; today, only 21 acres having combined sewers remain (Tetra Tech 2000 and 2001). These combined sewer areas are scattered in isolated sub-basins of the sanitary sewer network as shown on Table 3-1. The sewer separation effort was partial in nature, however, because foundation drains that contribute significant flows during rain events remain connected to the sanitary system. CSO events are modeled by considering infiltration and sanitary flows, and the hydraulic characteristics of the sanitary sewer pipe network. Modeling of CSO events was accomplished using the steps discussed below.

1. **Develop RUNOFF Module**
   The urban sewered area was divided into 13 sub-basins called sewersheds according to the main laterals serving them. These sub-basins are shown on Figure 3-5, and their associated hydraulic characteristics are summarized in Table 3-1. The sub-basins were further subdivided in order to assign a drainage area to each lateral connected to the main interceptor as shown in Figure 3-5. The SWMM RUNOFF module was used to calculate the runoff from each of these sub-basins. The hydrologic characteristics of each of these areas were initially estimated using the data in Table 2-1.

2. **Model Infiltration into the Sanitary System**
   Rainfall dependent infiltration was modeled as a fraction of the runoff generated from the drainage areas defined in step 1 that discharge into the catch basins. The details of the modeling procedure for rain-dependent infiltration are described in detail in the SWMM Users Manual. Typical proportions of runoff that are assigned to infiltration using this approach range from 2.5 to 10 percent (James et.al. 2000b). Using a trial and error procedure in SWMM, in which the predicted combined sanitary flow was compared to the total wet weather WWTP sanitary flow, a value of 10 percent was used to represent the fraction of urban runoff infiltrating into the sanitary system. Observed total wet weather flows to the WWTP are in the range of 20 to 32 MGD. Additional calibration of the hydrologic parameters of the sub-basins was performed to mimic the relatively long durations (two to three days) of the infiltration hydrographs. According to SWMM documentation, the time-base hydrographs can be increased by reducing basin widths, which has the effect of increasing storage in the subbasin.

3. **Model Sanitary Sewer Network**

   The sanitary sewer network was modeled using the SWMM EXTRAN module. Figure 3-3 shows the layout of the existing sanitary network. Pipe size and connectivity data were supplemented with ground elevation and pipe invert data furnished by GSD and Huff & Huff, Inc. (Huff & Huff), to create the SWMM model (GSD and Huff & Huff 1987; Huff & Huff 1989). In most cases, for simplicity, only pipes with diameters exceeding 15 inches were included in the model. Manning's n values of 0.013 to 0.015 were assumed to represent the friction factors for such old sewer pipes. Figure 3-4 shows a typical CSO structure that connects the main laterals to the main Cedar Creek interceptor and also outfall pipes to the creek. To model the hydraulics of the CSO structures, some of the conduits connecting the overflow manholes to the main Cedar Creek interceptor were represented as orifices. Modeling these connecting pipes as orifices is justified because they have restrictive openings to 12 inches in diameter compared to the upstream connecting weirs (dams). Outfall pipes from the overflow manholes were modeled as circular side-flow orifices. As shown in Figure 3-4, the overflow manholes have been modified by construction of dams whose purpose is to raise the surcharge elevation. Because the weir flow increases more rapidly with head compared to the capacity of the outflow pipe, the outflow characteristics of the combined weir-outfall pipe configuration resembles orifice flow rather than weir flow for a wide range of surcharge conditions. The size of the outfall orifices was equated to the cross-sectional area of the outfall pipes. The hydraulic data for each CSO structure is summarized in Table 3-2.

4. Model Sanitary Flow

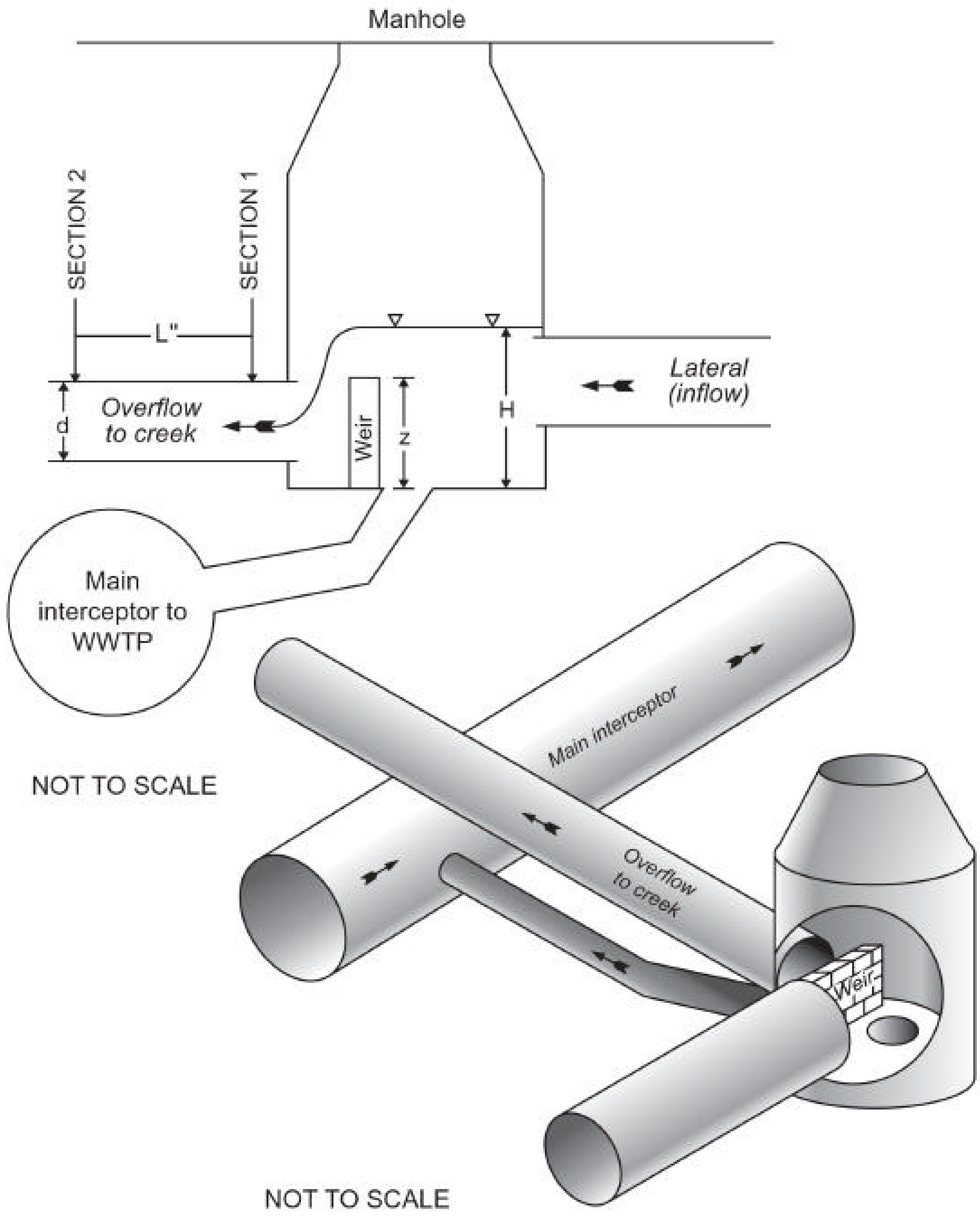
Sanitary flow in each lateral pipe was assumed to be uniform and was computed as the proportion of the contributing service area. According to GSD, the average daily dry weather flow generated from the approximately 7,836-acre service area is about 5.2 MGD. Of the 7,836 acres, the contributing area from the original combined sewer area is 5,116 acres. The remaining 2,720 acres is contributed by separated areas. Sanitary flow from these areas is not included in the CSO calculations. For simplicity in modeling, the water quality parameters for the sanitary flow were also assumed constant in the SWMM. Typical values of these parameters for untreated domestic sewage are summarized in Table 3-3.

FIGURE 3-3
GALESBURG SANITARY SEWER MAP

A COPY OF THE MAP OF THE GALESBURG SANITARY SEWER SYSTEM CAN BE VIEWED AT THE GALESBURG PUBLIC LIBRARY WHERE A COMPLETE COPY OF THE DRAFT CEDAR CREEK TMDL DOCUMENT IS LOCATED.

FIGURE 3-4

TYPICAL CSO STRUCTURE



Key:
- H = Height of water in the manhole
- z = Height of the weir
- L" = Length of the overflow pipe from section 1 to section 2
- d = Diameter of the overflow pipe

SOURCE: MODIFIED FROM USGS 1989b

CEDAR CREEK TMDLs
GALESBURG, ILLINOIS

FIGURE 3-4
TYPICAL CSO STRUCTURE

Tetra Tech EM Inc.

TABLE 3-1

SUB-BASIN HYDRAULIC CHARACTERISTICS

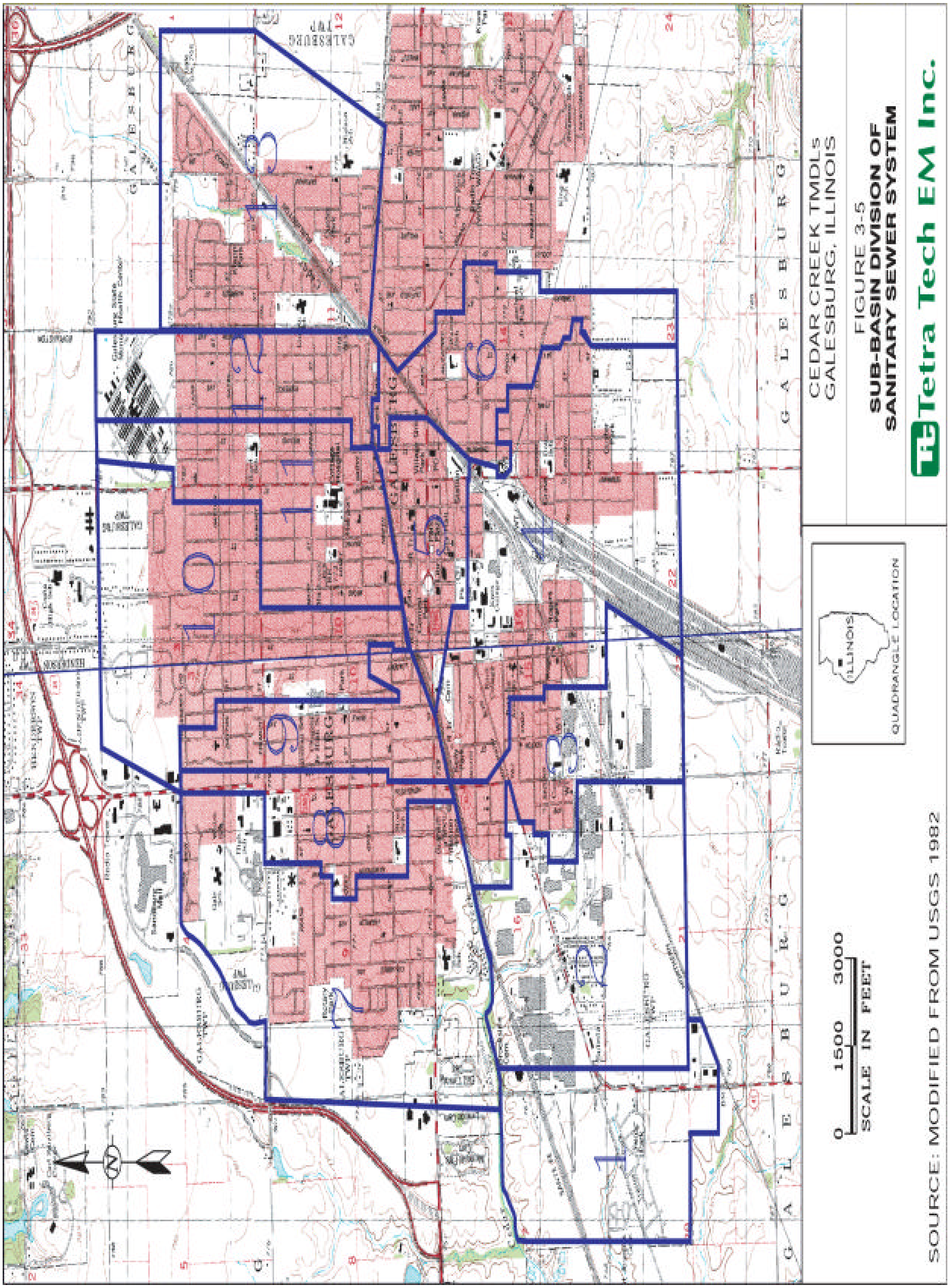
Basin Name (Label)	CSOs[a]	Total Acres Served	Combined Acres Drained (2001)	Estimated Sanitary Flows[b] (ft^3/s)
Northeast (10)	1	1,179	1	1.21
Pearl St. (25)	3	170	0	0.17
	4	10	0	0.01
Pine St.	5	270		0.28
Prairie St. (30)	7	90	0	0.09
	8	90	0	0.09
	10	40	0	0.04
	12	40	0	0.04
	14	40	0	0.04
	17	45	0	0.05
	20	45	0	0.05
Downtown (35)	6	30	0	0.03
	9	25	0	0.03
	11	13	0	0.01
	13	10	0	0.01
	15	10	4.6	0.01
	16	10	0	0.01
	18	15	2.1	0.02
	19	15	0	0.02
	21	15	0	0.02
	24	3	0	0.00
West St. (40)	22	960	0	0.99
	23	25	0	0.03
	45	12	4.2	0.01
Maple Avenue	25	18	0	0.02
Basin (50)	26	50	0	0.05
	27	55	0	0.06
	29	55	0	0.06
Henderson North (60)	28	226	0	0.23
Henderson South (65)	30	270	0	0.28
Edwards St (70)	33	560	0	0.57
McClure St. (75)	31	60	0	0.06
	32	100	0	0.10
Railroad Creek Basin (45)	34	560[c]	9.4[c]	0.57[c]
	35			
	36			
	37			
	38			
	39			
	40			
	41			
Total Area (acres)		**5,116**	**21.3**	**7.9[d]**

Notes: **Source: Huff & Huff 1989**

CSO **Combined sewer overflow**
ft^3/s **Cubic foot per second**

[a] **Huff & Huff (1989) reports that CSOs No. 2, 25, 30, and 31 have been eliminated.**
[b] **Sanitary flows are computed as proportional to the service area. The total service area is 7,836 acres, including 2,720 acres of originally separated areas.**
[c] **The total acres served, combined acres drained, and estimated sanitary flow for the CSOs in the railroad creek basin are not available. The values presented in the table apply to the entire basin.**
[d] **According to GSD, the average daily sanitary flow to the WWTP is 5.2 MGD (8.0 ft^3/s).**

FIGURE 3-5
SUB-BASIN DIVISION OF SANITARY SEWER SYSTEM



5. **Develop TRANSPORT Module**

The SWMM transport module was used to combine infiltration flow, including the 21 acres of combined flow, with the sanitary flow calculated from step 4. The resulting hydrographs and associated water quality constituents were used as inputs at the upstream nodes of the sanitary pipe network in the EXTRAN module of SWMM. For modeling purposes, infiltration flows were assumed to be of the same quality as direct runoff. This assumption is conservative, especially with regard to suspended solids, because groundwater flows generally have lower suspended solids content than surface runoff.

6. **Develop EXTRAN Module**

The EXTRAN module simulated flow hydraulics in the main interceptor and adjoining lateral. Hydrographs generated in the RUNOFF module (step 1) were routed through the TRANSPORT module to include sanitary flows. The resulting hydrographs were then used as inputs to the EXTRAN module to simulate flows and pressure heads in the sanitary network. Overflows to the listed segment of Cedar Creek were identified as flows in the outfall CSO points discussed in step 3.

The completed SWMM for this effort therefore consisted of use of the RUNOFF, TRANSPORT, and EXTRAN modules to simulate CSOs during large storm events. Direct runoff to the Cedar Creek segment, including water quality constituents from the watershed, were simulated using the RUNOFF module.

TABLE 3-2

CSO STRUCTURE HYDRAULIC DATA

CSO No.	Cedar Creek Node No.	Invert Elevation of Lateral Inflow Pipe (feet)[a]	Invert Elevation of Cedar Creek Interceptor (feet)[a]	Diameter of Orifice (inches)	Diameter of Overflow Pipe (inches)	Diameter of Lateral Inflow Pipe (inches)	Elevation of Weir (feet)[a]	Length of Weir (inches)	Y crest (feet)
1	55330	85.4	82.5	10	18	NA	86.7	36	1.3
2	55140	NA	NA	NA	NA	NA	NA	NA	NA
3	55320	81.6	75.9	10	24	3	83.1	60	1.5
4	55320	81.4	75.9	8	8	10	82.2	46.375	0.8
5	55310	80.6	75.3	12	18	24	81.6	38	1.0
6	55300	80.3	73.4	8	12	21	82.3	46.5	2.0
7	55300	80.3	73.4	8	15	18	82.3	43.75	2.0
8	55290	79.1	71.5	8	24	24	81.1	44.5	2.0
9	55290	79.1	71.5	8	21	21	81.1	44.5	2.0
10	55270	78.1	69.2	8	16	16	78.8	31	0.7
11	55270	76.6	69.2	8	18	24	80.7	42.5	4.1
12	55260	78.6	68.5	8	18	18	79.6	47	1.0
13	55260	76.6	68.5	8	18	18	79.1	45.5	2.5
14	55250	76.3	67.5	8	15	20	78	45	1.7
15	55250	76.3	67.5	8	24	24	78	51	1.7
16	55250	75.4	67.5	8	15	15	76.6	45	1.2
17	55240	80.2	66.8	8	20	20	82.7	45	2.5
19	55240	75.3	66.8	8	24	24	77.3	41.5	2.0
18	55230	75.4	66.6	10	24	21	78.4	60	3.0
20	55220	74.6	66.1	8	12	24	77.5	39	2.9
21	55215	NA	65.7	8	18	18	NA	39	1.1
45	55210	NA	65.4	8	10	10	NA	0	NA
22	55200	73.5	65	15	18	24	75.5	43	2.0
23	55190	72.7	64.3	8	12	12	73.7	35.5	1.0
24	55190	75.6	64.3	8	12	12	76.1	35	0.5
25	55160	74.6	63	8	15	15	76.1	30	1.5
26	55170	69.2	63.3	8	18	18	70.8	21	1.6
27	55150	74.7	62.8	6	15	15	75.9	45	1.2
34	55140	69.6	61.5	15	36	36	73.7	41	4.1
28	55130	NA	61.3	12	24	24	NA	41.25	1.3
29	55130	NA	61.8	8	15	15	NA	45.125	1.3
30	55130	67.6	61.8	10	24	24	74.4	41.25	6.8
31	55120	69.5	60.7	8	18	18	76	45.675	6.5
32	55090	NA	59.4	18	10	24	NA	45	3.8
33	55070	73.4	59.1	NA	21	18	74.9	24.5	1.5
35	45020	NA	71.2	8	12	12	NA	20.5	2.0
36	45060	82.5	78.7	12	12	12	84.7	44.25	2.2
37	45060	83.6	78.7	12	12	12	86.7	34	3.1
38	45070	NA	81.5	12	18	18	NA	36	2.0
39	45100	90.7	89.5	12	24	24	99.2	21	1.0
40	45120	91.6	92	12	10	72	94.8	72	3.2
41	45130	95.8	98.5	12	24	24	97.8	24.75	2.0

Note: Source: Huff & Huff 1989 and 2000

NA Not available

[a] All elevations are given in reference to a local datum of 0.0 feet.

TABLE 3-3

TYPICAL COMPOSITION OF UNTREATED DOMESTIC WASTEWATER

Constituent	Concentration (mg/L)		
	Strong	Medium	Weak
TSS	350	220	100
Free Ammonia	50	25	12

Notes:

mg/L **Milligram per liter**
TSS **Total suspended solids**

3.2 MODELING OF WATER QUALITY USING SWMM

Water quality constituents were modeled using the RUNOFF module. The urban area contains about 10 to 15 percent undeveloped pervious area that is represented in Figure 2-1 by the unshaded portion inside the urban watershed boundary. For flow and water quality modeling purposes, this undeveloped area was represented as "agricultural" even though it may contain a variety of other land uses. Three constituents were modeled: ammonia-N, TSS, and BOD. Of these three constituents, ammonia-N and TSS were focused on in this study because the Cedar Creek segment was listed because of elevated nutrient and siltation levels. However, BOD is also of interest because of its effects on ammonia-N and DO concentrations. Ammonia-N and BOD loads predicted by the SWMM were used as inputs in the QUAL2E model. TSS is regarded as an inert or passive constituent in the QUAL2E model; therefore, no attempt was made to model instream TSS concentrations. For the purpose of this study, TSS levels predicted using the SWMM RUNOFF module are assumed to be the instream average concentrations. Furthermore, TSS is assumed to be an appropriate surrogate parameter for sediment loads to the listed segment of the creek.

SWMM provides several methods for modeling water quality constituents. In the simplest case, constant concentrations are applied to the runoff hydrographs to predict pollutant loads. Depending on need and the complexity of the problem on hand, the purpose of the results, and availability of calibration data, pollutographs can be generated using complex constituent buildup and washoff mechanisms that involve many calibration parameters. For the listed segment of Cedar Creek, limited storm-specific water quality data are available. No flow hydrographs or pollutographs are available that would justify the use of the more elaborate buildup procedures available in the SWMM program. Particularly for TSS modeling, the processes of sediment entrainment, transport, deposition, and erosion from the stream channel are poorly understood and too data-intensive to model. In addition, TSS loads are being used as surrogate for silt/mud, which was one of the causes of the listing of the Cedar Creek segment. Under these circumstances, the rating curve procedure that is based on a power-law relationship between pollutant loads and flow was adopted because it is simple to calibrate and appropriate for the quality of available data. In this procedure, pollutant loads are predicted as functions of flow using only two parameters that are adjusted during calibration to match observed concentrations in the listed segment of the creek.

3.3 HYDROLOGIC CALIBRATION AND VERIFICATION

Calibration is a process in which field data are used to adjust the initial estimates of model parameters to enable the model to replicate the observed data. Hydrologic calibration was performed prior to water quality calibration to verify that the model could reproduce the flow hydrograph for the given meteorological conditions. Hydrologic calibration was performed first because flows determine pollutant concentrations. Flow data were chosen so that the model would be able to predict pollutant flows under a wide range of flow conditions in the creek. Rain events used for the calibration are listed in Table 3-4.
Three storms that occurred in the watershed are presented in Table 3-5. These storms were selected for flow calibration and verification based on availability of data. Because the time distributions of the storms were unknown, Huff rainfall distributions for northwest Illinois were used to synthesize the hydrograph from the rainfall depth (ISWS 1989). Whenever possible, the Huff rainfall distributions were modified to reflect any observed storm intensities such as the maximum 5-minute and 1-hour storm intensities. The hydrologic parameters that most influence the runoff volumes were basin width and infiltration. These were adjusted until the predicted peak discharge matched the observed value. Attempts were also made to match the total storm volume if it was recorded. This calibration procedure was repeated for the other storms. Depression storage was also adjusted as part of the calibration effort. Because the model was used in single-event mode, average antecedent conditions were assumed in every case. By assuming average antecedent conditions, the model is expected to overestimate runoff volumes if drier periods actually precede a storm and underestimate runoff volumes if wetter conditions actually precede a storm. Table 3-5 and Figures 3-6a and 3-6b summarize the results of flow calibration at selected sites shown in Figure 2-1 along the Cedar Creek watershed. In Table 3-5, two storms were selected from available data at Site 8 to verify the predictive ability of the model for the particular choice of calibration parameters.

Site 8 is located approximately one mile downstream of the listed segment (see Figure 2-1) but is the only site with sufficient calibration and verification data. The Huff rainfall distributions were used to synthesize the time distribution of the storms shown in Table 3-6. The results of the verification runs indicate that subject to the assumptions made, the model is capable of predicting runoff from the watershed with sufficient accuracy for the purposes of this study.

TABLE 3-4

SUMMER 1986 STORM DATA USED FOR HYDROLOGIC CALIBRATION

	Rain Gage	Day	Time	Precipitation (inches)	Maximum Intensity (inches/hour)	Duration (minutes)
Storm 1 (May 16 and 17, 1986)	1	16-May	2110-2125	0.09	0.09	15
	1	17-May	0200-1910	2.25	0.54	1.030
	2	16-May	2004-2017	0.15	0.15	13
	2	17-May	0057-2256	3.04	0.83	1.319
	3	16-May	1429-2048	0.27	0.22	349
	3	17-May	0052-1809	2.33	0.51	1.037
	GWD	17-May	NR	3.50	NR	NR
Storm 2 (July 7 through 10, 1986)	2	7-Jul	1713-1731	0.07	0.07	18
	2	8-Jul	2232-0359	0.94	0.63	327
	2	10-Jul	0531-0604	0.16	0.14	69
	2	10-Jul	1528-2235	0.39	0.32	427
	3	7-Jul	0351-0401	0.13	0.13	10
	3	8-Jul	2222-0354	1.01	0.64	332
	3	10-Jul	0459-0643	0.24	0.18	104
	3	10-Jul	2118-2208	0.06	0.07	50
	GWD	10-Jul	NR	1.16	NR	NR
Storm 3 (July 31 through August 1, 1986)	2	31-Jul	0112-0542	4.16	1.97	270
	3	31-Jul	0112-0531	3.42	1.9	259
	4	**31-Jul**	**0108-0448**	**3.91**	**191**	**220**
	GWD	**31-Jul**	**NR**	**4.12**	**NR**	**NR**
Storm 4 (August 26 through 27, 1986)	1	26-Aug	0440-0820	0.44	0.34	222
	2	26-Aug	0435-0745	0.31	0.28	190
	3	26-Aug	0430-0810	0.18	0.14	220
	4	26-Aug	0432-0723	0.44	0.4	171
	GWD	26-Aug	NR	0.23	NR	NR
Storm 5 (September 11 through 12, 1986)	1	11Sep	0350-0655	0.44	0.34	222
	1	11-Sep	1410-1600	0.11	0.1	110
	2	11-Sep	0340-0900	0.91	0.68	356
	2	11-Sep	1413-1614	0.15	0.14	121
	3	11-Sep	0257-0926	0.86	0.56	389
	3	11-Sep	1410-1619	0.22	0.19	129
	4	11-Sep	0310-0927	1.03	0.43	377
	4	11-Sep	1413-1612	0.19	0.16	19
	GWD	11-Sep	NR	1.02	NR	NR

Notes:
GWD Galesburg Water Department
NR Not recorded

TABLE 3-5

PEAK FLOW CALIBRATION AND VERIFICATION RESULTS AT SITE 8

Rain Event	Average Rainfall Depth (inches)	Predicted Flow (ft^3/s)	Observed Flow[a] (ft^3/s)
Calibration 07/31/86	4.16	820	860
Verification 10/02-03/86	2.10	218	260
Verification 11/18/85	1.12	52	35[b]

Notes:

ft^3/s Cubic foot per second

[a] Source: USGS 1987
[b] Peak observed on November 20, 1985

FIGURE 3-6a
HYDROGRAPH PREDICTED BY SWMM FOR AUGUST 26, 1986, STORM AT SITES 1 AND 8

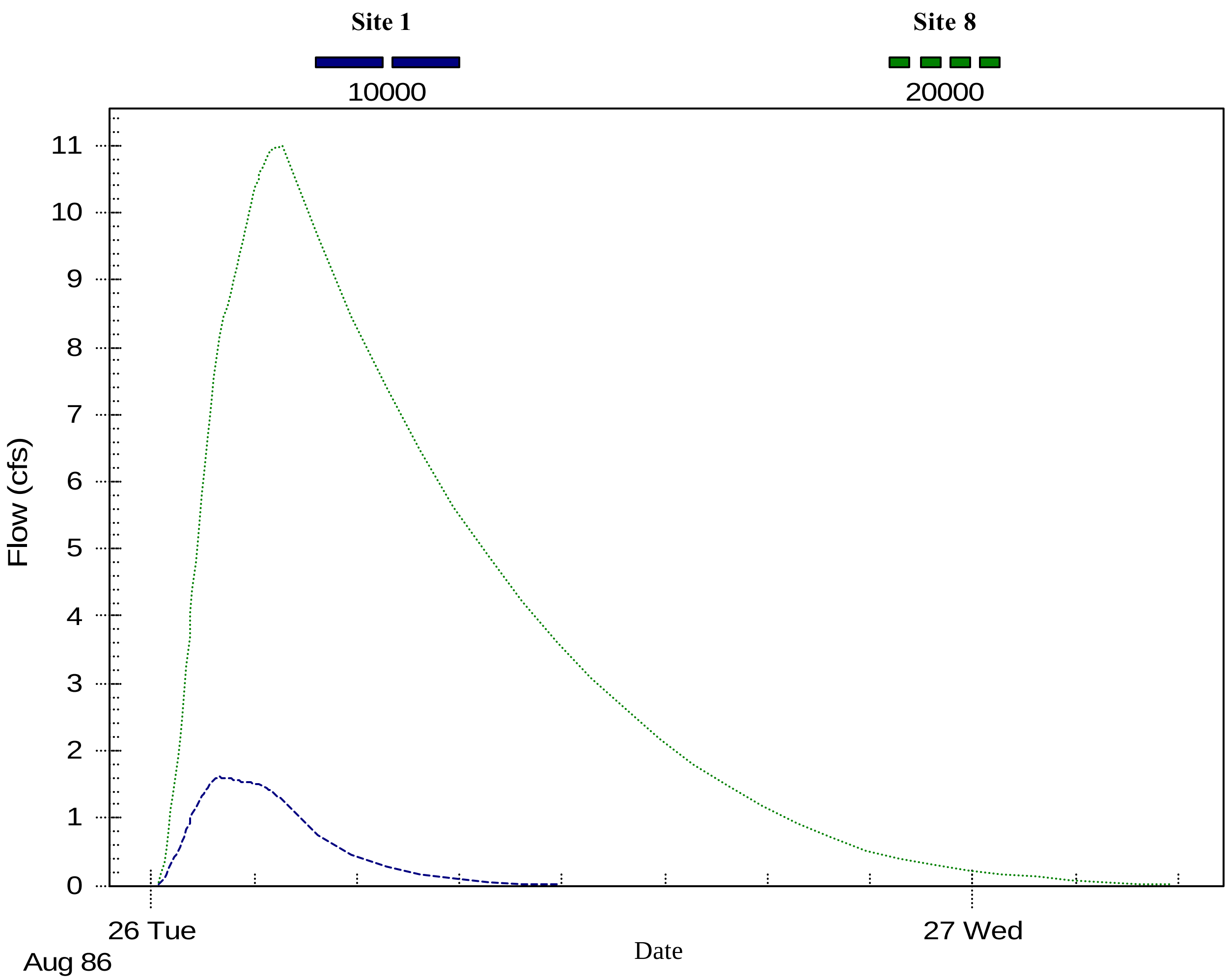
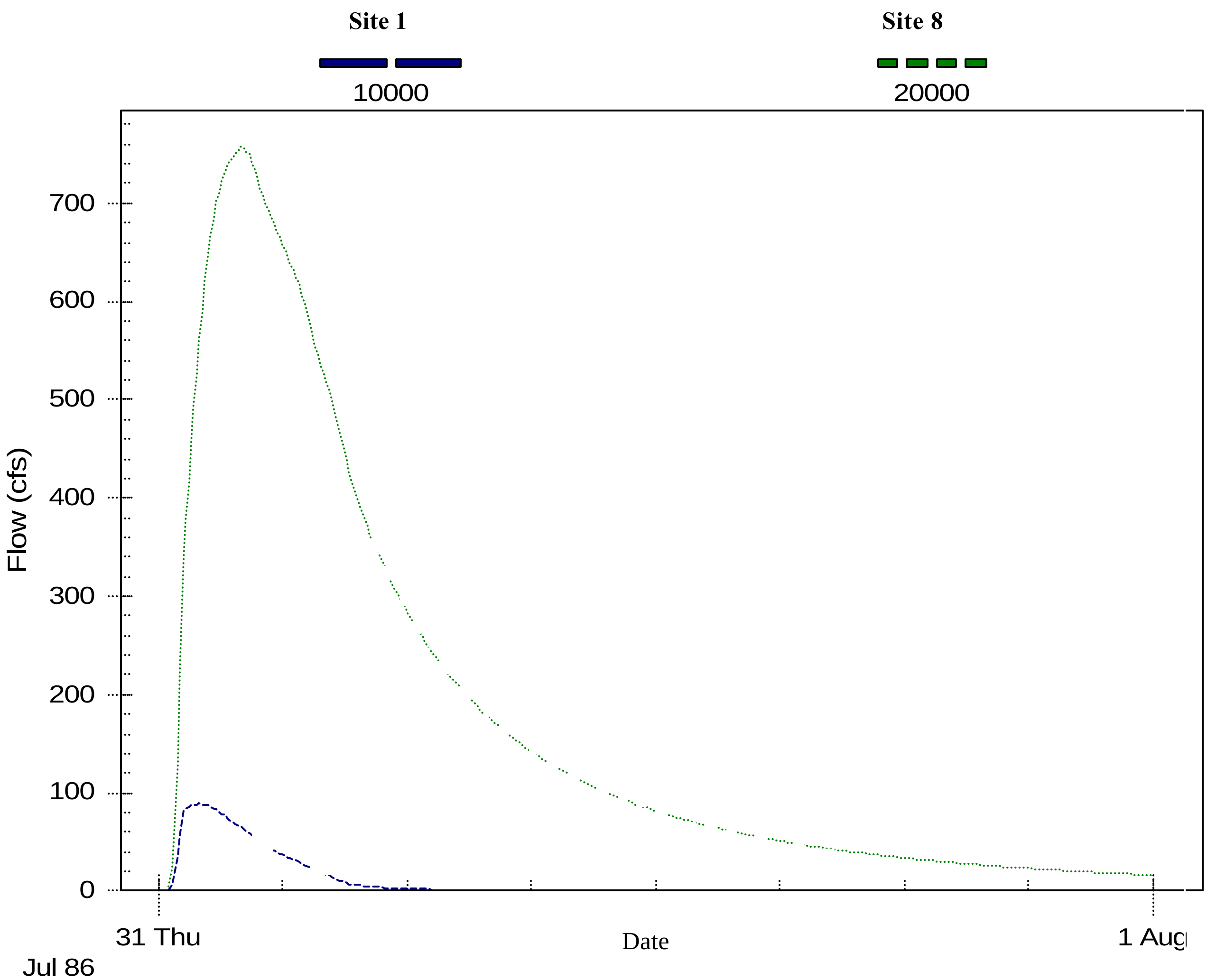


FIGURE 3-6b
HYDROGRAPH PREDICTED BY SWMM FOR JULY 31, 1986, STORM AT SITES 1 AND 8



3.4 WATER QUALITY CALIBRATION AND VALIDATION

Water quality constituents were calculated after satisfactory hydrologic calibration (peak flow and volumes) of the model. Water quality measurements for the August 26, 1986, storm (Storm Four) were used to calibrate the water quality model parameters. Because pollutographs were not recorded during these storms, event mean concentrations (EMC) were used for calibration instead of pollutographs. EMCs for each storm were computed from the total pollutant load and runoff volumes. The average runoff rate (discharge) was computed from the total runoff volume and the average hydrograph duration. Table 3-7 shows the five storms and corresponding loading rates measured by USGS. It should be noted that in Table 3-7, the pollutant loads and runoff volume were not measured directly during the storm. USGS computed these quantities using measurements of flows and concentrations at selected sewer outfall locations in the creek segment (USGS 1989b). The rating curve coefficients for each constituent ("PSHED," "WASHPO," and "RCOEFF" in SWMM input code) were adjusted by trial and error until the flow-weighted concentrations produced by the model matched the storm EMCs.

The SWMM water quality calibration results are presented in Table 3-8, and Figures 3-7a and 3-7b present typical shapes of pollutographs predicted by the model. The rainfall depths presented on Table 3-8 are derived from Table 3-4. Rain gages one and two are located near the northeast and southwest corners of the corporate boundary of the city of Galesburg. Rain gages three and four are located approximately 4 miles northwest and 6 miles southeast of the WWTP, respectively. The city of Galesburg Water Department (GWD) rain gage is located at the GWD plant in Galesburg. The total rainfall depths from this gage were to supplement rainfall data from the other four gages to obtain representative rainfall depths for the Cedar Creek watershed tributary to the listed segment. In general, if two or more gages within the watershed reported the same rainfall depth, this value was used to represent the watershed average precipitation. If gages one or two did not report any readings, then readings from gages three, four, and the GWD were averaged to obtain the representative precipitation. A slight adjustment to the depths was also made to account for the uneven duration of the storms reported for each gage. Storm one is represented by rain gage two. Storm two is represented by the GWD gage. Storm three is represented by rain gage two. Storm four is represented by rain gages one and four. Storm five is represented by rain gage two. This procedure was used in order to represent each storm modeled in SWMM with a single duration.

TABLE 3-6

HUFF RAINFALL DISTRIBUTIONS

Cumulative % of Storm Time	Incremental Percent of Storm Rainfall for Storm Type[a]			
	First-Quartile	Second-Quartile	Third-Quartile	Fourth-Quartile
0	0	0	0	0
5	16	3	3	2
10	17	5	3	3
15	10	4	3	3
20	9	4	3	2
25	8	6	3	3
30	6	7	4	3
35	5	10	4	3
40	4	12	4	3
45	4	11	5	3
50	3	8	6	3
55	2	6	7	4
60	2	5	12	3
65	2	4	13	4
70	2	3	9	6
75	2	3	6	6
80	2	2	4	8
85	2	2	3	13
90	1	2	3	12
95	1	1	2	8
100	2	2	3	8

Notes:

Source: ISWS 1989

[a] First-quartile storms have durations less than six hours, second-quartile storms have durations greater than six hours but less than 12 hours, third-quartile storms have durations greater than 12 hours but less than 24 hours, and fourth-quartile storms have durations exceeding 24 hours.

TABLE 3-7

AVERAGE RUNOFF AND LOADING RATES FOR THE FIVE MEASURED STORMS IN 1986

Storm No.	Storm Duration (minutes)	Average Daily Flow (ft^3/s)	Mean Loading Rate (lb/s)	Total Load (lb)
4	190	2.9	0.04	407
2	841	7.4	0.03	1.350
3	270	32	0.24	3.930
5	477	1.54	0.15	4,380
1	1.319	151	0.34	27.300
TSS				
4	190	2.9	0.3	3.140
3	270	7.4	0.3	5.070
2	841	1.54	0.3	13.000
5	477	32	0.7	19.700
1	1.319	151	1.6	128.000
Ammonia-N				
4	190	2.9	0.001	6.65
2	841	1.54	0.000	13
5	477	32	0.001	16.2
3	270	7.4	0.008	127
1	1.319	151	0.010	791

Notes:

Ammonia-N	Ammonia-Nitrogen
BOD	Ultimate carbonaceous biochemical oxygen demand
ft^3/s	Cubic foot per second
lb	Pound
lb/s	Pound per second
TSS	Total suspended solids

Source: USGS 1989b

TABLE 3-8

SUMMARY OF SWMM CALIBRATION RESULTS

Storm	May 16, 1986 (Storm 1)		July 7, 1986 (Storm 2)		July 31, 1986 (Storm 3)		August 26, 1986 (Storm 4)		September 11, 1986 (Storm 5)	
	Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted
SITE 1: FARNHAM ROAD (Agricultural Area)										
Rainfall depth (inches)	3.04	3.04	1.16	1.16	4.16	4.16	0.44	0.44	1.06	1.06
Volume (ft^3)	2,040,000	34,000	131,000	112,600	386,000	790,000	24,600	21,020	42,100	95,000
BOD (mg/L)	17-25	NE	11	29	1.8-14	26	11	24.8	2.3-13	NE
Mean (mg/L)	21	8	11	9	7.77	4.9	11	11.6	13	9
Total load(lb)	2,670.0	1168	90.0	63	176.0	242	16.9	15.3	22.9	54
TSS (mg/L)	57-1420	NE	566	NE	27-1160	2230	NA	448	21-44	NE
Mean (mg/L)	590.5	847	566	708	445.2	444.7	324	377	34.67	691
Total load(lb)	81,800	18,000	2,650	5,000	4,190	90,700	498	495	852	4,100
Ammonia-N (mg/L)	0.15-1.5	NE	NA	NE	0.15-0.41	0.78	NA	0.7	0.10-0.12	NE
Mean (mg/L)	0.45	0.25	NA	0.26	0.28	0.17	NA	0.37	0.11	0.27
Total load(lb)	20.4	5.4	0.82	1.9	2.41	8.5	0.15	0.5	0.26	1.6
SITE 8: HIGHWAY 34 IN GALESBURG (Urban Area)										
Rainfall Depth	3.04	NE	1.15	NE	4.16	4.16	0.44	0.44	1.06	1.06
Volume (ft^3)	8,740,000	8,225,000	1,730,000	2,600,000	20,300,000	15,800,000	296,000	313,700	2,600,000	2,000,000
BOD (mg/L)	42.4	5.0	9.9	14.0	2.2	2.6	17.4	22.3	2.0	1.8
Total load (lb)	23,100	2,509	1,070	2,300	2,810	2,542	321	437	3,740	2,270
TSS (mg/L)	198.0	NE	95.4	143.0	290.0	680.7	134.3	128.0	15.3	133.0
Total load (lb)	108,000	130,000	10,300	23,200	3,620	671,800	2,480	2,504	16,800	16,900
Ammonia-N (mg/L)	1.2	0.2	0.1	0.2	0.1	0.1	0.3	0.3	0.0	NE
Total load (lb)	671	77	10.3	30	90.5	128	5.26	5.44	13.9	24.3

Notes:

Ammonia-N	Ammonia-nitrogen
BOD	Ultimate carbonaceous biochemical oxygen demand
ft^3	Cubic foot
lb	Pound
mg/L	Milligram per liter
NA	Not available
NE	Not evaluated
SWMM	Storm Water Management Model
TSS	Total suspended solids

FIGURE 3-7a
AMMONIA-N AND TSS POLLUTOGRAPHS PREDICTED BY SWMM FOR AUGUST 26, 1986, STORM AT SITES 1 AND 8

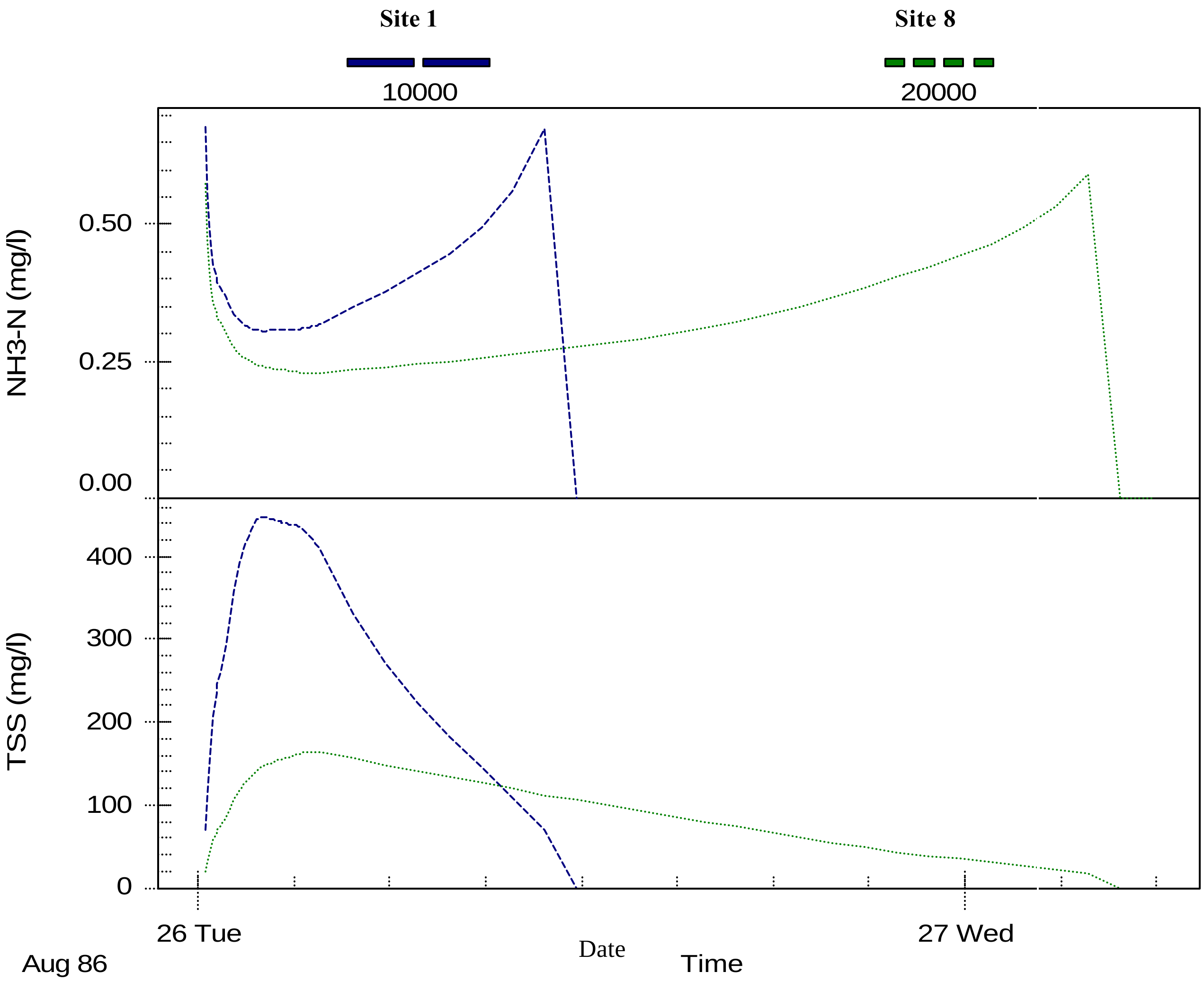
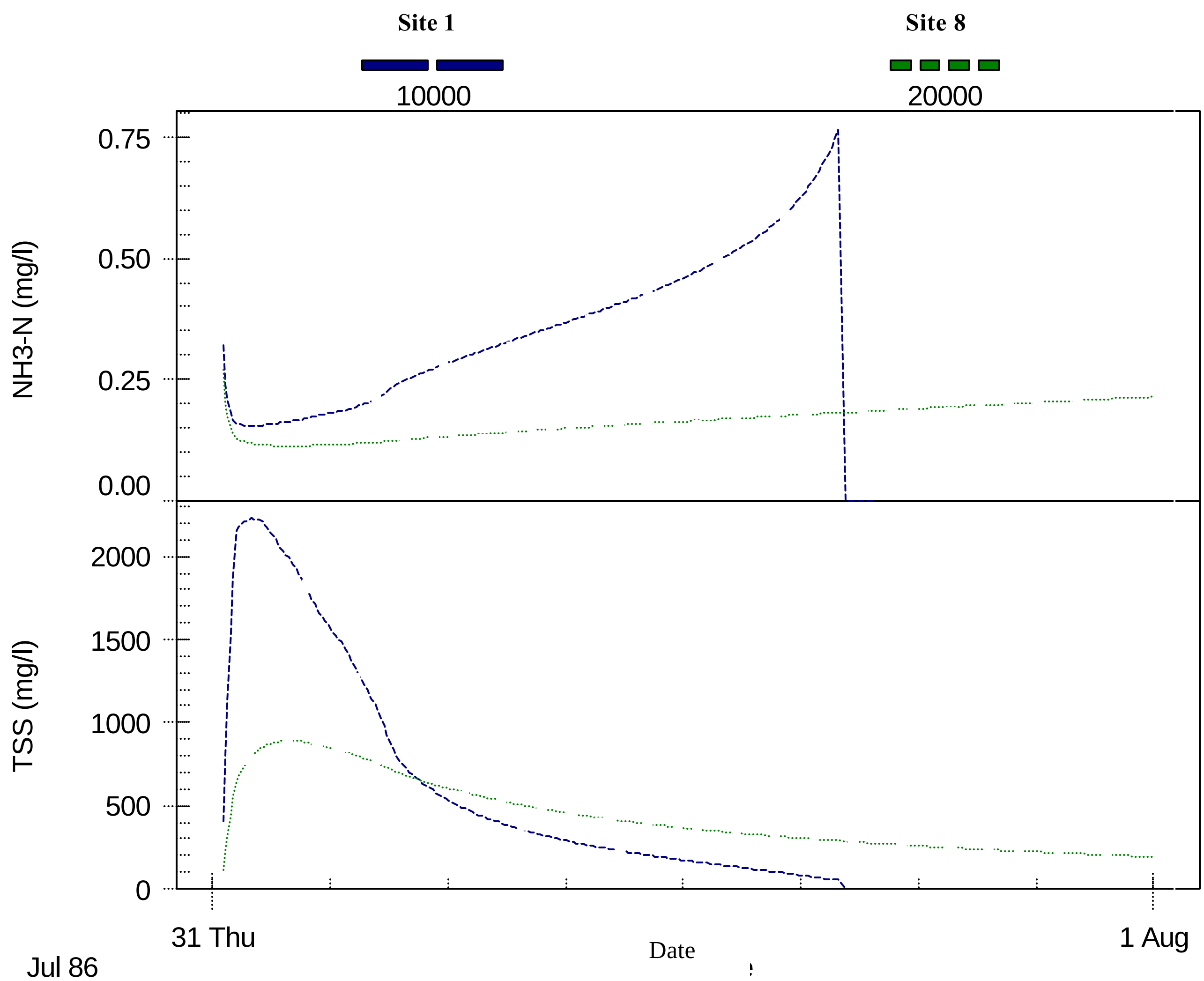


FIGURE 3-7b
AMMONIA-N AND TSS POLLUTOGRAPHS PREDICTED BY SWMM FOR JULY 31, 1986, STORM AT SITES 1 AND 8



The shapes of the pollutographs on Figures 3-7a and 3-7b result from the rating curve procedure that uses the power-law relationship. When using the rating curve method, the loading rate of a constituent at a certain time is computed as:

$$P_{off} = R_{coeff}\, W_{flow}^{Washpo}$$

where:

P_{off}	=	Constituent load washed off at a certain time in pounds per second
R_{coeff}	=	Coefficient that includes correct units conversion
W_{flow}	=	Sub-basin runoff cubic feet per second
W_{ashpo}	=	Wash-off exponent

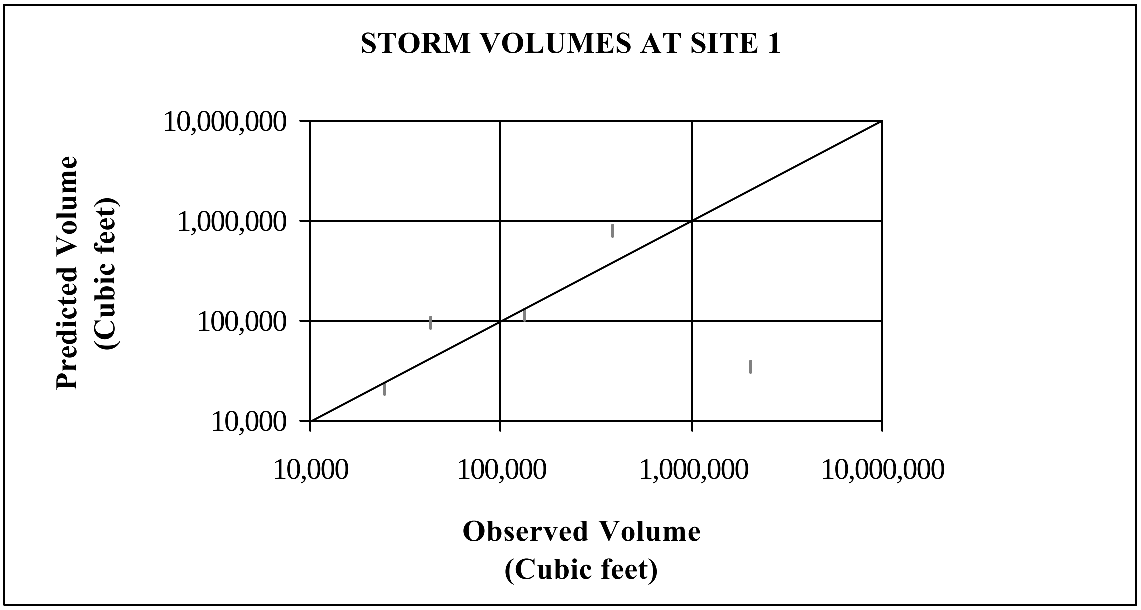
For TSS, typical values of W_{ashpo} are in the range 1 to 3 (EPA 1988). The calibrated value used in this study was 1.4. For dissolved constituents like ammonia-N, W_{ashpo} is typically in the range 0.5 to 1.0. The calibrated value for W_{ashpo} for the urban and agricultural areas was 0.83. The value of R_{coeff} for ammonia-N in the agricultural and urban areas was 9.0. In the urban area, the value of R_{coeff} for TSS was 1,250, while for the agricultural area, the value was 11,250.

In Figures 3-7a and b, ammonia-N concentrations decrease as flow increases presumably because of the dilution effect. This behavior arises because W_{ahspo} is less than 1.0. The ammonia-N pollutographs drop sharply after runoff ceases because concentration is not defined without flow. Unlike ammonia-N, TSS concentrations increase as flow increases because W_{ashpo} is greater than 1.0. This behavior appears reasonable because higher flow rates tend to entrain more sediment than low flows. Such behavior has been observed in field studies. Data from the storms of May 5, July 7 and 31, and September 11, 1986, were used to verify the calibrated model.

3.5 SWMM RESULTS

The results indicate that SWMM predictions for flow, BOD, and ammonia-N parameters match the observed data reasonably well as shown in Figures 3-8 through 3-10. Storm four was used for calibration. Storms one, two, three, and five were used for model verification. The flow volume accuracy

FIGURE 3-8
RELATIONSHIP OF PREDICTED AND OBSERVED STORM VOLUMES AT SITES 1 AND 8



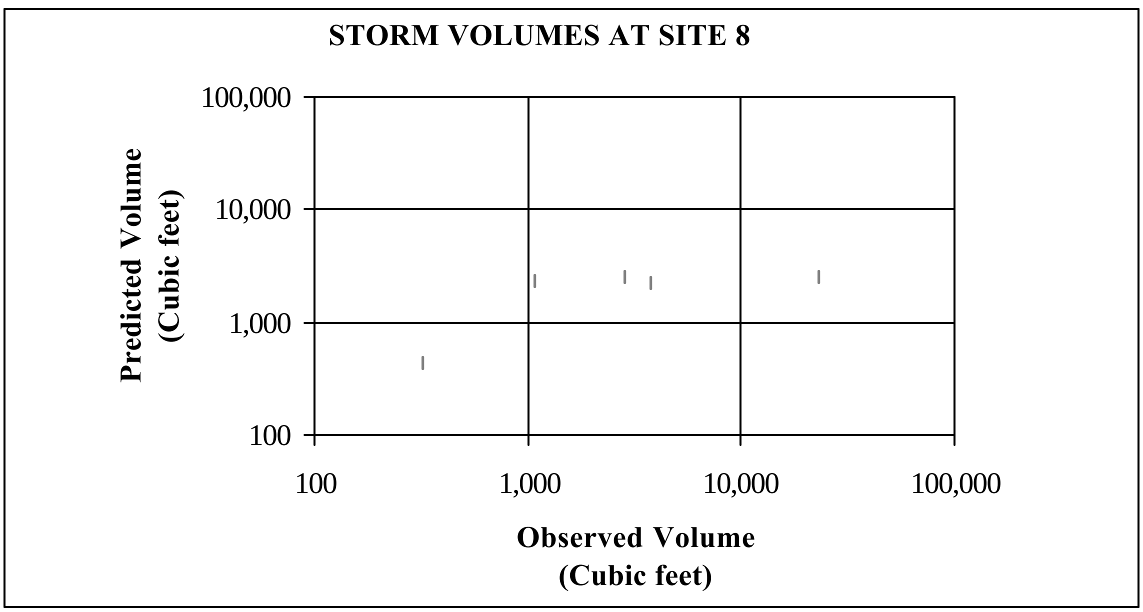
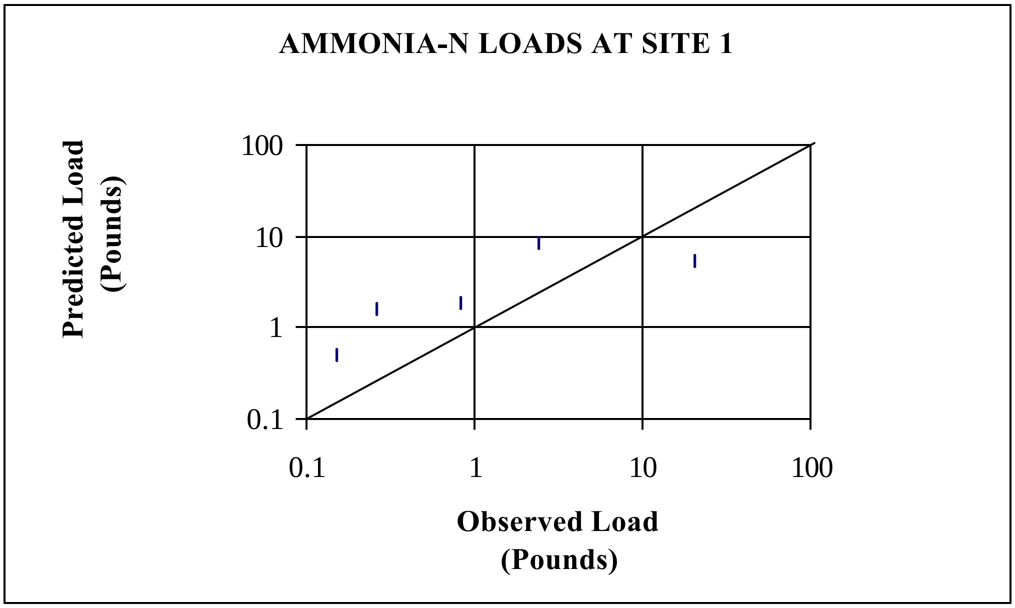


FIGURE 3-9
RELATIONSHIP OF PREDICTED AND OBSERVED AMMONIA-N LOADS AT SITES 1 AND 8



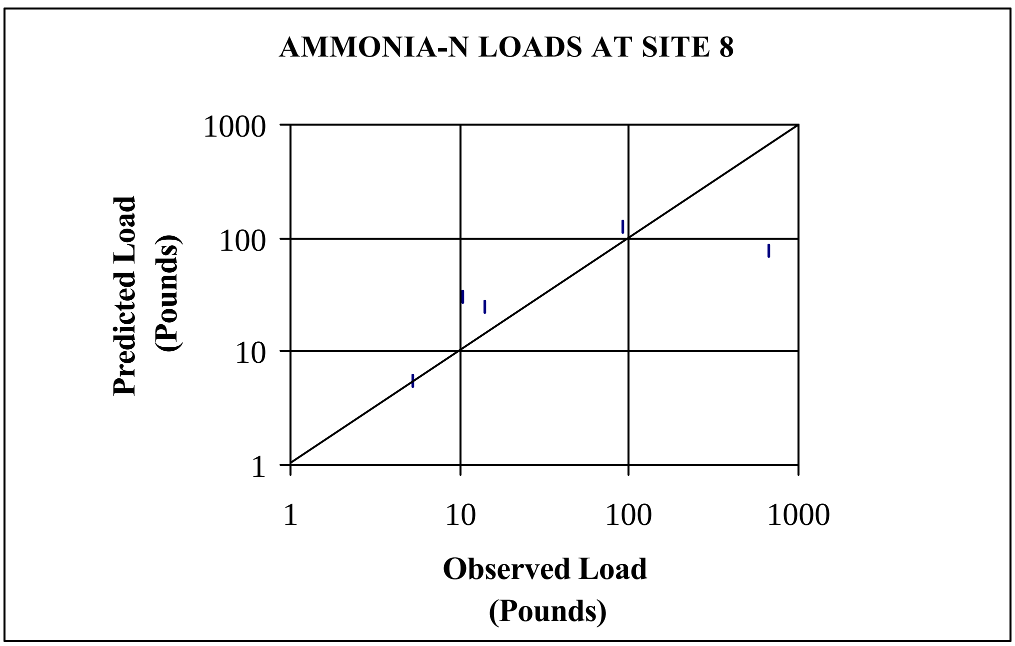
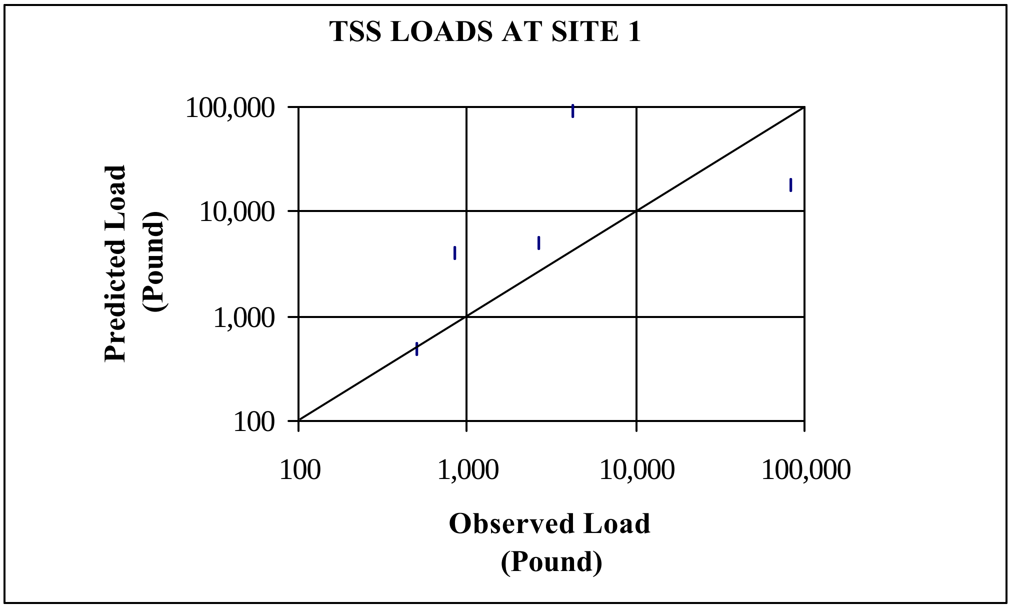
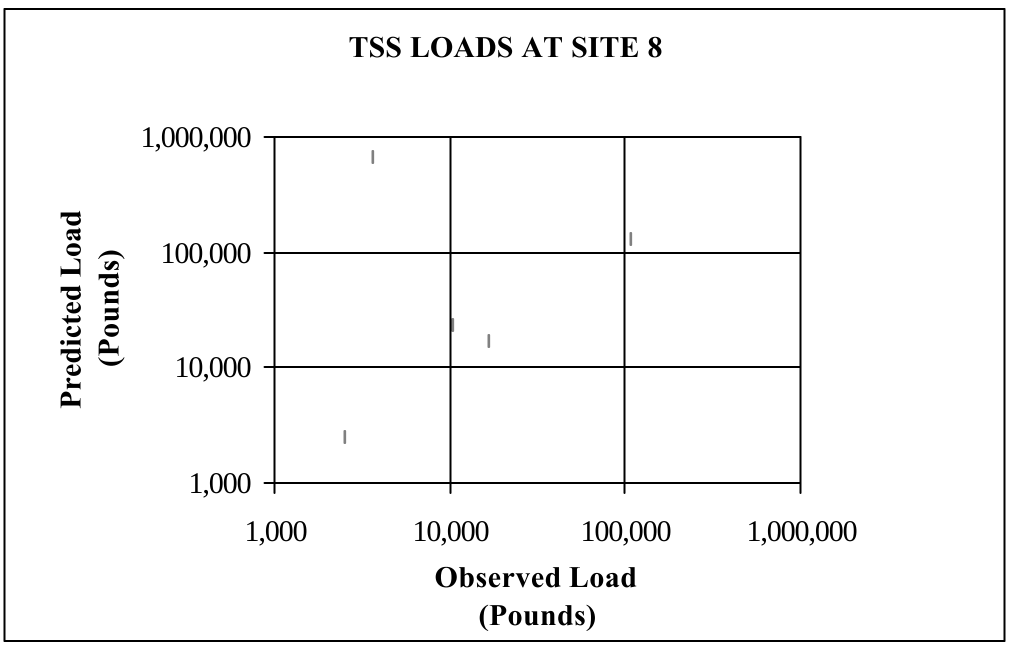


FIGURE 3-10
RELATIONSHIP OF PREDICTED AND OBSERVED TSS LOADS AT SITES 1 AND 8





is highest because flow is the easiest quantity to measure accurately compared to the other constituents. Model TSS predictions for Storms two and three match the observed loads reasonably well. The model, however, overpredicts TSS loads for Storm five and underpredicts TSS loads for Storm one at Site 1. This inconsistency is not surprising given the complexity of the processes involved, including the source of the sediment and the sediment mode of transport, both of which are still poorly understood. TSS loads predicted represent the total sediment load carried primarily in suspension. The component of sediment transported as bed-load is not directly addressed even though at the high transport volumes that occur during large storm events, sediment transported as bed-load is indistinguishable from sediment carried in suspension. During calibration, small changes in runoff rates caused very large changes in predicted TSS loads. Sediment may originate either from the watershed in association with runoff or be a product of erosion from the creek bed and banks. Small storm events may not generate sufficient force to erode stream banks or mobilize bed sediments.

In the urban areas, sediment was assumed to be entrained and transported by the same mechanism as in the agricultural areas even though the former involves quite different mechanisms. In addition, the silt deposited in the concrete-lined portion of the channel becomes a source of sediment during high flows. Such silt behaves hydraulically differently from sediment in the unlined segments of the creek. The TSS model results therefore reflect the inability of the model to discriminate between such diverse processes. Based on the overall quality of the calibration and verification, the calibrated model may be used as a predictive tool capable of producing reasonably accurate results for planning purposes. Uncertainties inherent in this model can be substantially reduced if the model results are used in conjunction with an appropriate monitoring program, especially for TSS loads.

3.6 CSO SIMULATION

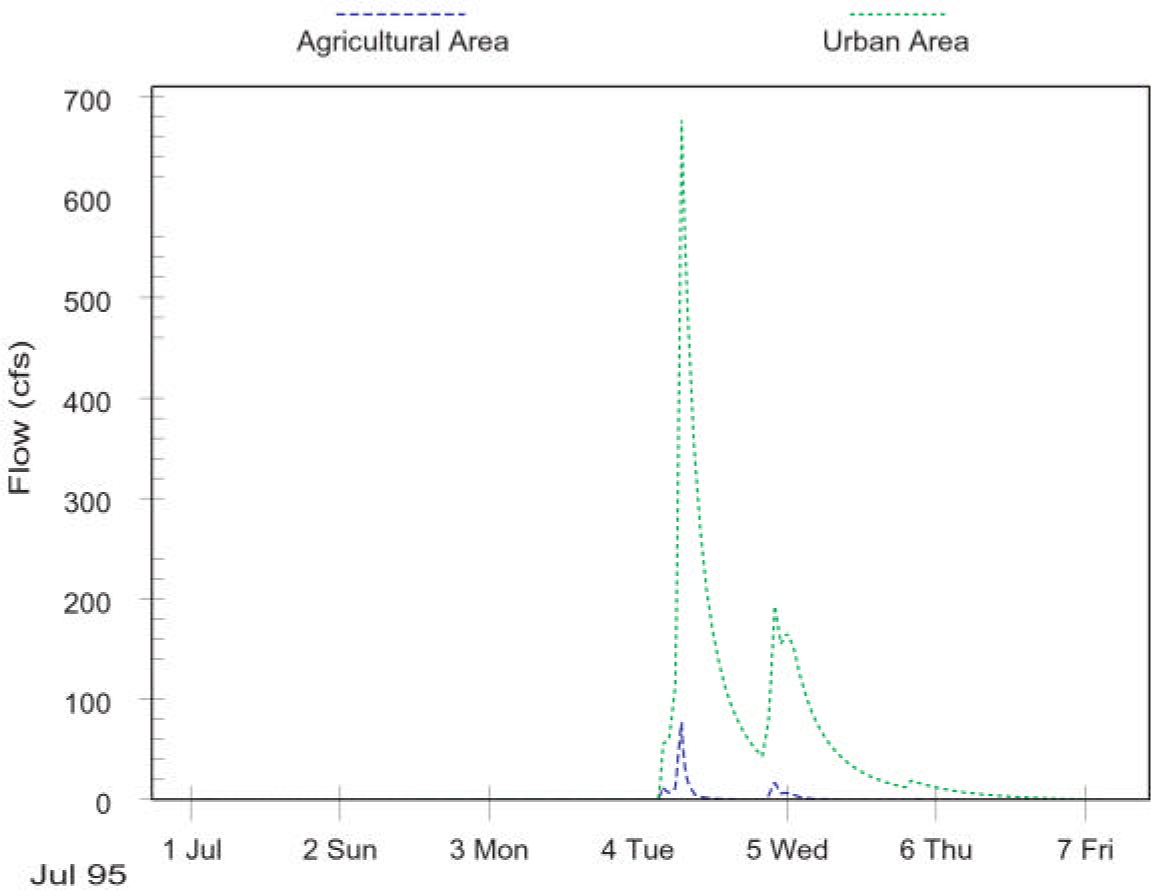
The purpose of the SWMM CSO simulation was to evaluate the performance of the sanitary system following improvements that have been made to the system since 1987. These improvements are described in Section 3.1.3 and consisted of raising the crest elevation of the overflow weirs in the outfall manholes and construction of the 60-inch-diameter main interceptor to the WWTP. In addition, some CSO points were eliminated.

Typically, CSOs occur during large storm events. A large storm event is any storm that produces runoff exceeding the capacity of the main interceptor to the WWTP. Large storms with high intensities represent a worst-case scenario from the standpoint of CSO volumes. Inspection of the Alexis National Oceanic and Atmospheric Administration (NOAA) gage indicated that the storm of July 4, 1995, is suitable for this purpose. The total precipitation during this storm was about 4.8 inches in 20 hours, and the maximum hourly intensity was 2.1 inches per hour. According to ISWS's Bulletin 70, the July 4 storm was approximately a 20-year frequency storm (ISWS 1989). Precipitation records from the Galesburg Water Department indicate that approximately the same amount of precipitation was recorded by the NOAA gage at Alexis. This means the storm that passed through Alexis was essentially unchanged as it passed through Galesburg.

Figures 3-11a through 3-11c present qualitative results of CSO simulation for the July 4, 1995, storm. In this CSO simulation, infiltration into the sanitary sewers was represented by an equivalent of 520 urban watershed acres, which represents about 10 percent of the total urban sewered area. It should be noted that the hydrologic parameters for these infiltration areas are used only to model the infiltration flows according to the modeling approach provided in SWMM. They are being used to enable the SWMM to produce infiltration flows of magnitude comparable to those observed at the WWTP. CSO monitoring records show that during this storm, the average daily flow to the WWTP was 30 to 32 MGD (46 to 50 cubic feet per second [ft^3/s]) and CSOs occurred at several locations. SWMM predicts the peak flow of 73 ft^3/s, which is approximately 50 percent greater than the average daily flow to the WWTP. Figure 3-11c shows that the CSO flow rates range from 0 to 0.5 ft^3/s. The estimated flow volume for all CSOs, including those shown in Figure 3-11c, is 0.5 million cubic feet (ft^3). The peak runoff from the urban watershed is about 700 ft^3/s compared to the peak of 73 ft^3/s in the main interceptor to the WWTP. From these results, the overflow CSO volumes appear to be less than one order of magnitude of the total runoff volumes. From a water quality standpoint, any overflow will therefore be significantly diluted by the storm runoff. The TSS concentration of infiltration flow, which constitutes groundwater, is typically less than that of either sanitary or storm runoff; therefore, overflows to the creek segment cannot be expected to contribute significant TSS loads compared to the nonpoint source loads. Ammonia-N concentrations in the sanitary flow will first be diluted by the infiltration flows by about a factor of 3 to 4. If the additional dilution effect from the storm water in the creek is taken into account, it is apparent that ammonia-N concentrations in the listed segment of the creek will tend to be minimally increased by CSOs.

For comparison purposes, the predicted total volume of runoff from the entire watershed on July 4, 1995, was about 15.2 million ft^3. The total sanitary flow to the WWTP is about 4.9 million ft^3. The volume of overflows from CSO outfalls is about 0.4 million ft^3. These results suggest that the sanitary system appears to have significantly reduced overflows. Because flow data to calibrate the sanitary flows were not available, the actual magnitude of the flow volumes is less important than the relative magnitude compared to the runoff volume, overflow volume, and sanitary flow volume.

FIGURE 3-11a
RUNOFF PREDICTED BY SWMM DURING JULY 4, 1995, STORM



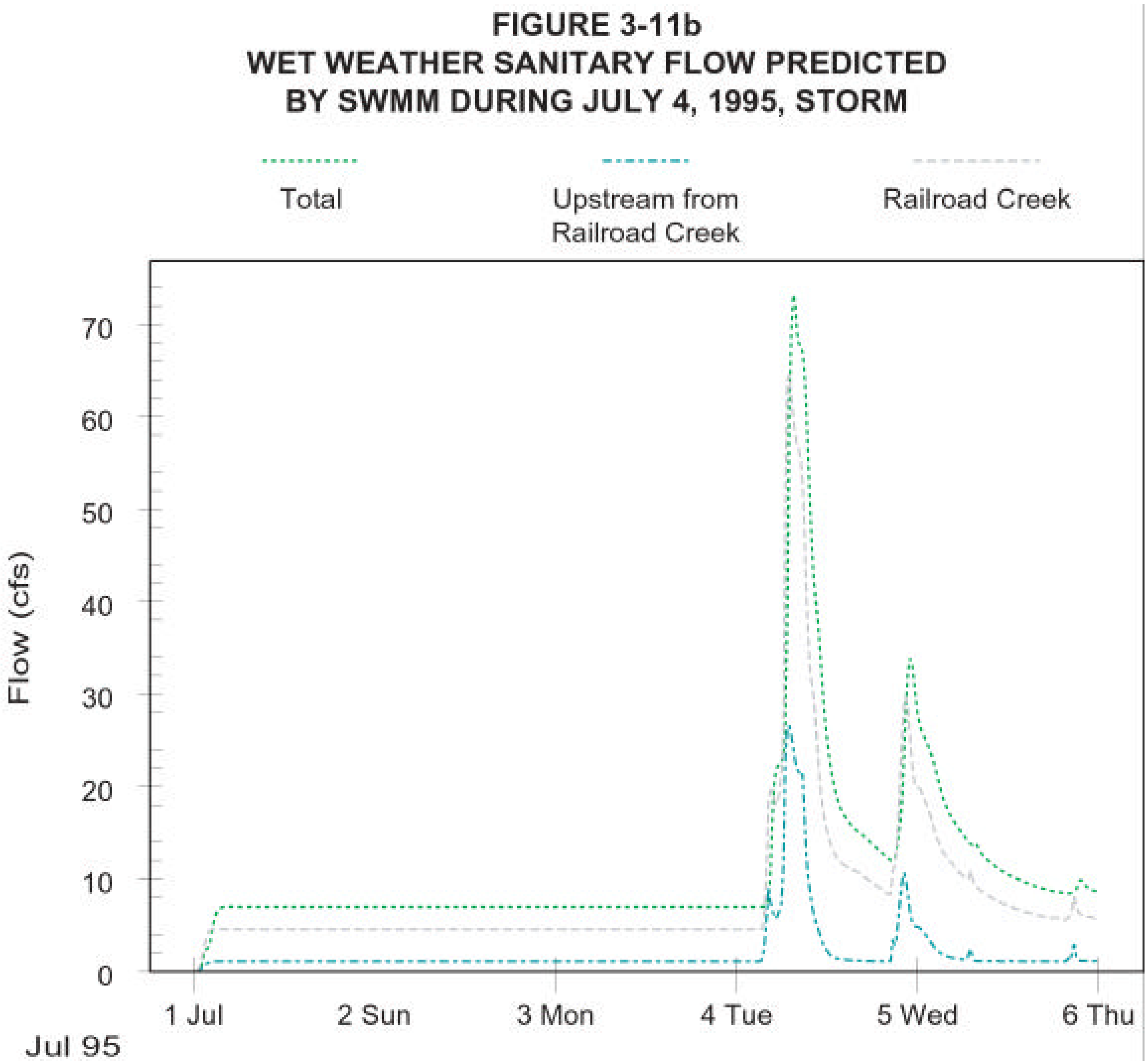
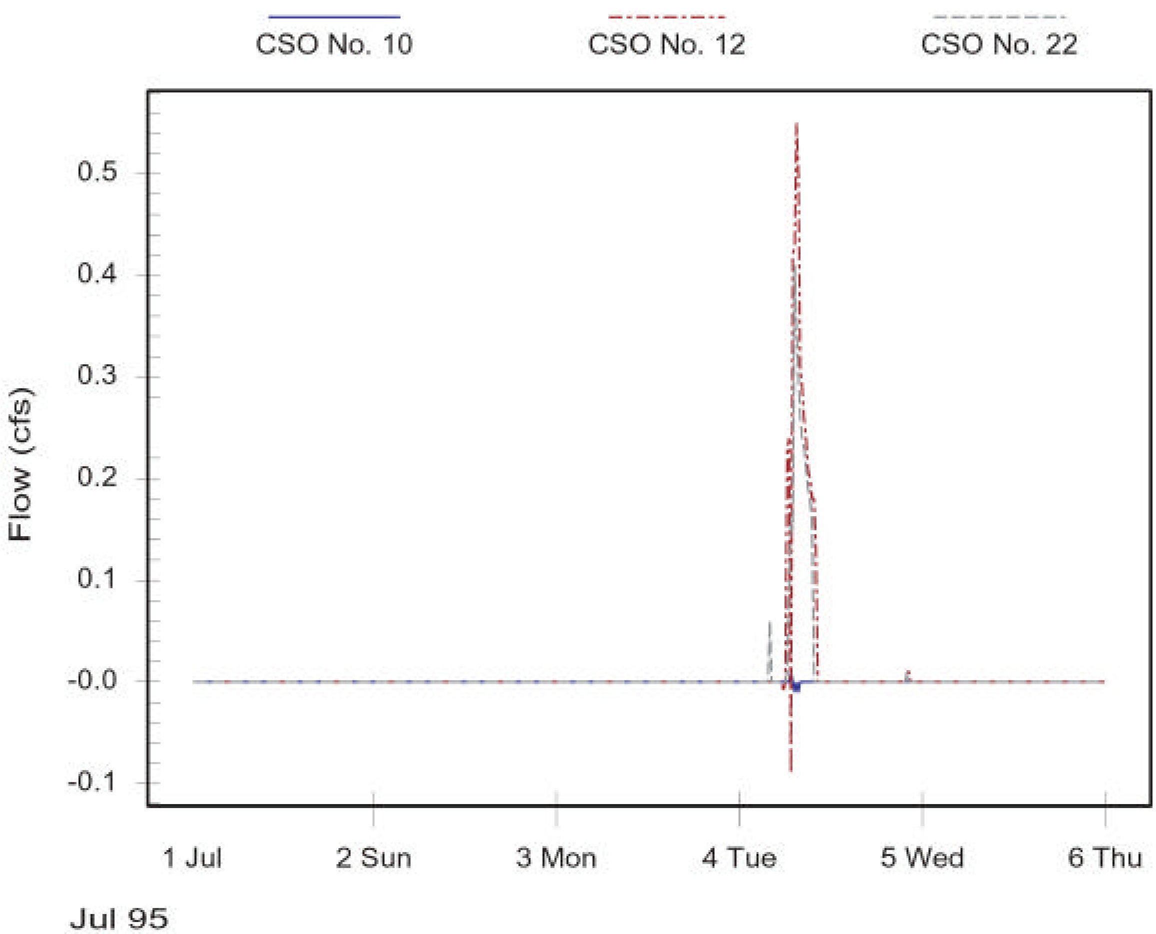


FIGURE 3-11b
WET WEATHER SANITARY FLOW PREDICTED
BY SWMM DURING JULY 4, 1995, STORM
Total
Upstream from Railroad Creek
Railroad Creek
Flow (cfs)
0
10
20
30
40
50
60
70
1 Jul
2 Sun
3 Mon
4 Tue
5 Wed
6 Thu
Jul 95

FIGURE 3-11c
CSOs PREDICTED BY SWMM DURING JULY 4, 1995, STORM



4.0 QUAL2E MODEL DEVELOPMENT

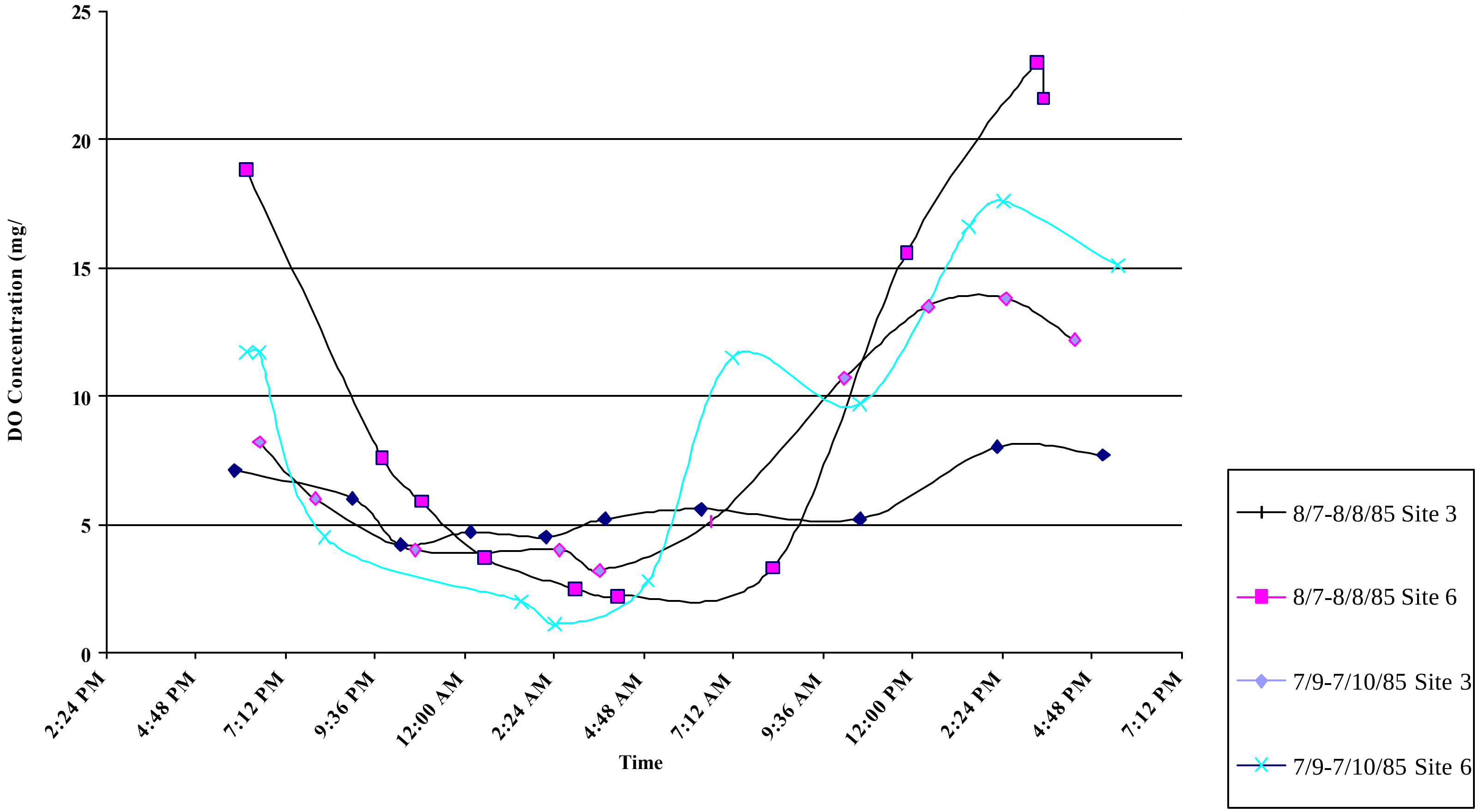
QUAL2E model, a one-dimensional, steady-state, water quality model (NCASI 1985), was used to simulate ammonia-N and DO concentrations in the listed segment of Cedar Creek and the processes affecting each using inflow concentrations predicted by SWMM. QUAL2E model simulations supported the identification of the two critical conditions, base-flow and first-flush events, because the QUAL2E model identified DO concentrations below 5.0 mg/L during base-flow and first-flush events and ammonia-N concentrations above 0.41 mg/L during first-flush events. QUAL2E model development depends on the assumption that USGS data collected during low- and high-flow conditions are accurate. USGS data were key in determining the initial conditions of the listed segment of the creek and in calibrating and verifying the model (USGS 1987, pages 98 through 108, 128 through 131, and 148, 149, 158, and 159).

The QUAL2E model is a steady-state model with the option of running diurnal simulation. Ideally, a diurnal simulation would best model the DO diurnal variation observed in the creek; however, USGS sampling data are not detailed enough to sufficiently calibrate a diurnal simulation. For example, samples were not collected at sufficient time intervals to identify the 24-hour maximum and minimum DO concentrations. Figure 4-1 shows extreme diurnal variation of DO observed along Cedar Creek at Sites 3 and 6 (see Figure 2-1).

After simulating a typical base-flow and first-flush event, the model was used to determine the key factors that impact water quality in the listed segment of the creek and associated load reductions necessary to bring the creek into compliance. Load allocations were then used to determine effective solutions for increasing DO concentrations and reducing ammonia-N loads.

Development of the QUAL2E model involved various steps, including model set-up and calibration and verification. Model set-up involved several tasks, including determining the geometry of the listed segment of the creek, base flow, kinetic rates and coefficients, initial stream concentrations, and incremental inflow concentrations. This section describes each task of model development and the key assumptions made throughout the process. QUAL2E model results are summarized at the end of this section.

FIGURE 4-1
DIURNAL VARIATIONS DURING LOW FLOW



4.1 MODEL SET-UP

The first task in setting up the model included schematization of the listed segment, which involved evaluation of hydraulic characteristics of the listed segment of the creek and general characteristics of the watershed in Galesburg. Once the initial framework was set up, several types of data were needed as inputs for the QUAL2E model, including geometric inputs, base flow, various kinetic rates and coefficients, initial stream concentrations, and incremental inflow and pollutant concentrations. Inputs used for the base-flow and first-flush simulations are discussed below and provided in Attachment B.

4.1.1 Geometric Inputs

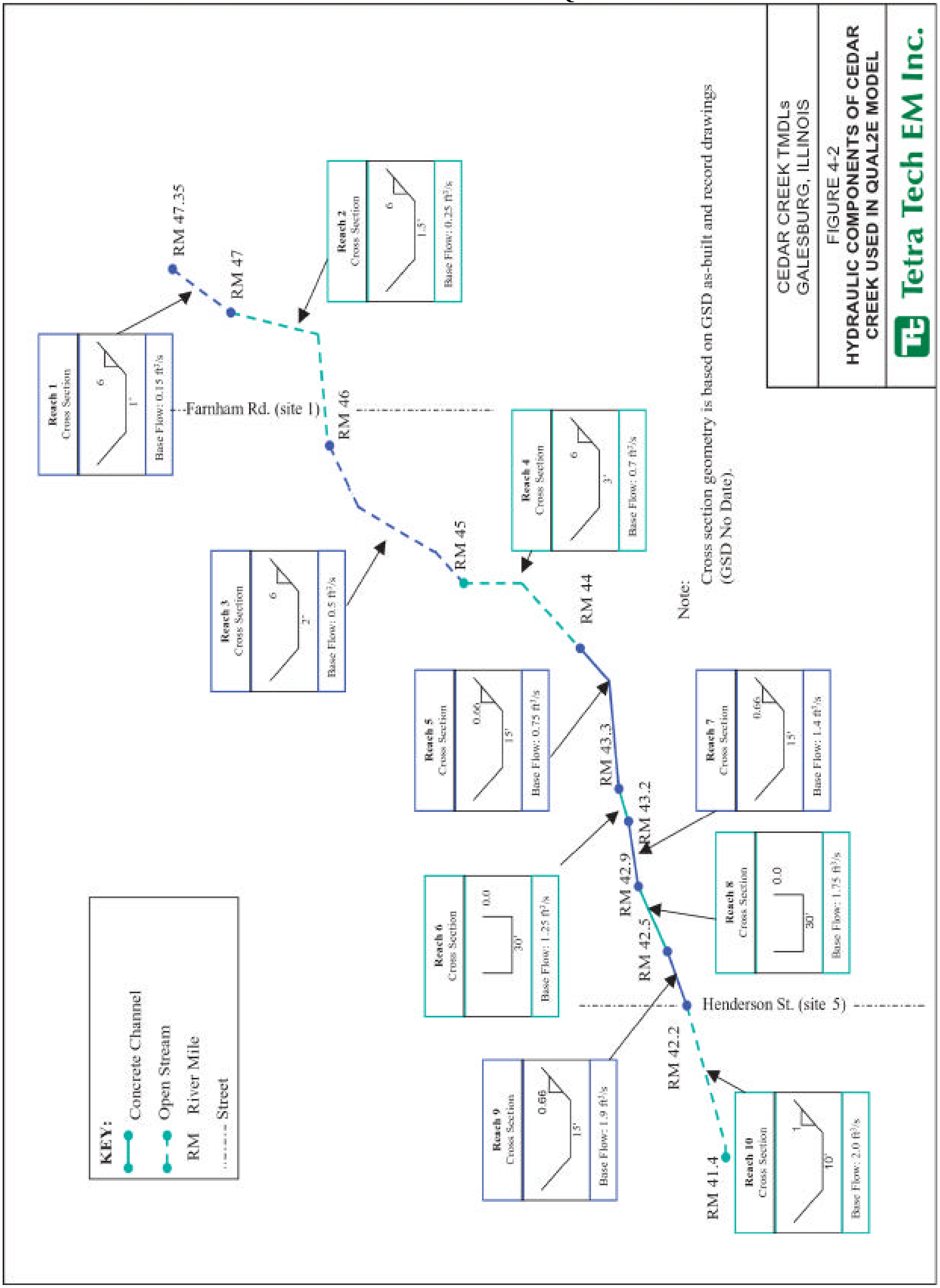
The 5.95-mile listed segment of Cedar Creek was divided into 10 reaches primarily defined by geometric characteristics, including width, side-slope, and roughness (Manning's coefficient). Geometric cross sections were obtained from as-built and record drawings of the paved portion of the channel and field estimates for the unpaved portions (GSD No Date; IEPA 1991, 1994, and 2000a). Figure 4-2 shows the 10 reaches defined along the creek. During base-flow conditions, the widths, side-slopes, and roughness values were altered from the values shown in Figure 4-2 because (1) the flow width is less than 5 feet and (2) the stream meanders along the bed because of debris from previous storms that accumulates in the concrete channel.

The division of the segment into 10 reaches was also based on restrictions of the QUAL2E model, which requires each reach to be divided into subreaches of equal length. These subreaches are used as computational elements for calculating the mass balance of inputs and outputs along the creek. The QUAL2E model also requires that each reach contain no more than 20 subreaches. Consequently, using a subreach length of 0.05 mile, the maximum length of each reach along the listed segment was one mile (NCASI 1985).

4.1.2 Base Flow

Base flow needs to be calculated for two purposes: (1) to evaluate flow during base flow events and (2) to determine the initial flow in the creek segment prior to storm events. As discussed in Section 2.3, the listed segment of Cedar Creek is an ephemeral stream that has no flow for a significant part of the dry period. Therefore, for the purposes of this study, base flow was defined to be flow that prevails in the creek after surface runoff ceases. Hydrograph separation using the USGS 1986 discharge records was determined to be the best approach for determining base flow in the Cedar Creek segment. An evaluation of discharge and precipitation records at site 1 (at Farnham Road) and site 8 (downstream of the listed segment at highway 34) in 1986 indicates that the estimated base flow in the listed segment of Cedar Creek was about 0.5 ft^3/s at site 1 and about 2 ft^3/s at site 8. Figures 4-3a through 4-3f summarize flow conditions at sites 1 and 8 in July, August, and September in 1986 that were used to estimate base flow. A field visit to Cedar Creek in October 2000 verified the presence of base flow from the agricultural area at Farnham Road. At the time of the visit, the watershed had not had precipitation for a period of several days and the creek flow at Farnham Road was estimated to be about 0.5 to 1.0 ft^3/s.

FIGURE 4-2
HYDRAULIC COMPONENTS OF CEDAR CREEK USED IN QUAL2E MODEL



4.1.3 Kinetic Rates and Coefficients

Rate constants and coefficients used in the QUAL2E model to simulate chemical and physical process in the Cedar Creek segment were based on USGS measurements, literature reviews, sensitivity analysis, and calibration and verification results. Table 4-1 lists the rates and coefficients used to run the QUAL2E model, values selected for each parameter, and rationales for the selection of each value.

USGS modeled Cedar Creek from RM 19 through RM 41.6 using the QUALII model in 1989 (USGS 1989a). Although the model did not extend sufficiently upstream to include the entire length of the listed segment, kinetic rates measured by USGS along the upstream portion of the modeled segment were evaluated for use in this QUAL2E model. Generally, kinetic rates measured by USGS in Cedar Creek were preferred over values reported in literature. Key literature reviewed is listed in Table 4-1 in the "References" column.

After initial kinetic rates and coefficients were input into the QUAL2E model, a sensitivity analysis was performed to evaluate the relative influence of the model parameters and processes they represent in determining DO and ammonia-N concentrations along the listed segment of the creek. To perform the sensitivity analysis, model parameters were varied by the range of acceptable values specified in the QUAL2E model user's manual (NCASI 1985) and were varied by the standard deviation of USGS measurements when appropriate. The sensitivity analysis indicated that reaeration coefficients and SOD, BOD decay, and ammonia-N benthos rates significantly affect DO concentrations, but most of these parameters were measured by USGS and are reported in literature. Organic nitrogen hydrolysis, ammonia-N oxidation, and ammonia-N benthos rates and coefficients significantly affect ammonia-N concentrations, but most of these parameters were also measured by USGS or are reported in literature. The final selection of the values used as kinetic rates and coefficients in the QUAL2E model were verified by performing calibration and verification. Table 4-1 summarizes all information considered to select appropriate kinetic rates and coefficients.

FIGURE 4-3a

DISCHARGE AND PRECIPITATION DATA AT SITE 1 IN JULY 1986

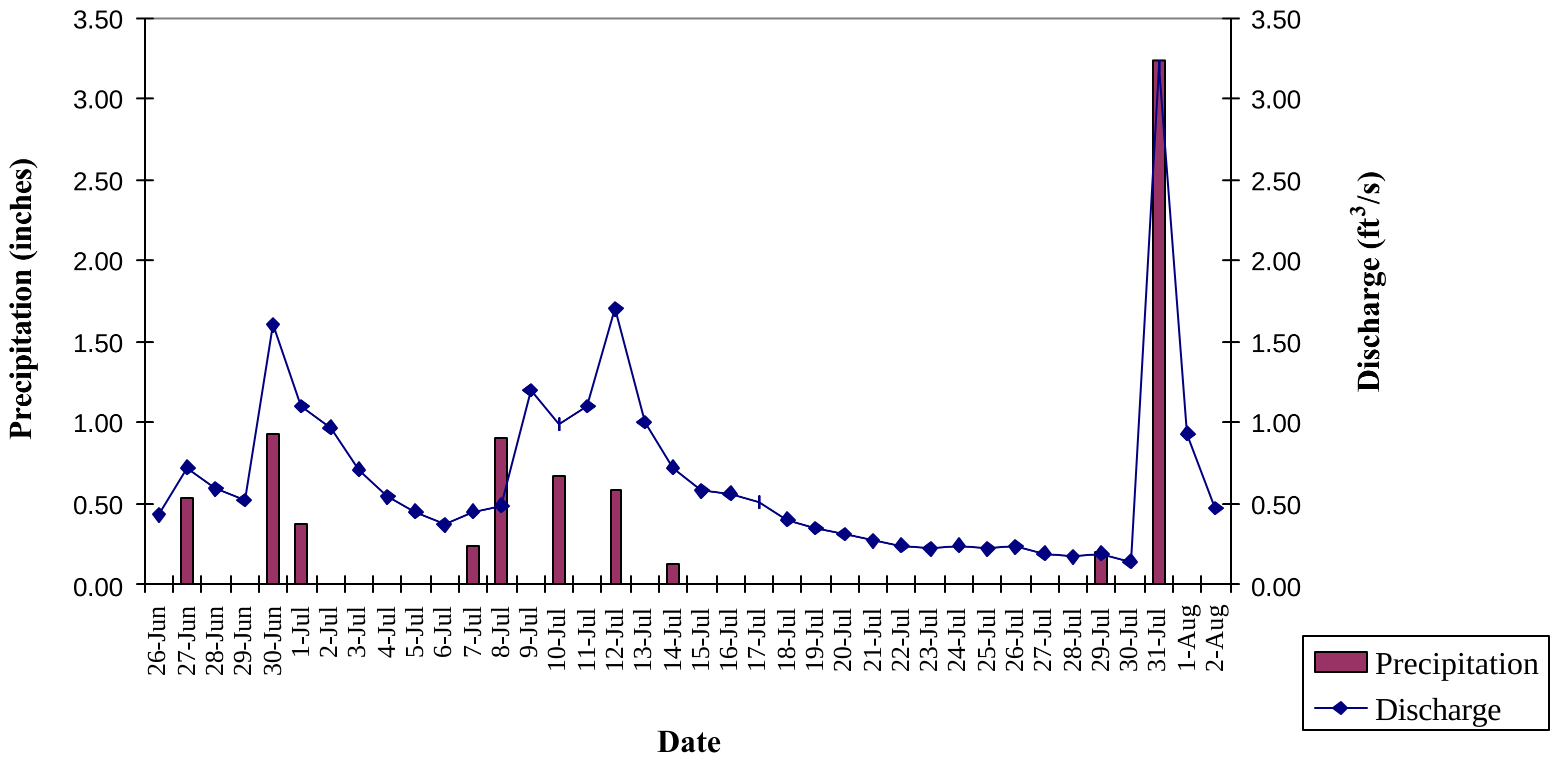


FIGURE 4-3b

DISHCARGE AND PRECIPITATION DATA AT SITE 1 IN AUGUST 1986

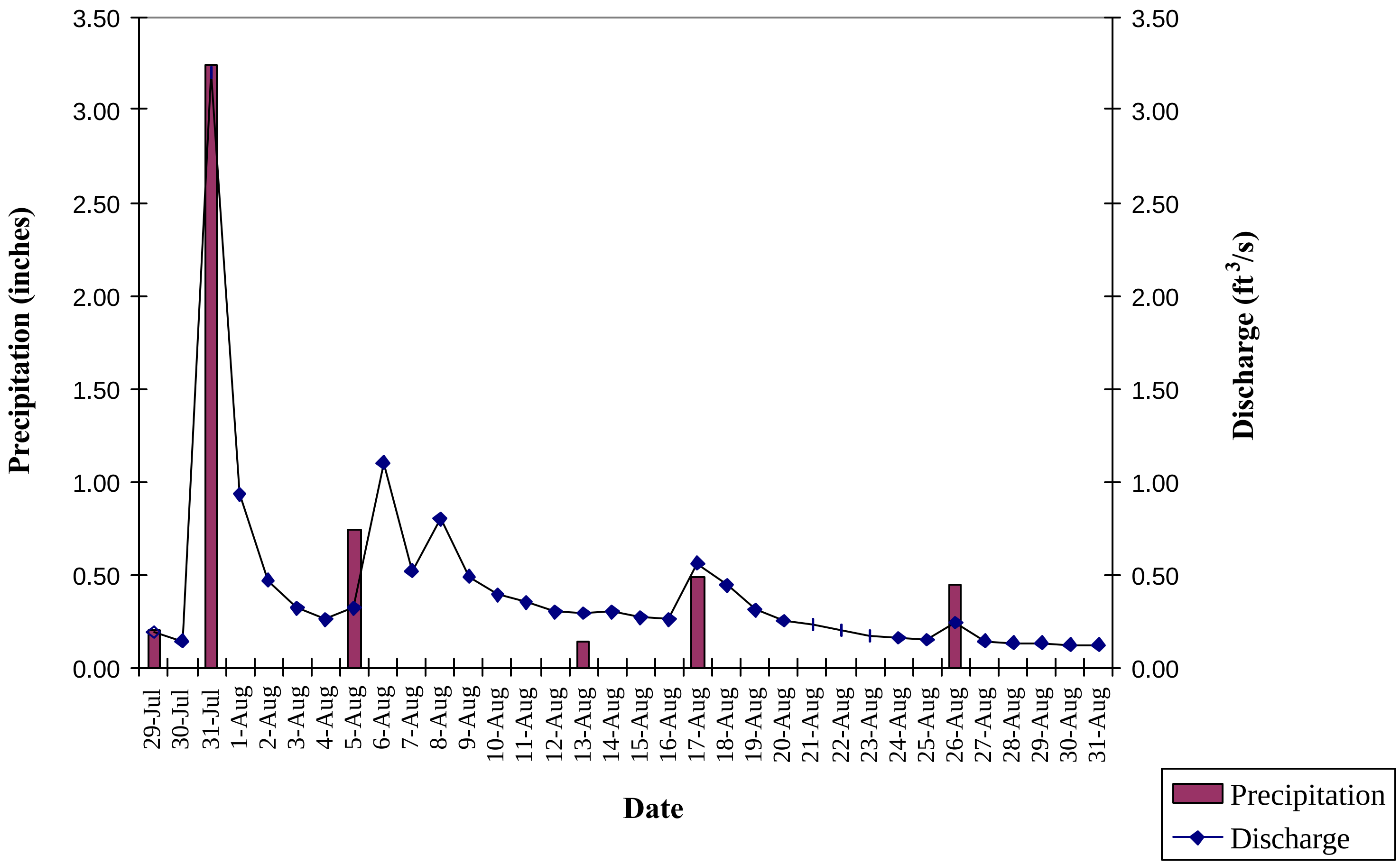


FIGURE 4-3c

DISCHARGE AND PRECIPITATION DATA AT SITE 1 IN SEPTEMBER 1986

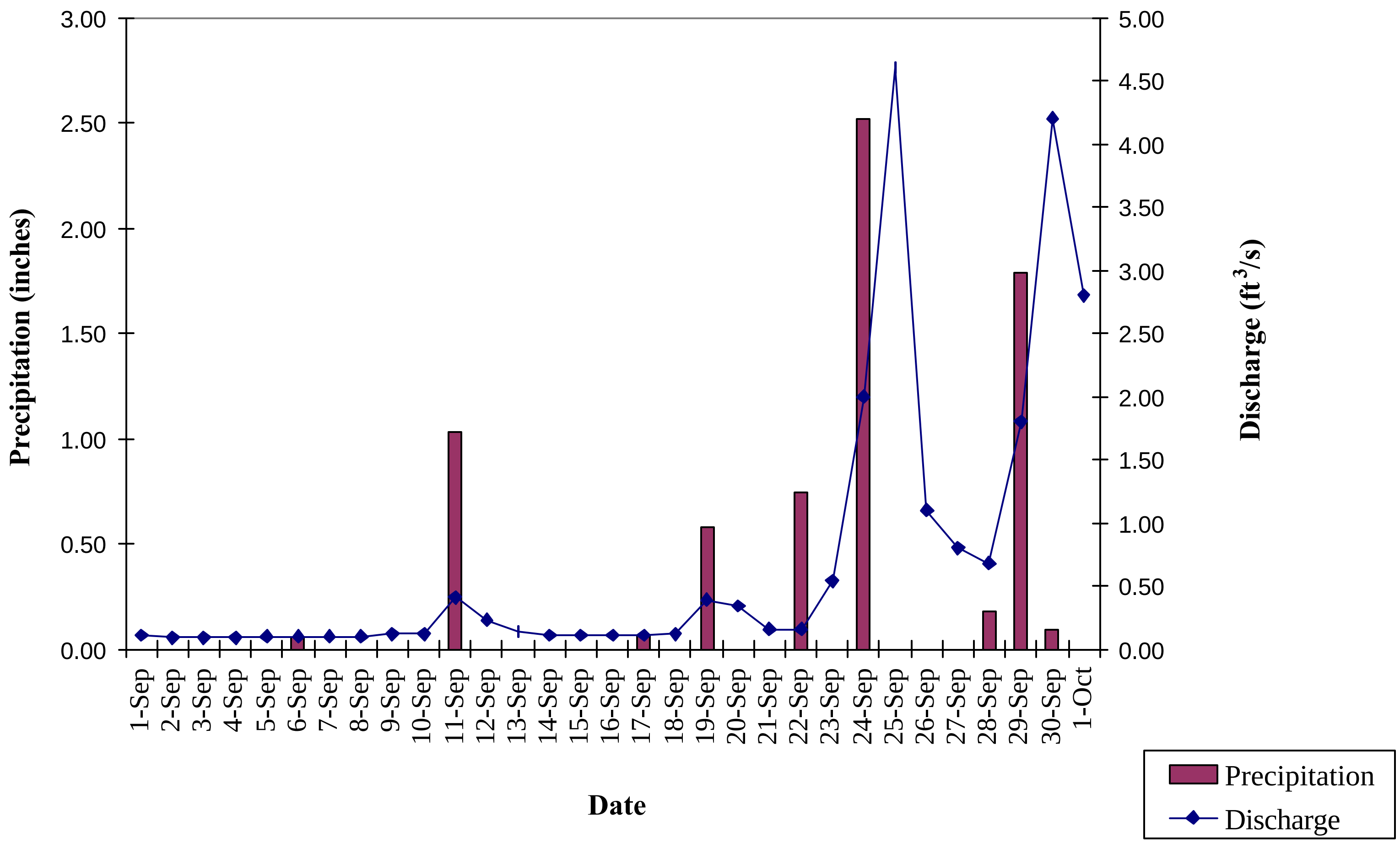


FIGURE 4-3d

DISCHARGE AND PRECIPITATION DATA AT SITE 8 IN JULY 1986

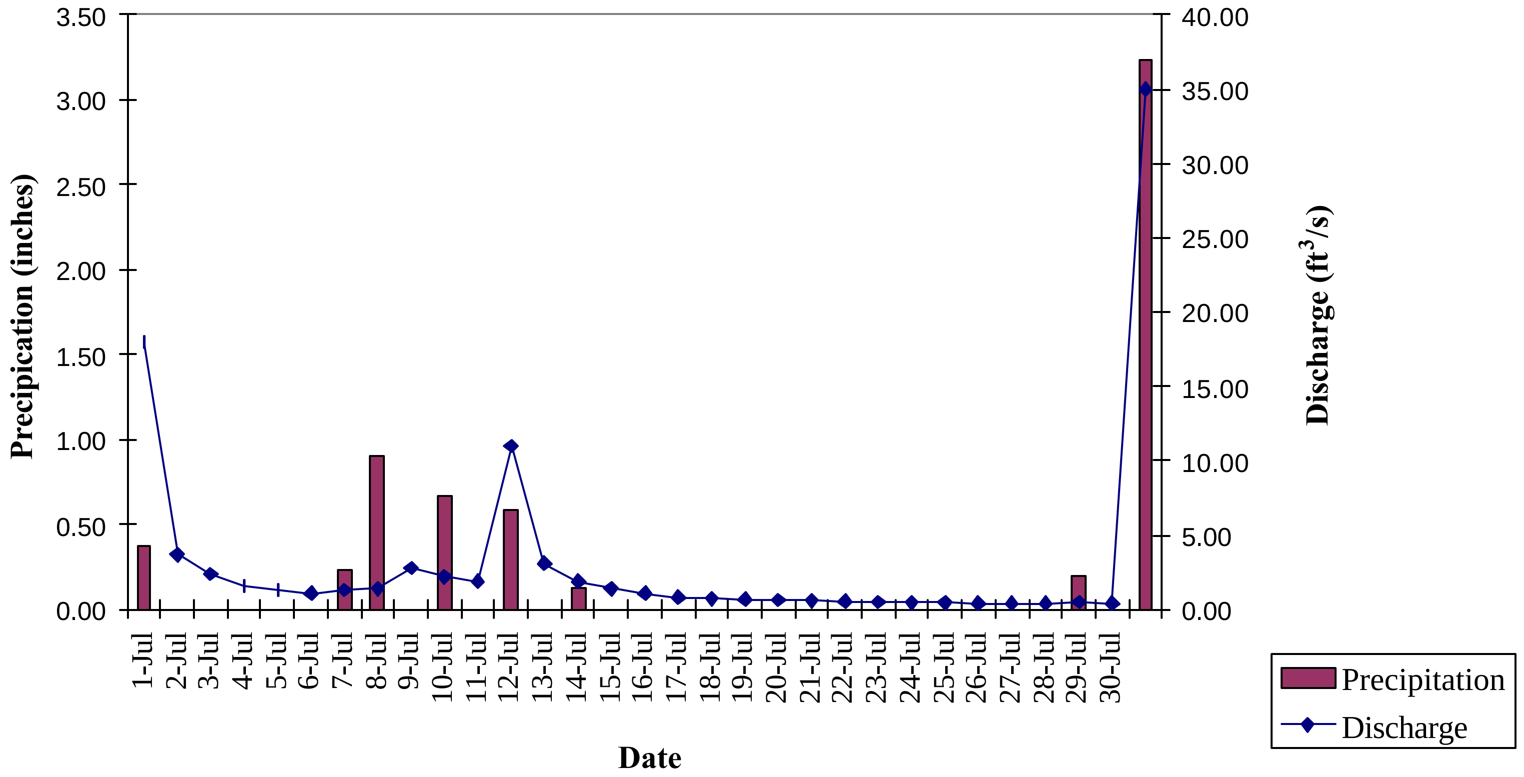


FIGURE 4-3e
DISCHARGE AND PRECIPITATION DATA AT SITE 8 IN AUGUST 1986

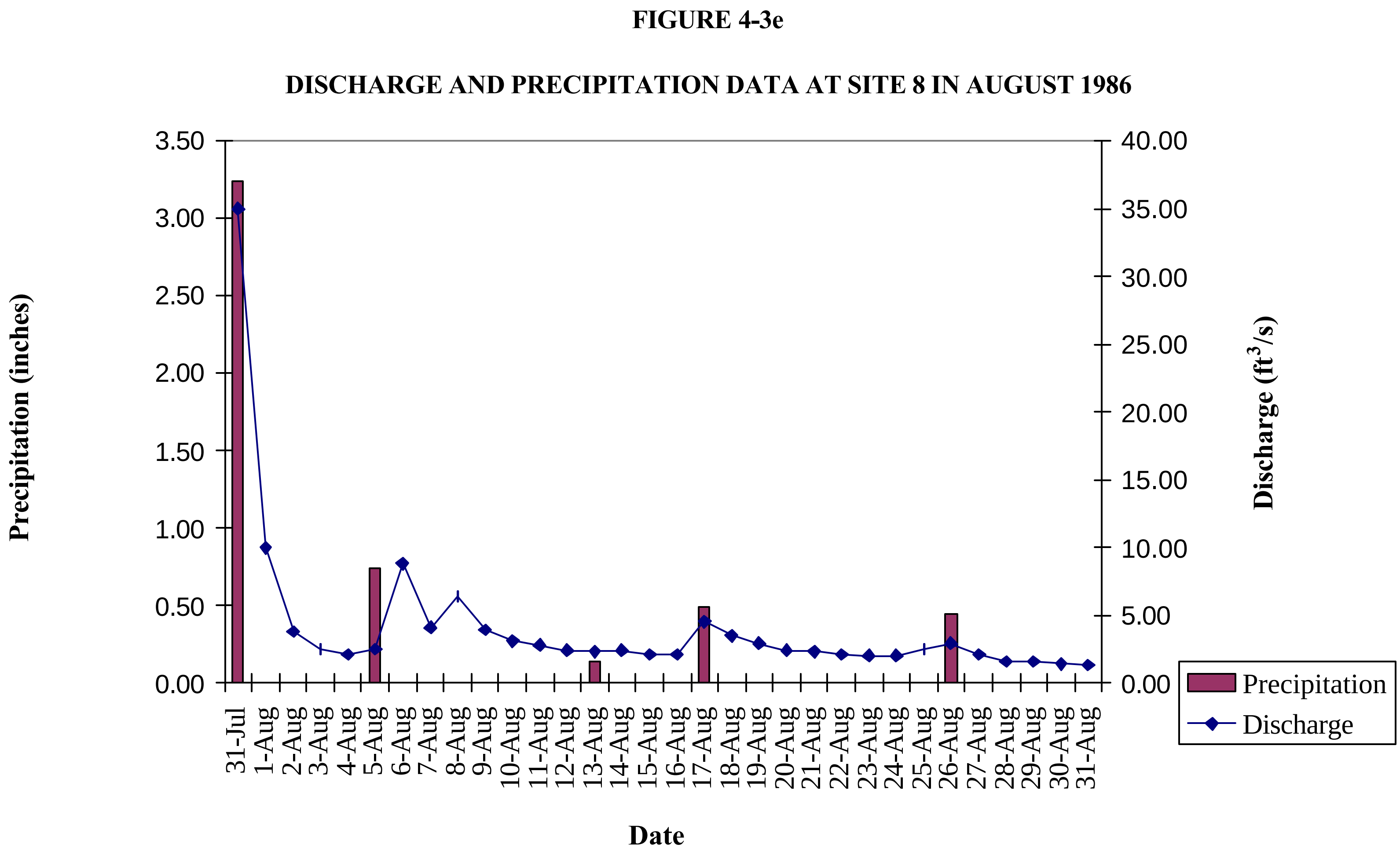


FIGURE 4-3f

DISCHARGE AND PRECIPITATION DATA AT SITE 8 IN SEPTEMBER 1986

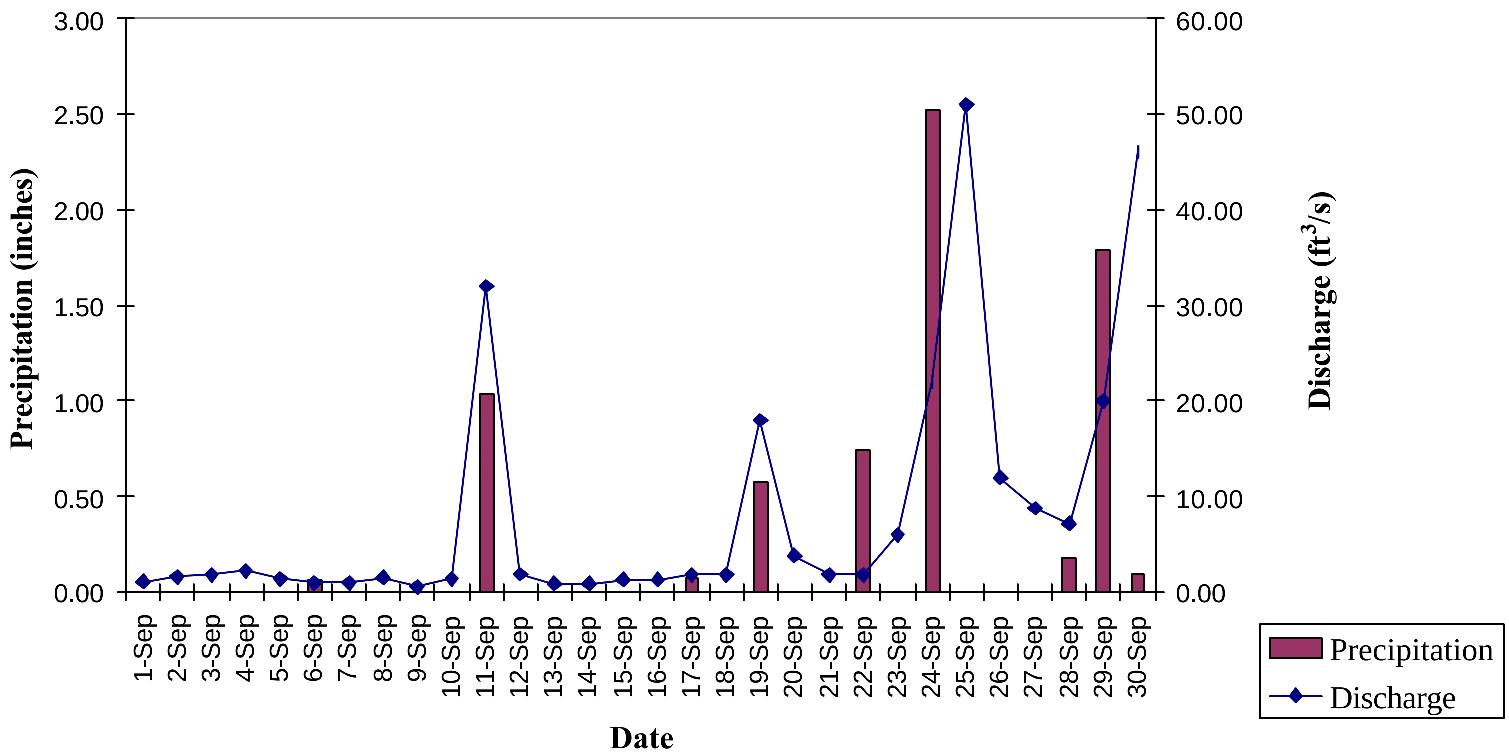


TABLE 4-1

SUMMARY OF RATES AND COEFFICIENTS USED IN QUAL2E

Rate or Coefficient	Value Used	Rationale for Value Used	Reference(s)
Dispersion Constant (D_L) (ft^2/s)	Reach 1-4: 26 Reach 5-9: 18 Reach 10: 66	***Range:*** 6 to 6,000 ft^2/s ***Default Value:*** None ***Measured Values***: None ***Literature Review:*** · D_L= 500 Ru* (for reaches 1-4 and 10); R = hydraulic radius, u* = shear velocity · D_L= $(0.011U^2W^2)/H$ (for reaches 5-9); U = velocity, W = width, H = depth ***Sensitivity analysis:*** As constant changed from 6 to 6,000 ft^2/s, DO concentrations varied by about 2 %, and ammonia-N concentrations varied by about 1%.	EPA 1985 EPA 1995 USGS 1987
BOD decay (1/day, base e)	0.13	***Range:*** 0 to 10/day ***Default Value:*** 0 ***Measured Values:*** BOD decay rate in Cedar Creek just below the segment is about 0.13/day with a standard deviation of 28% (0.10 to 0.17/day). ***Literature Review:*** Values range from 0.004 to 5.6/day with a median of 0.2/day. ***Sensitivity Analysis*****:** DO concentrations varied by about 75 % during the moderate storm event and by less than 2 % during base flow when the rate changed from 0 to 10/day. However, DO concentrations varied by less than 2 % when the rate varied by the standard deviation (0.10 to 0.17/day). In addition, a BOD decay rate of 0.13/day yielded instream BOD concentrations comparable to values measured in the Cedar Creek segment after the August 26 storm. A BOD decay rate of 10/day grossly underestimates the BOD concentrations measured in the creek during the storm.	EPA 1985 EPA 1995 USGS 1987 USGS 1989a
BOD settling (1/day)	1	***Range:*** 0 to 10/day (EPA 1995, page 48) ***Default Value:*** 0 ***Measured Values***: None ***Literature Review:*** · Settling Rate = V_s/d; V_s = settling velocity, d = depth · Measured phytoplankton settling velocities range about from 0 to 1 ft/s, and the depth of the creek segment ranges from about 0 to 1 ft. The BOD settling rate would be about 1/day assuming BOD has a similar settling	EPA 1985 EPA 1995 USGS 1987

TABLE 4-1 (Continued)

SUMMARY OF RATES AND COEFFICIENTS USED IN QUAL2E

		velocity as phytoplankton. *__Sensitivity Analysis:__* BOD settling had no effect on DO concentrations.BOD concentrations decreased by about 50% when BOD settling increased from 0 to 10/day; however, a BOD settling value of 10/day underestimated the BOD concentrations measured in the Cedar Creek segment during the August 26 storm.	
SOD rate (g/ft^2-day)	Reach 1-4: 0.21 Reach 5-9: 0.14 Reach 10: 0.23	*__Range:__* 0 to 1 *__Default Value:__* 0 *__Measured Values:__* Values for reaches 1 through 4 and 10 were measured at about 0.21 and 0.23 g/ft^2-day, respectively, with a standard deviation of 38 %. (SOD is assumed to be less in the concrete channel than in the natural channel, but no measurements were taken.) *__Literature Review:__* Values range from 0 to 1.3 g/ft^2-day with an average of 0.3 g/ft^2-day. *__Sensitivity Analysis__*: DO concentrations decreased by 100 % when the SOD increased from 0 to 1 g/ft^2-day and decreased by about 50 % when the SOD increased by the standard deviation (0.13 to 0.29 g/ft^2-day). SOD values above 0.21 g/ft^2-day yielded DO concentrations lower than concentrations measured in the creek segment during base flow.	EPA 1985 EPA 1995 NCASI 1985 USGS 1987 USGS 1989a
Reaeration coefficient (1/day, base e)	Reach 1-4: 10 Reach 5-10: 8	*__Range:__* 0 to 100/day *__Default Value:__* None *__Measured Values:__* Reaeration coefficients determined for Cedar Creek below the listed segment ranged from 3 to 10/day. *__Literature Review:__* QUAL2E uses equations to calculate the reaeration rate for a given depth and velocity; however, no equation is applicable to the extremely low depths and velocity of the listed segment of Cedar Creek; therefore, a reaeration coefficient was input into the model. Literature reviewed revealed that reaeration coefficients for shallow, slow-moving streams range from about 0 to 40/day. *__Sensitivity Analysis:__* DO concentrations increased by over 100% as the reaeration coefficient increased from 0 to 40/day. A reaeration coefficient of about 10/day along reaches 1 through 4 and 8/day along reaches 5 through 10 yielded DO concentrations equivalent to those measured in the Cedar Creek segment during base flow.	EPA 1985 EPA 1987 NCASI 1985 Smoot 1989 USGS 1987 USGS 1989a Wilcock and others 1998
O-N Hydrolysis (1/day)	0.02	*__Range:__* 0 to 10/day *__Default Value:__* 0 *__Measured Values:__* None *__Literature Review:__* Suggested value of 0.02/day*__Sensitivity Analysis:__* DO concentrations varied by about 10%, and ammonia-N concentrations varied by about 70% as O-N hydrolysis increased from 0 to 10/day. A value close to zero yields an ammonia-N concentration comparable to the ammonia-N concentration measured in the creek during	EPA 1985 EPA 1995 USGS 1987

		base flow and after the August 26 storm.	
O-N Settling (1/day)	1	***Range:*** from 0 to 10/day ***Default Value:*** 0 ***Measured Value:*** None ***Literature Review:*** · Settling Rate = V_s/d; V_s = settling velocity, d = depth · Measured phytoplankton settling velocities range about from 0 to 1 ft/s, and the depth of the creek segment ranges from about 0 to 1 ft. The BOD settling rate would be about 1/day assuming that O-N has a similar settling velocity as phytoplankton. ***Sensitivity Analysis:*** O-N settling had essentially no effect on DO or ammonia-N concentrations.	EPA 1985 EPA 1995 USGS 1987
Ammonia-N Oxidation (1/day)	1.25	***Range:*** 0 to 10/day ***Default Value:*** 0 ***Measured Values:*** A value of about 1.25/day was measured in Cedar Creek below the listed segment. ***Literature Review:*** Values range from 0 to 9/day. ***Sensitivity Analysis:*** DO concentration decreased by less than 20% and ammonia-N concentrations decreased by almost 100% as the ammonia-N oxidation rate increased from 0 to 10/day. An ammonia-N oxidation rate of 10/day grossly underestimates the ammonia-N concentrations detected in the listed segment of the creek during base flow and during the August 26 storm.	USGS 1987 USGS 1989a EPA 1985 EPA 1995
Ammonia-N Benthos (mg/ft^2-day)	0	***Range:*** No limit ***Default Value:*** 0 ***Measured Value:*** None ***Literature Review:*** None ***Sensitivity Analysis:*** DO concentrations decreased by almost 100% and ammonia-N concentrations increased by well over 100% as the ammonia-N benthos rate increased from 0 to 100 mg/ft^2-day. However, an ammonia-N benthos rate above 0 yields ammonia-N concentrations much greater than concentrations measured in the creek segment during base flow and during the August 26 storm.	USGS 1987 EPA 1995
NO_2 Oxidation (1/day)	10	***Range:*** 0 to 10/day ***Default Value:*** 2 ***Measured Value:*** Based on concentrations of nitrite and nitrate, USGS calculated an NO_2 oxidation rate of 20/day for the modeled segment of Cedar Creek below the listed segment. USGS used the maximum oxidation rate because only a small fraction of nitrite contributed to the concentration of nitrite and nitrate. USGS's model assumed that all nitrite is immediately oxidized into nitrate. ***Literature Review:*** NO_2 oxidation rates range from 0 to 9/day.	EPA 1985 EPA 1995 USGS 1989a

		Sensitivity Analysis: DO concentrations varied by less than 2 % and ammonia-N concentrations did not vary as the NO_2 oxidation rate increased from 0 to 1/day. DO and ammonia-N are affected by the NO_2 oxidation rate because nitrite concentrations are extremely small compared to nitrate concentrations.	
Dis-P Benthos (mg/ft^2-day)	0	***Range:*** No limit ***Default Value:*** 0 ***Measured Values:*** None ***Literature Review:*** None ***Sensitivity Analysis:*** DO and ammonia-N concentrations did not change as the dis-P benthos rate increased from 0 to 100 mg/ft^2-day. However, a dis-P benthos rate greater than 0 yielded a dissolved phosphorous concentration above the concentration measured in the Cedar Creek segment after the August 26 storm.	EPA 1995 USGS 1987
Chl-a Algae (µg chl-a/mg algae)	10	***Range:*** 0 to 100 µg chl-a/mg algae ***Default Value:*** 10 µg chl-a/mg algae ***Measured Values:*** None ***Literature Review:*** None ***Sensitivity Analysis:*** DO concentrations decreased by less than 10% and ammonia-N concentrations increased by about 10 % as chl-a algae increased from 0 to 100 µg chl-a/mg algae. A value of 10 best correlated with the concentrations of DO and chl-a measured in the listed segment of the creek during base flow.	EPA 1995 USGS 1987
Algae Settling (ft/day)	1	***Range:*** 0 to 3 ***Default Value:*** 1 ***Measured Values:*** Values ranged from about 0.35 to 1.0 ft/day in Cedar Creek just below the listed segment. ***Literature Review:*** · Settling Rate = V_s/d; V_s = settling velocity, d = depth · Measured phytoplankton settling velocities range about from 0 to 1 ft/s, and the depth of the creek segment ranges from about 0 to 1 ft. ***Sensitivity Analysis:*** DO and ammonia-N concentrations varied by less than 1 % as the algae settling rate varied from 0 to 3 ft/day.	EPA 1985 EPA 1995 USGS 1987 USGS 1989a
Nonalgal Light Extinction (1/ft)	0	***Range:*** 0 to 3 ***Default Value:*** 0 ***Measured Values:*** None ***Literature Review:*** None ***Sensitivity Analysis:*** DO and ammonia-N concentrations did not change as the nonalgal light extinction coefficient was increased from 0 to 3/ft.	EPA 1995

Notes:

%	Percent
Ammonia-N	Ammonia-nitrogen
BOD	Ultimate carbonaceous biochemical oxygen demand
Chl-a	Chlorophyll-a
Dis-P	Dissolved phosphorous
DO	Dissolved oxygen
EPA	U.S. Environmental Protection Agency
ft	Foot
ft/s	Foot per second
ft^2-day	Square foot-day
g	Gram
mg/ft^2-day	Milligram per square foot-day
NCASI	National Council of the Paper Industry for Air and Stream
ment, Inc.	
NO_2	Nitrite
O-N	Organic nitrogen
SOD	Sediment oxygen demand
USGS	U.S. Geological Survey
µg	Microgram

4.1.4 Initial Stream Concentrations

Although this modeling effort focuses on DO and ammonia-N concentrations, BOD, organic nitrogen, nitrate-nitrogen, dissolved phosphorus, and chlorophyll-a concentrations were also modeled to better simulate the processes affecting DO and ammonia-N levels. The initial stream concentrations of each of these parameters were determined from concentrations measured in the listed segment of the creek by USGS during low-flow conditions in 1985 (see Table 2-2). The same initial concentrations were used in the base-flow simulation as in the first-flush simulation and are presented in Attachment B.

4.1.5 Incremental Inflow and Pollutant Concentrations

For base flow simulation, incremental inflows for each reach were calculated by distributing the base flow observed at Site 1 to each reach above Site 1. The base flow observed at Site 8 was distributed to the reaches of the listed segment above Site 8 and below Site 1. Distribution was based on drainage area associated with each reach. The pollutant concentrations for base-flow simulation were all from nonpoint sources and were back-calculated from flow records and average concentrations of the key parameters measured along the listed segment of Cedar Creek by USGS during low-flow conditions. The estimated pollutant concentrations were compared with typical groundwater concentrations for verification.

For first-flush simulation, incremental inflows were determined by distributing total agricultural runoff predicted by SWMM to reaches above Site 1 and total urban runoff predicted by SWMM to reaches of the listed segment above Site 8 and below Site 1. The distributed incremental inflows from runoff were then added to the incremental inflows from base flow. Inflow pollutant concentrations of ammonia-N, BOD, and DO were also predicted by SWMM. Incremental pollutant concentrations of organic nitrogen, nitrate-nitrogen, dissolved phosphorus, and chlorophyll-a were back-calculated from concentrations of each of these parameters measured during storm events. Table 2-3 summarizes the concentrations of TSS and ammonia-N measured during the storm events; the other parameters are not shown because they are not a concern in the study reach. Runoff from the urbanized portion was influenced only by nonpoint source pollutants borne by storm water runoff. Hydrographs and pollutographs showing SWMM results inputted into the QUAL2E model are presented in Figures 3-6a and b and 3-7a and b, respectively.

4.2 CALIBRATION AND VERIFICATION

Data used for calibration and verification of the base-flow simulation were obtained from sampling conducted on July 10, 1985. These data were selected for calibration because flow measured on July 10 corresponded with typical base-flow rates. Data used for calibration and verification of the first-flush simulation were obtained from sampling conducted on August 26, 1986. A storm on August 26, 1986, resulted in 0.44 inch of precipitation in the watershed and was representative of a first-flush event. In addition, this event was the only storm sampled by USGS that had sufficient precipitation and discharge data to predict runoff in SWMM and water quality data needed to run the QUAL2E model.

Flow is typically calibrated first because it determines constituent concentrations. SWMM was used to predict flows in the Cedar Creek segment and was calibrated and verified first. Then, the predicted flows were input into QUAL2E to determine flow distribution along the creek segment. The QUAL2E model results were verified using observed flow measurements at Sites 1 and 8 on July 10, 1985 (base flow) and August 26, 1986 (first-flush event). Figures 4-4 and 4-5 show the flows along the creek segment predicted by the calibrated QUAL2E models for July 10, 1985, and for August 26, 1986, respectively.

Water quality parameter concentrations were calibrated and verified after the flows along the creek segment predicted by QUAL2E model were considered acceptable. For the base flow simulation, ammonia-N concentrations were calibrated with average ammonia-N concentrations measured by USGS on July 10, 1985, throughout the day. DO, however, could not be calibrated with the average DO concentrations because of the extreme diurnal variations observed in the creek (see Figure 4-1). Average DO concentrations measured along the listed segment of Cedar Creek during low-flow conditions in 1985 remained above 5 mg/L, but DO concentrations plummeted to as low as 1.1 mg/L during a 24-hour period. Therefore, calibrating the model with average DO concentrations would lead to a false conclusion that DO concentrations are not a concern. To provide the most conservative results, DO concentrations were calibrated with an average of the lowest three DO concentrations measured at each site on July 10, 1985.

The water quality data collected by USGS during the August 26, 1986, storm that were used for calibration of a first-flush event only include results from sampling conducted at Site 8, which is about one mile downstream of the listed segment. Consequently, the water quality data could only be used for general comparison, not for detailed calibration of the QUAL2E model's first-flush simulation. The data gap is considered to be insignificant because inflow pollutant concentrations, which are the key QUAL2E

FIGURE 4-4

BASE FLOW PREDICTED BY CALIBRATED QUAL2E MODEL FOR JULY 10, 1985, BASE FLOW EVENT

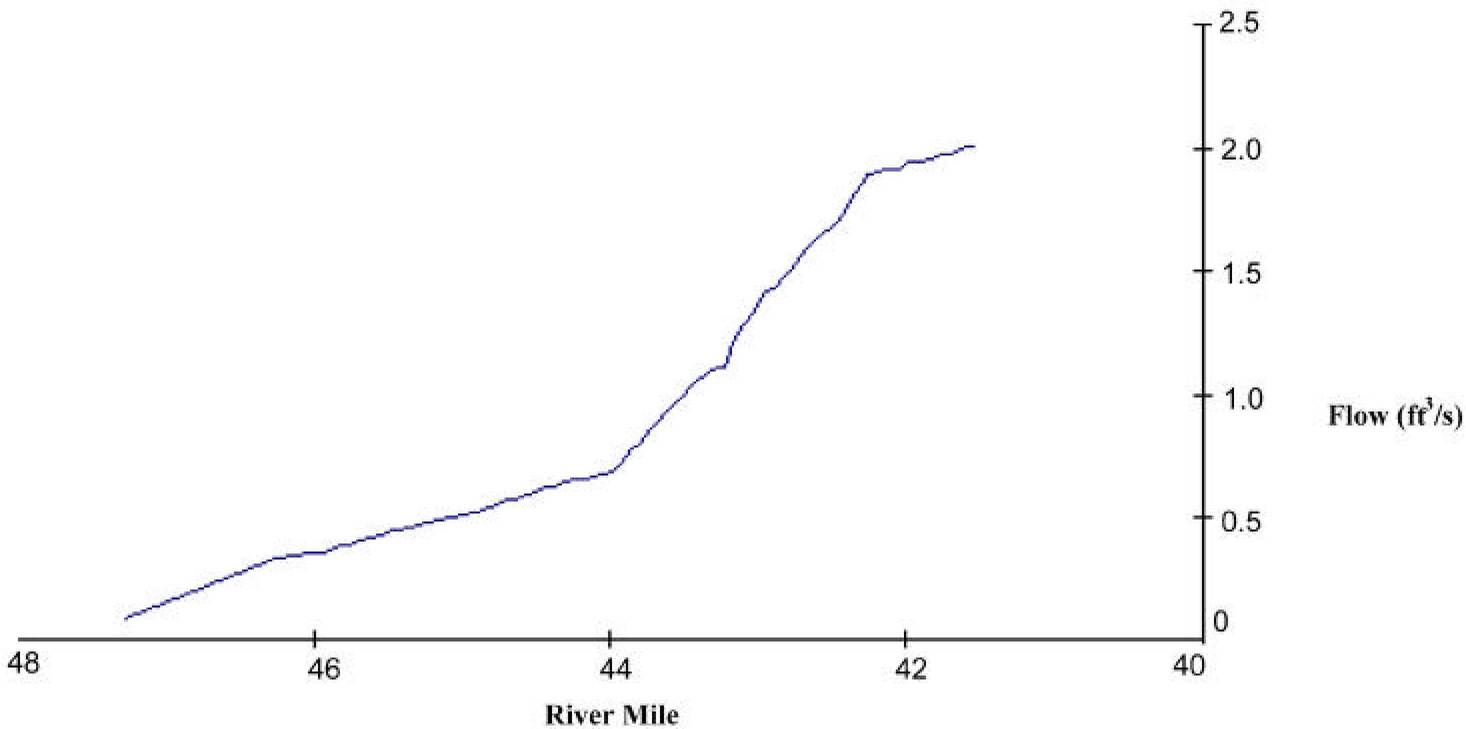
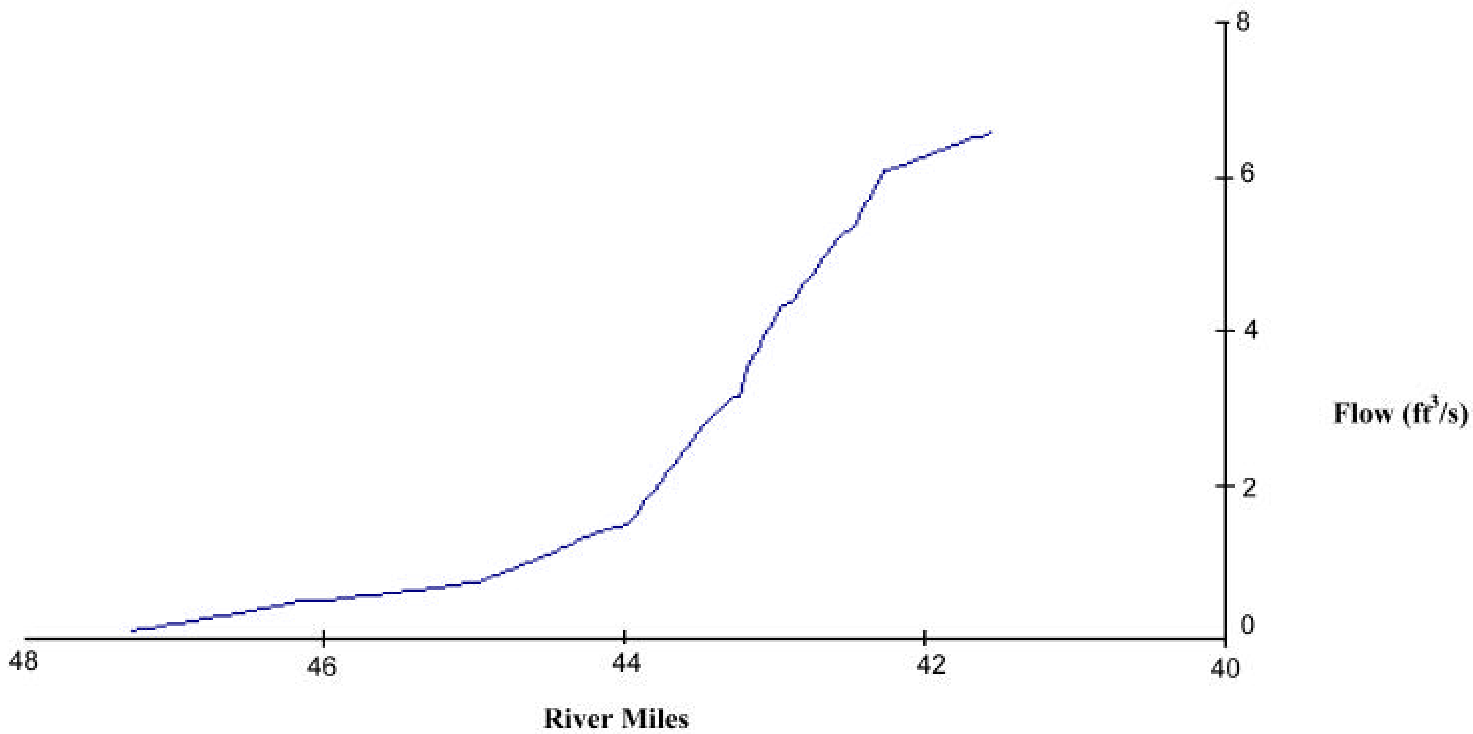


FIGURE 4-5

FIRST-FLUSH EVENT FLOW PREDICTED BY CLAIBRATED QUAL2E MODEL FOR AUGUST 26, 1986, STORM



model inputs for determining the instream concentrations of ammonia-N, were calibrated and verified using SWMM. Base-flow and first-flush simulations were calibrated and verified simultaneously as an iterative process until both simulations predicted concentrations matching those observed by USGS. The first-flush simulation was calibrated by using results from the sensitivity analysis to adjust rates that were not measured by USGS nor discussed in literature. For example, the benthos ammonia-N rate was not measured by USGS and is not sufficiently discussed in literature. However, ammonia-N concentrations measured in the listed segment of the creek indicate that the benthos ammonia-N rate needs to be close to zero because any value greater than zero drastically overpredicts observed ammonia-N concentrations. After initial calibration of the first-flush simulation, the calibrated variables were input into the base-flow simulation. Concentrations predicted by the QUAL2E model's base-flow simulation were compared with concentrations measured by USGS during low-flow conditions, and kinetic rates and estimated inflow concentrations that were back-calculated from instream concentrations were readjusted to better match observed data. Kinetic rates were readjusted within the ranges discussed in Table 4-1, which are either cited in literature or were observed in the listed segment of the creek. Inflow concentrations were readjusted based on the level of uncertainty of sampling results. Adjusted kinetic rates were then recalibrated into the first-flush simulation, and the process was continued until QUAL2E model predictions for both the base-flow and first-flush scenarios were within 30 percent on average of the concentrations measured by USGS.

4.3 QUAL2E MODEL RESULTS

A comparison of flow and water quality data predicted by the QUAL2E model and observed by USGS on July 10, 1985, and August 26, 1986, are discussed below.

Table 4-2 compares the calibrated flows with the measured flows at Site 1 and Site 8. Although Site 8 is below the listed segment, flow measurements at Site 8 should be comparable to the calibrated flow at the end of the listed segment. The differences between the calibrated and observed flows are acceptable because low flows are extremely sensitive to the model. In addition, for the base flow simulation, the modeled flow is based on a hydrograph separation using all USGS 1986 data and the measured flow is based on one measurement taken on July 10, 1985.

TABLE 4-2

COMPARISON OF CALIBRATED FLOWS WITH MEASURED FLOWS

	Flow Calibrated by QUAL2E Model (ft^3/s)	Flow Measured by USGS (ft^3/s)
Base Flow (July 10, 1985)		
Site 1	0.5	0.1
Site 8	2	2
First Flush (August 26, 1986)		
Site 1	0.6	0.2
Site 8	6.6	3

Figures 4-6 and 4-7 show the calibrated QUAL2E model's predicted DO and ammonia-N concentrations for the July 10, 1985, base-flow simulation along the entire lengths of the listed segment. Figures 4-8a through 4-14 compare the concentrations of each parameter predicted by the calibrated model's base-flow simulation with data collected on July 10, 1985, during low-flow conditions along a portion of the listed segment. The comparison of calibrated and measured DO concentrations shown in Figure 4-8a is reasonable after consideration of the extreme diurnal variations shown in Figure 4-8b. On Figure 4-8b, the vertical black bars represent the range of DO concentrations measured on July 10, 1985. Although the actual DO profile was difficult to predict, the model was able to sufficiently predict the range of the three 24-hour minimum DO concentrations, which are most critical for this study.

Figures 4-15 and 4-16 show the QUAL2E model's calibrated DO and ammonia-N concentrations, respectively, for the August 26, 1986, first-flush simulation. Table 4-3 compares the calibrated concentrations of each parameter predicted by the QUAL2E model with data collected during the August 26, 1986, storm. Measurements are from Site 8, which is about one mile downstream of the end of the listed segment, should be used merely to determine the acceptability of the calibrated concentrations. Based on comparison of observed and modeled concentrations for both the base-flow and first-flush simulations, the calibrated QUAL2E model is capable of predicting concentrations of ammonia-N and DO in the Cedar Creek segment resulting from nonpoint sources in the watershed.

TABLE 4-3

CALIBRATION RESULTS FOR FIRST-FLUSH EVENT

	Calibrated Concentration at End of Segment (mg/L)	Measured Concentrations About 1 Mile Downstream of End of Segment (mg/L)
BOD	18.9	5.5 to 14
Ammonia	0.57	0.13 to 0.29
Organic Nitrogen	0.56	0.51 to 0.87
Phosphorus	0.18	0.26 to 1.7
Nitrite Plus Nitrate	0.69	0.59 to 0.88

Notes:

BOD Carbonaceous biochemical oxygen demand
mg/L Milligram per liter

FIGURE 4-6

DO CONCENTRATIONS PREDICTED BY CALIBRATED QUAL2E MODEL FOR JULY 10, 1985, BASE FLOW EVENT

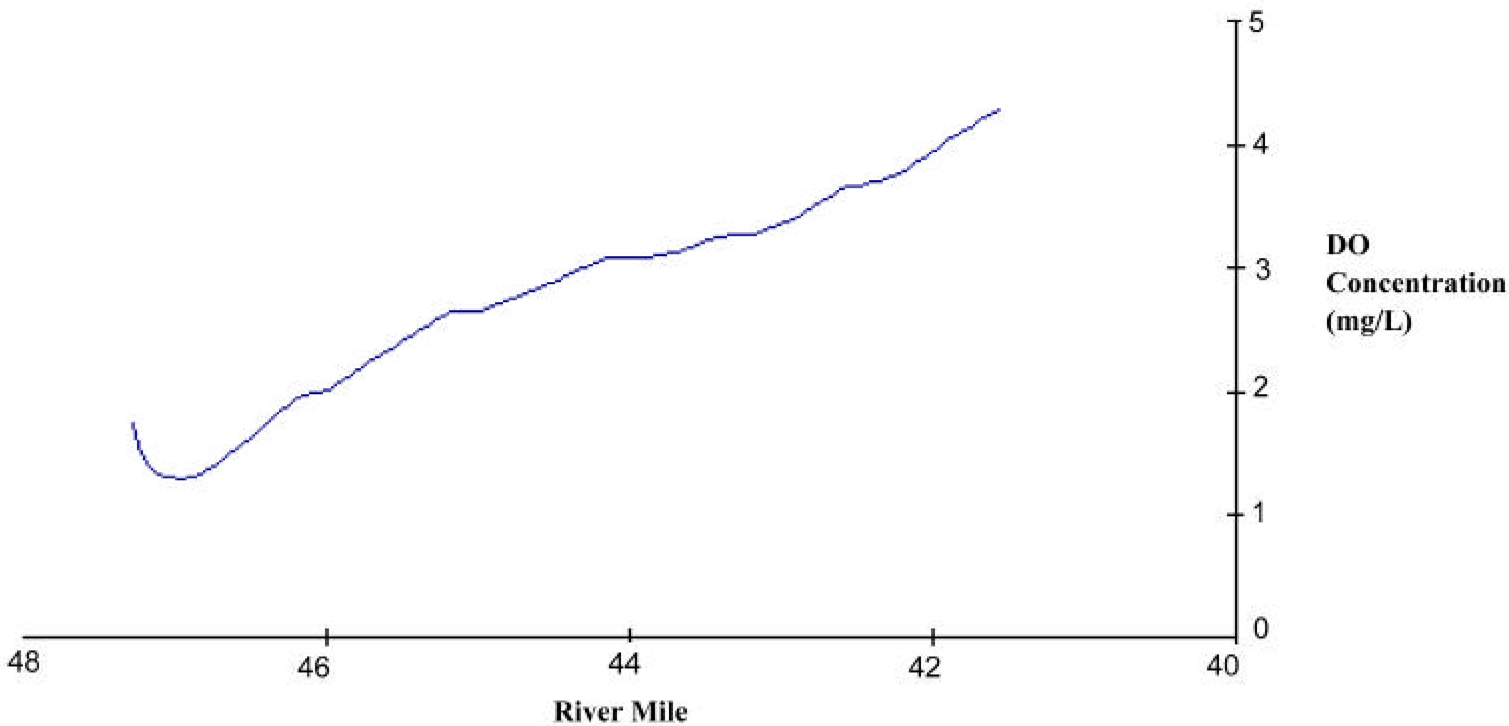


FIGURE 4-7
AMMONIA-N CONCENTRATIONS PREDICTED BY CALIBRATED QUAL2E MODEL FOR JULY 10, 1985, BASE FLOW EVENT

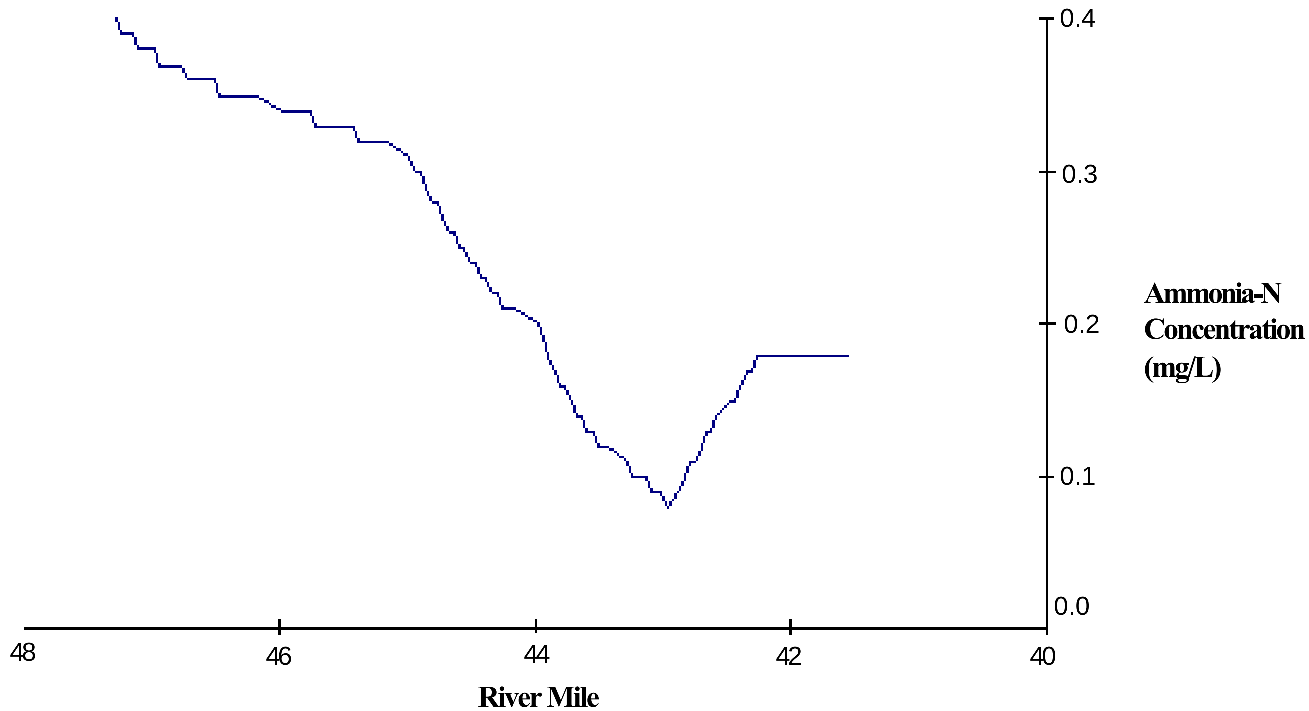


FIGURE 4-8a
CALIBRATED AND OBSERVED MINIMUM DO CONCENTRATIONS ON JULY 10, 1985

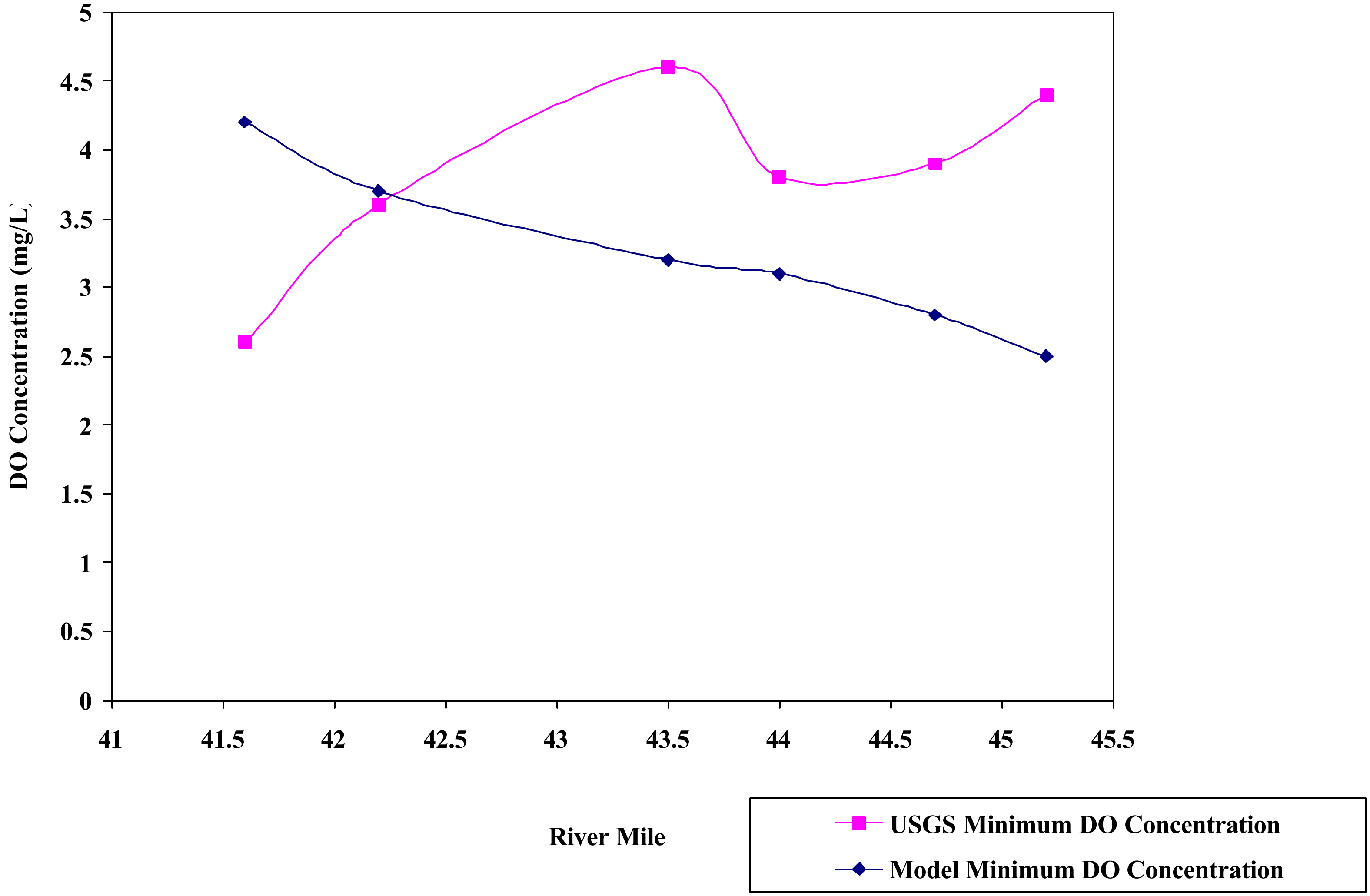


FIGURE 4-8b
CALIBRATED AND OBSERVED DO CONCENTRATIONS RELATIVE TO DIURNAL VARIATION ON JULY 10, 1985

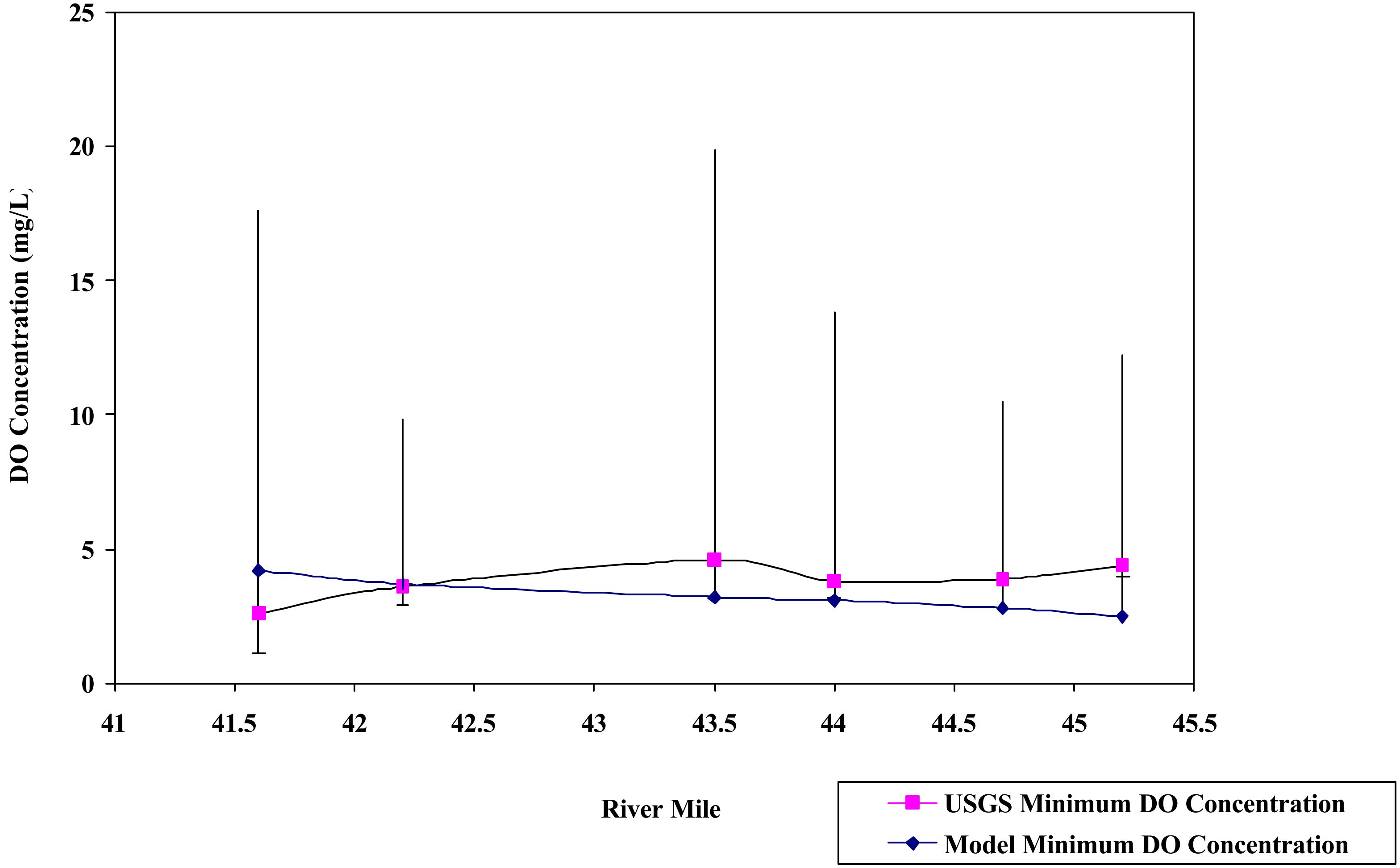


FIGURE 4-9
CALIBRATED AND OBSERVED AMMONIA-N CONCENTRATIONS ON JULY 10, 1985

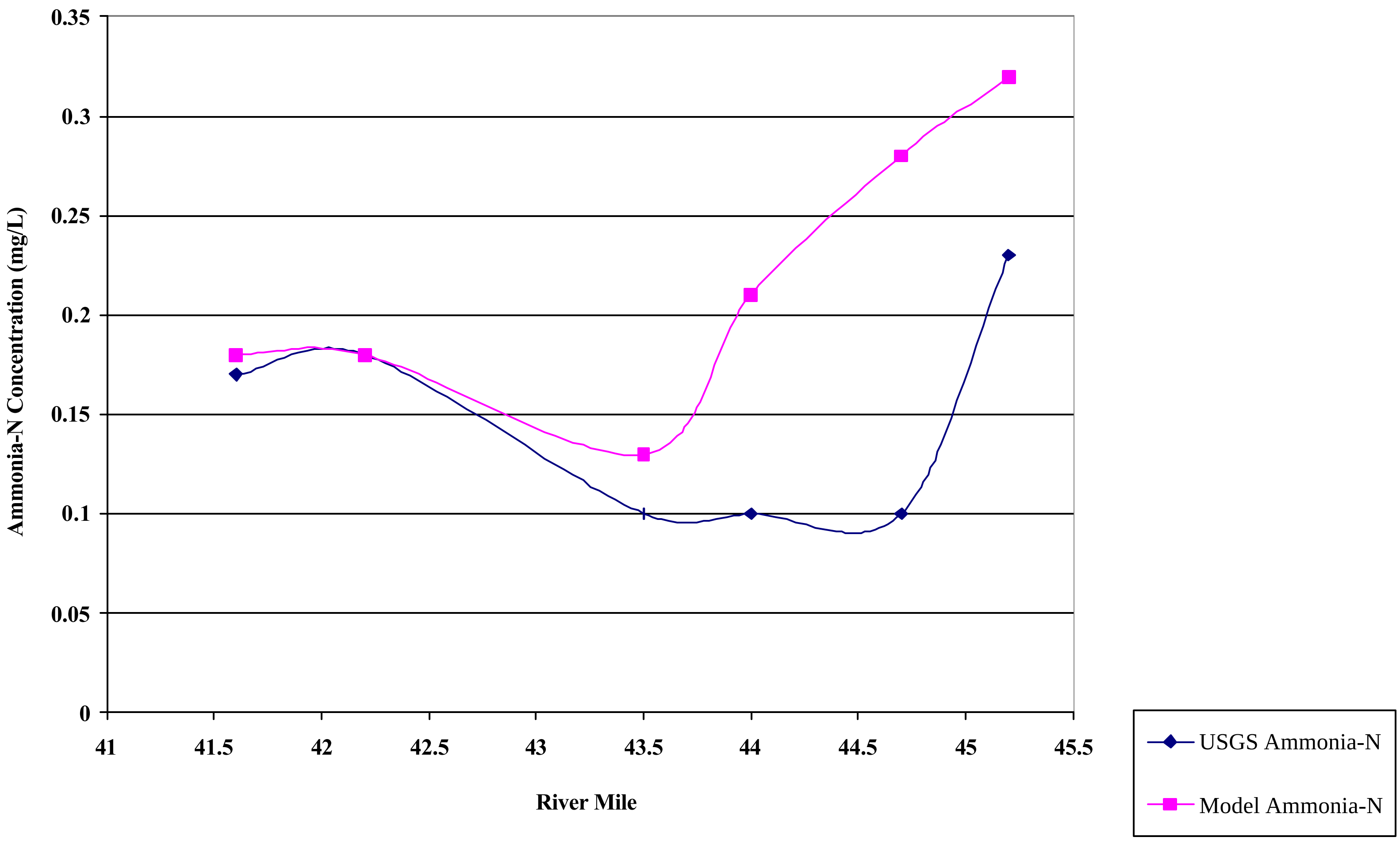


FIGURE 4-10
CALIBRATED AND OBSERVED BOD CONCENTRATIONS ON JULY 10, 1985

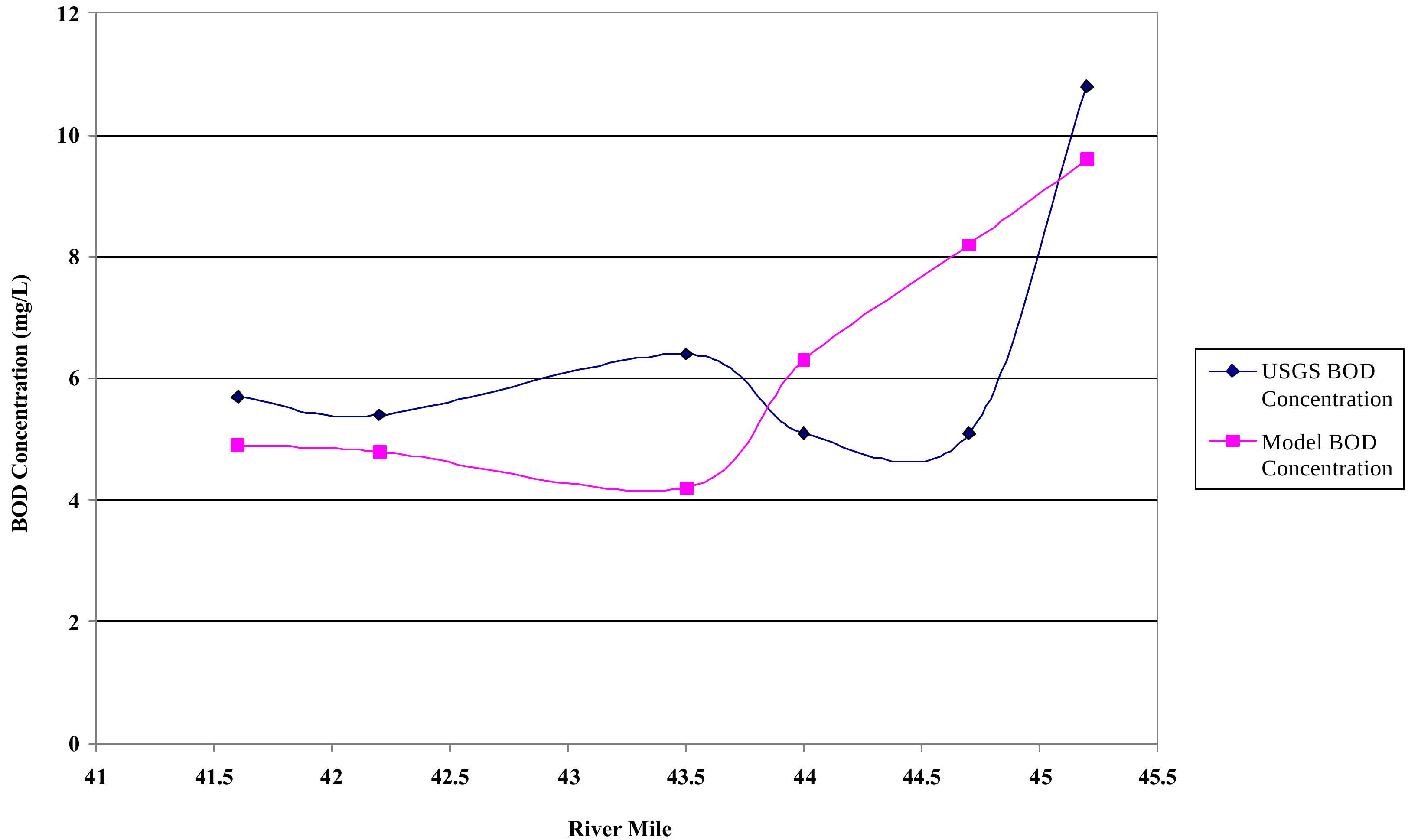


FIGURE 4-11
CALIBRATED AND OBSERVED ORGANIC-NITROGEN CONCENTRATIONS ON JULY 10, 1985

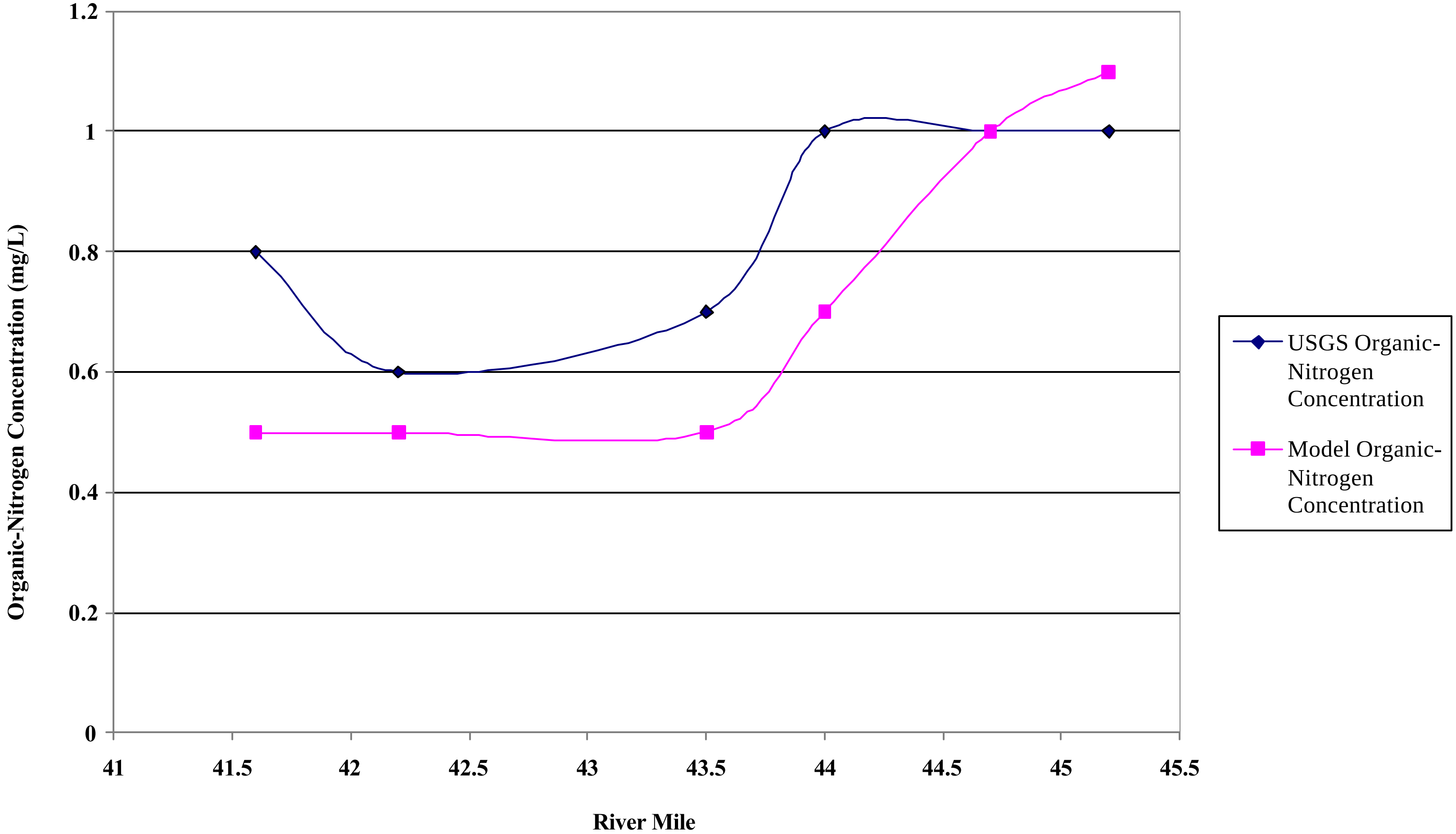


FIGURE 4-12
CALIBRATED AND OBSERVED NITRATE-NITROGEN CONCENTRATIONS ON JULY 10, 1985

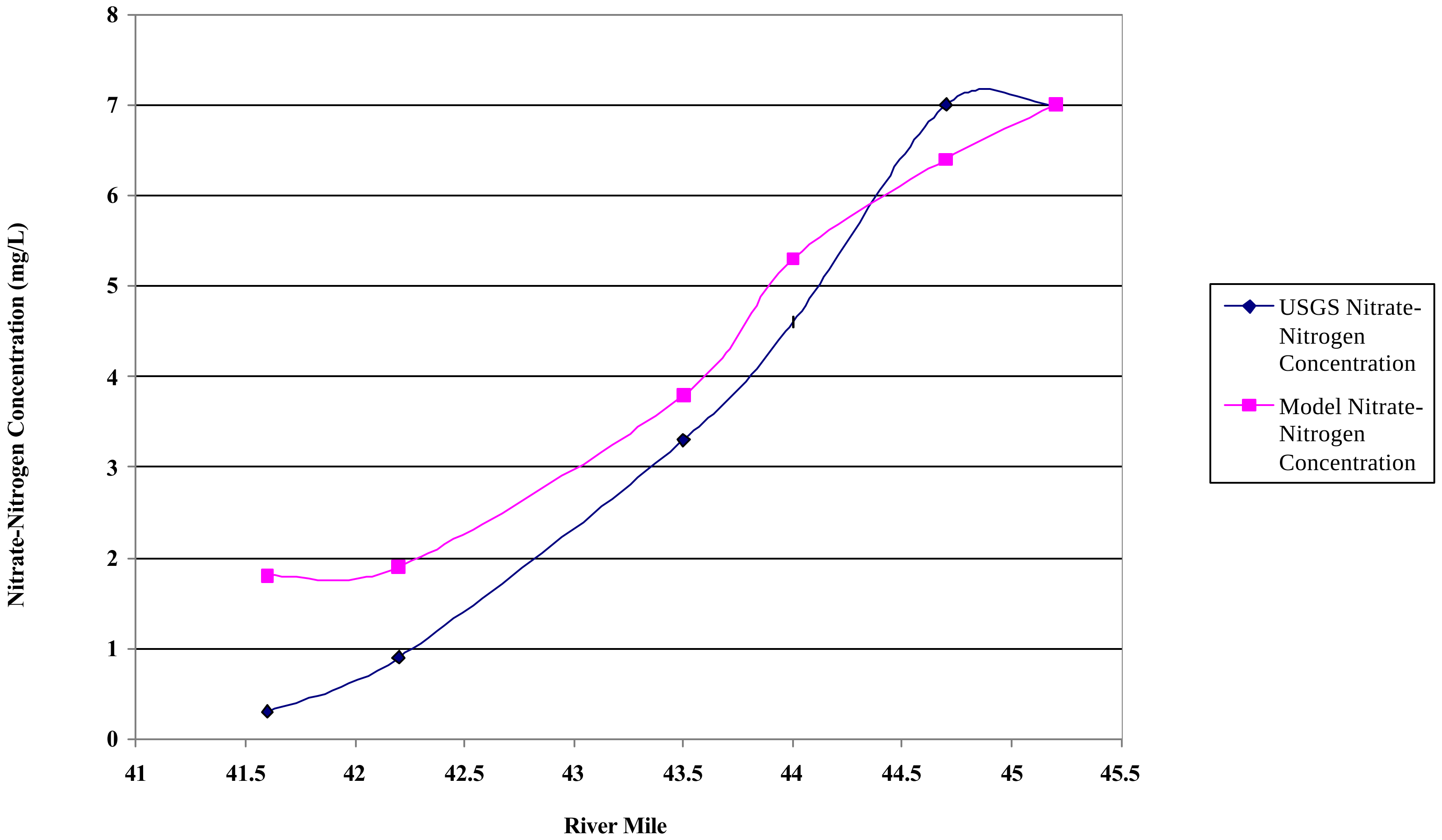


FIGURE 4-13
CALIBRATED AND OBSERVED DISSOLVED PHOSPHORUS CONCENTRATIONS ON JULY 10, 1985

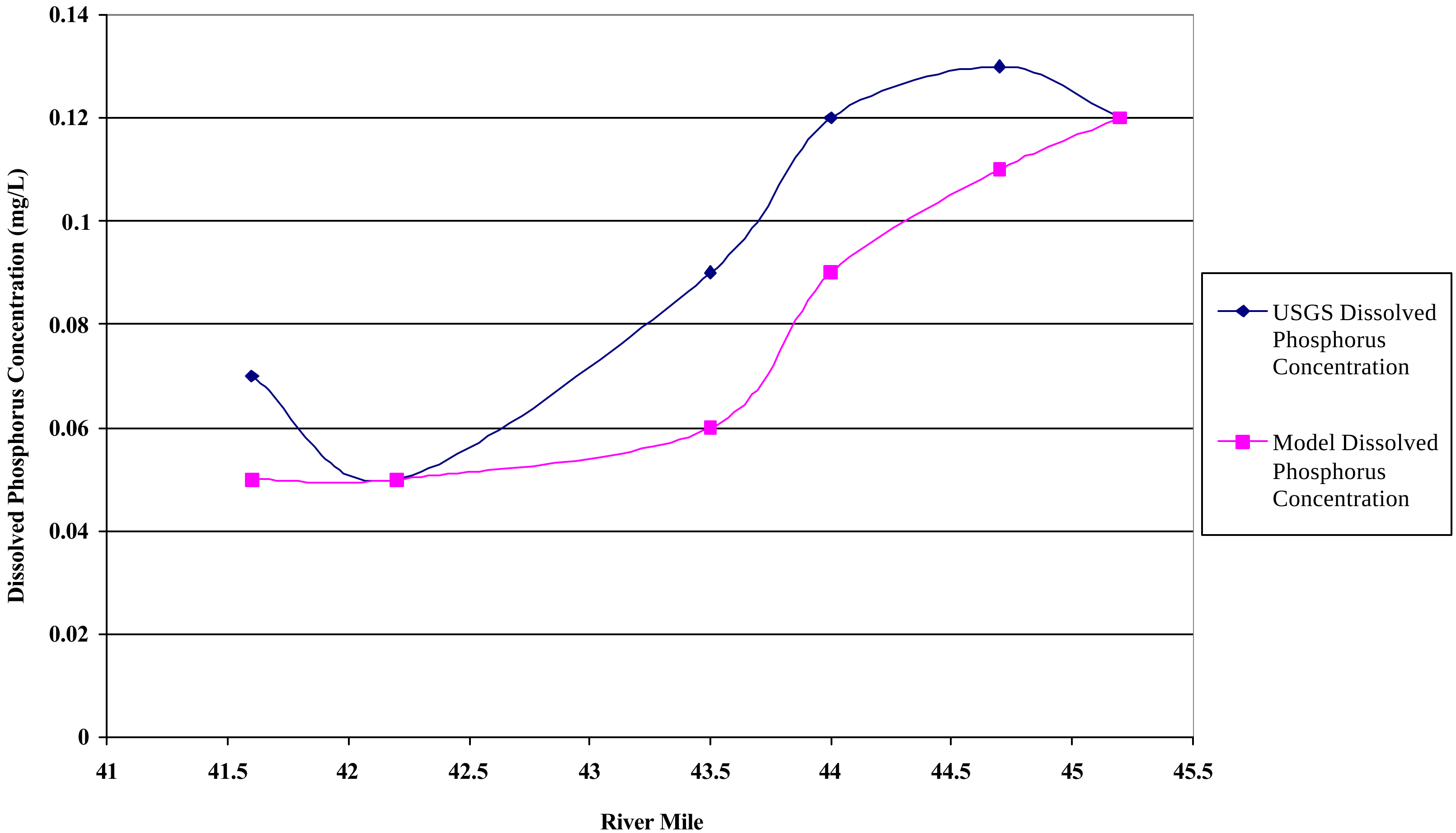


FIGURE 4-14
CALIBRATED AND OBSERVED CHLOROPHYLL-a CONCENTRATIONS ON JULY 10, 1985

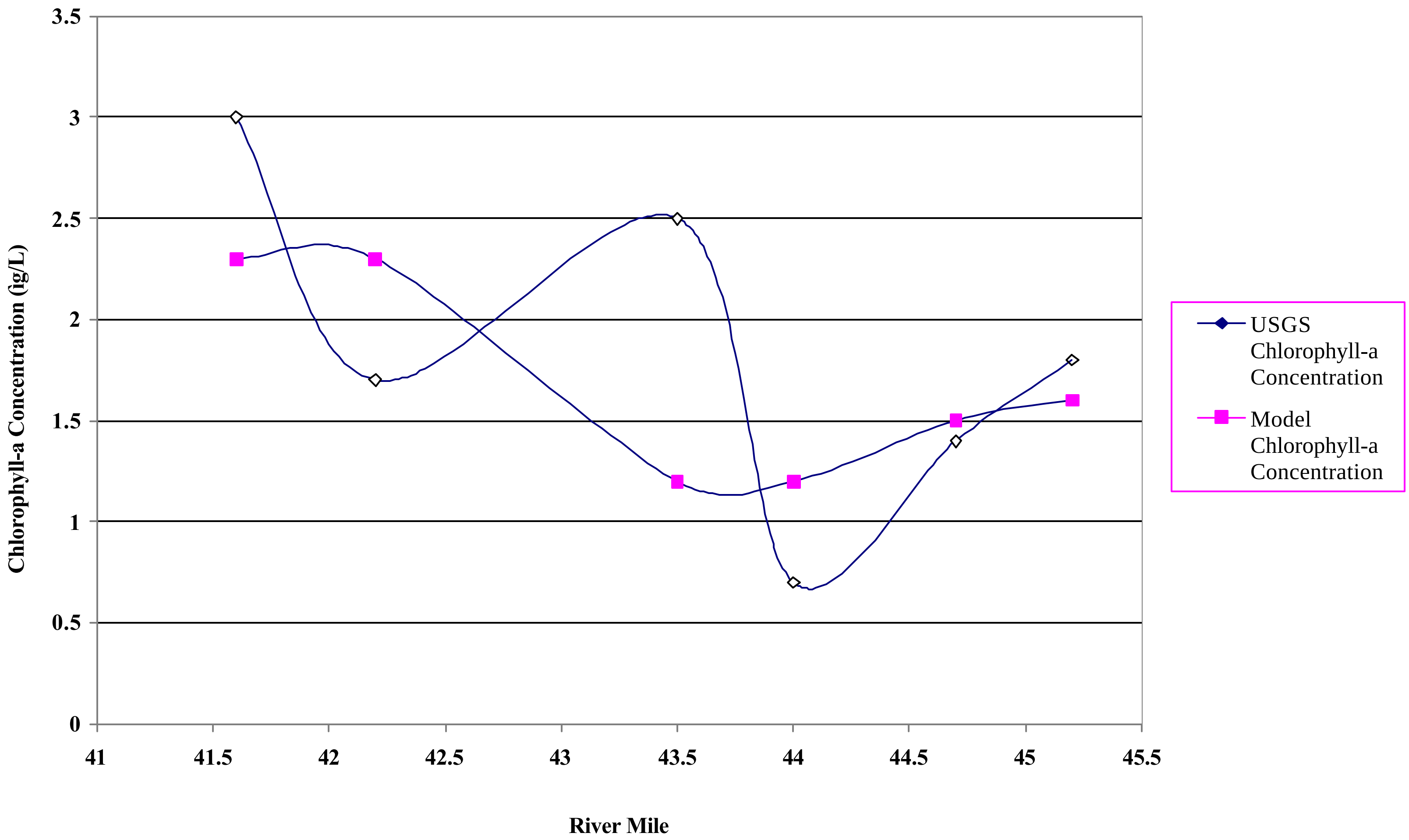


FIGURE 4-15

DO CONCENTRATIONS PREDICTED BY CALIBRATED QUAL2E MODEL FOR AUGUST 26, 1986, STORM

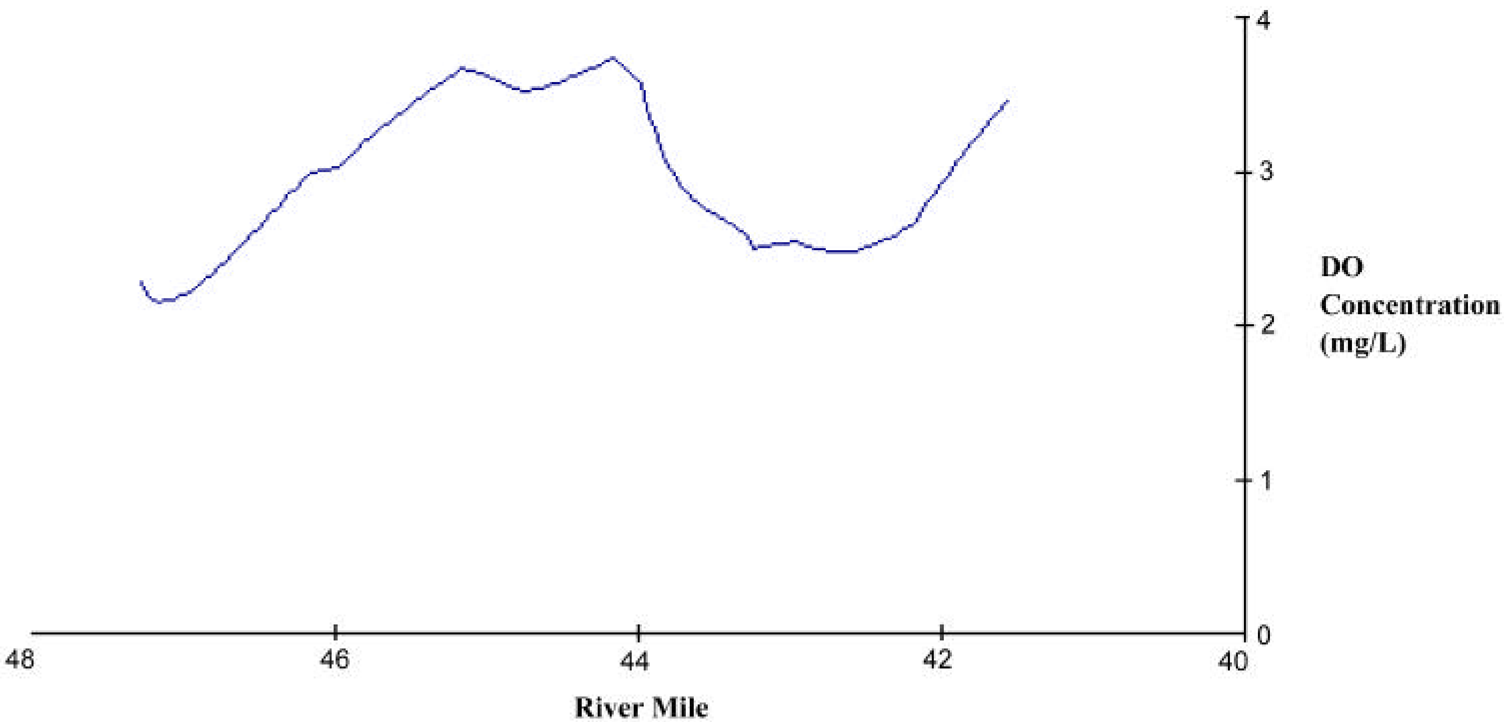
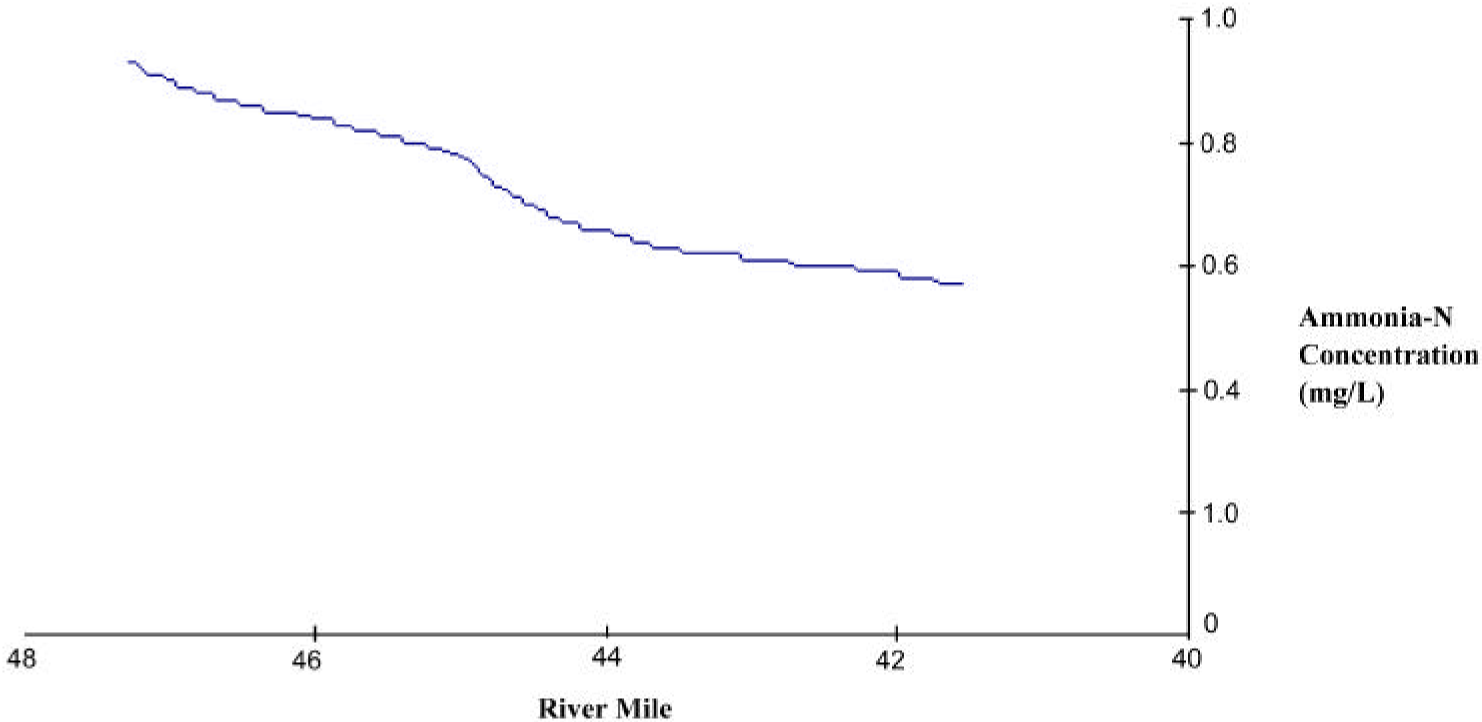


FIGURE 4-16

AMMONIA-N CONCENTRATIONS PREDICTED BY CALIBRATED QUAL2E MODEL FOR AUGUST 26, 1986, STORM



5.0 METHOD FOR DETERMINING LOAD ALLOCATIONS

Once SWMM and QUAL2E model were determined to be sufficient predictive tools, the models were used to determine load allocations. The load allocations were based on estimating seasonal pollutant loads entering the listed segment of the creek. SWMM was used to determine loads of ammonia-N and TSS from the summer season from May through October. The summer season loads were based on an average of 10 years of precipitation data from May through October from 1989 through 1999. The QUAL2E model was used to determine the factors causing water quality guidelines to be exceeded and the adjustments needed to ensure compliance in the Cedar Creek segment. Percent load reductions needed for compliance were calculated by comparing typical seasonal loads and base flow with loads needed to ensure compliance.

5.1 ESTIMATING SEASONAL POLLUTANT LOADS

To calculate typical seasonal loads, the calibrated SWMM was executed in "continuous" mode. The minimum data required for continuous mode simulation were continuous records of precipitation and temperature at hourly time intervals. In the case of the listed segment of Cedar Creek, such data were not available in the watershed. The nearest station with continuous precipitation and temperature records was the NOAA gage at Alexis, which is located approximately 20 miles west of Galesburg. This gage contains hourly precipitation and temperature data from May 1989 through June 1999 (NCDC 1989 through 1999). The NOAA gage at Galesburg does not report hourly precipitation, and the historical records contain long periods of missing data. Therefore, the precipitation data from the Galesburg station were not adequate to perform continuous simulation. Although storm patterns in Galesburg and Alexis may differ, the two locations were assumed to be climatically similar enough for planning level pollutant load estimates. Based on experience, water quality guidelines are likely to be exceeded during the summer dry period between the months of May and October. To determine TMDLs, the mean summer season loads and daily loads were established by taking the average loads of the summer seasons for the period from 1989 to 1999. Each summer season from May 1 to October 31 represents 184 days. In each year of the 10-year period, the summer season maximum pollutant concentrations and total and daily loads for ammonia-N and TSS were computed. The average 184-day seasonal loads and seasonal maximum concentrations of ammonia-N and TSS derived from the 10-year seasonal simulation are summarized in Table 5-1.

TABLE 5-1

SUMMARY OF SEASONAL LOADS OF TSS AND AMMONIA-N PREDICTED BY SWMM[a]

Agricultural Area									
		Loads				**Flow-Weighted Concentration (mg/L)**			
		TSS		**Ammonia-N**		**TSS**		**Ammonia-N**	
Year	**Mean Seasonal Flows (ft^3/s)**	**Seasonal Load (lb)**	**Daily Load (lb/day)**	**Seasonal Load (lb)**	**Daily Load (lb/day)**	**Mean**	**Peak**	**Mean**	**Peak**
1989	0.078	53,400	290	24	0.13	689	1,392	0.31	0.79
1990	0.100	68,900	374	32	0.18	671	1,493	0.32	0.79
1991	0.076	43,920	239	25	0.13	586	1,285	0.33	0.79
1992	0.087	68,600	373	26	0.14	793	1,469	0.30	0.79
1993	0.148	143,500	780	41	0.22	976	1,940	0.28	0.80
1994	0.048	23,810	129	16	0.09	504	1,004	0.34	0.79
1995	0.098	74,500	405	30	0.16	768	2,067	0.31	0.78
1996	0.117	80,200	436	36	0.20	694	1,484	0.30	0.79
1997	0.111	78,400	426	34	0.18	714	1,449	0.31	0.79
1998	0.063	43,300	235	11	0.06	1060	1,930	0.28	0.80
Mean[b]	**0.093**	**67,853**	**369**	**27**	**0.15**	**745**	**1,551**	**0.31**	**0.79**
Urban Area									
1989	2.23	681,000	3,701	289	1.57	308	616	0.13	0.61
1990	3.06	949,800	5,162	298	1.62	312	696	0.10	0.62
1991	2.08	548,100	2,979	292	1.59	265	540	0.14	0.62
1992	2.38	747,400	4,062	288	1.57	317	634	0.12	0.62
1993	4.11	1,748,000	9,500	295	1.60	429	999	0.07	0.62
1994	1.14	246,900	1,342	240	1.30	217	400	0.21	0.62
1995	2.77	878,000	4,772	298	1.62	319	844	0.11	0.62
1996	3.50	1,083,000	5,886	293	1.59	311	604	0.08	0.62
1997	3.04	970,000	5,272	293	1.59	321	686	0.10	0.62
1998	1.69	408,000	2,217	204	1.11	373	736	0.19	0.62
Mean[b]	**2.60**	**826,020**	**4,489**	**279**	**1.52**	**317**	**675**	**0.12**	**0.62**

Notes:

ft^3/s Cubic foot per second
lb Pound
mg/L Milligram per liter
TSS Total suspended solids

[a] Each season represents 184 days.
[b] Seasonal means are average of 10 seasonal values.

5.2 DETERMINING LOAD REDUCTIONS

Periodic water quality monitoring conducted along the listed segment of the creek from 1985 to 2000 and QUAL2E model simulations determined that DO concentration is the primary concern during base-flow conditions. TSS and ammonia-N loads are not of concern because groundwater, which is the source of water in the creek segment during base flow, contains low concentrations of TSS and ammonia-N. As mentioned in Section 1.0, a modeling endpoint of 6.0 mg/L was used as the TMDL endpoint to ensure that DO concentrations greater than 6.0 mg/L during any 16-hour period would be met. Elevated SOD rates and low reaeration rates are the primary causes of DO violations in the listed segment of the creek. The low flows (less than 2 ft^3/s) and lower turbulence (low Reynolds value) of the creek contribute to the high SOD rates and low reaeration rates. High temperature (greater than 70 F) also contributes to high SOD rates. In addition, high SOD rates may result from residual effects of CSOs; however, residual contribution of CSOs to SOD cannot be modeled explicitly. Low flows and shallow depths also cause extreme diurnal variations in the creek, which makes maintaining a DO concentration above 6.0 mg/L difficult (USGS 1987).

To determine adjustments in SOD and reaeration rates needed to ensure Cedar Creek compliance with DO concentrations along the listed segment, minor adjustments were applied to the July 10, 1985, base-flow calibration simulation to represent more typical base-flow conditions. For example, the temperature on July 10, 1985, was measured to be about 77 °F, but typical temperatures during July, August, and September are about 73 F (USGS 1987 and 1989a; MRCC 2000). In addition, loads were adjusted to match observed base-flow concentrations measured throughout the low-flow period instead of only on July 10. After minor adjustments, QUAL2E model simulations were run with decreasing SOD rates and increasing reaeration coefficients until the modeled DO concentration did not fall below 6.0 mg/L. A reaeration coefficient is a QUAL2E model input parameter with the unit of “per day” and directly corresponds to the reaeration rate. Table 5-2 shows the percent decrease in SOD rates and increase in reaeration coefficients needed to ensure that DO concentration violations would not occur during low-flow conditions. The reaeration coefficients that correspond to the reaeration rates determined to currently be in the listed segment of the creek are eight per day (base e) in the concrete portion and 10 per day (base e) in the natural portion (see Table 4-1 for rationale on the use of reaeration coefficients of eight and 10 per day).

TABLE 5-2

POSSIBLE COMBINATIONS OF REAERATION AND SOD ADJUSTMENTS IN CEDAR CREEK TO ENSURE COMPLIANCE WITH DO WATER QUALITY STANDARDS DURING LOW FLOW[a,b]

Decrease in SOD Rate (percent)	Target Reaeration Coefficient for the Natural Channel (per day, base e)	Target Reaeration Coefficient for the Concrete Channel (per day, base e)
0	22	20
50	20	18
100	16	14

Note:

SOD Sediment oxygen demand

[a] DO endpoint is 6.0 mg/L

[b] These adjustments do not ensure compliance with DO water quality standards in the headwaters during base flow because groundwater, which is the sole source of base flow in the headwaters, typically has DO concentrations as low as 2.0 mg/L.

To further illustrate the effects of SOD on DO concentrations, Figure 5-1 shows the DO concentrations predicted by the calibrated QUAL2E model during base flow after SOD was reduced by 50 and 100 percent. As shown in Figure 5-1, SOD reductions without any increase in reaeration are not sufficient to ensure that DO concentrations will remain above 6.0 mg/L.

Figures 5-2 and 5-3 show how increasing reaeration in combination with either a 50 or 100 percent SOD reduction affects DO concentrations along the creek segment during base flow. Specifically, Figure 5-2 shows that an SOD reduction of 50 percent and an increase in reaeration coefficients to 20 per day (base e) in the natural channel and 18 per day (base e) in the concrete channel ensures that DO concentrations will remain above 6.0 mg/L. The DO concentrations predicted by this QUAL2E simulation was below 6.0 mg/L for the first mile of the creek, but raising the DO concentration above 6.0 mg/L in the first mile is not feasible because typical groundwater DO concentrations are 2.0 mg/L, and the groundwater is the sole source of base flow near the headwaters.

Figure 5-3 shows that an SOD reduction of 100 percent and increase in reaeration coefficients to 16 per day (base e) in the natural channel and 14 per day (base e) in the concrete channel ensures that DO concentrations will remain above 6.0 mg/L. The DO concentration predicted by the QUAL2E model is again 6.0 mg/L for the first mile, but raising the DO above 6.0 mg/L in the first mile is not feasible as described above.

During first-flush events, TSS, ammonia-N, and DO are all of concern. TSS was detected at concentrations up to 1,420 mg/L during various storms in 1986, and the creek segment contained 65 percent silt/mud during a small storm in August 1999 (precipitation of 0.3 inch and intensity of 0.1 inch per hour [NCDC 1989 through 1999]). As demonstrated by Cedar Creek monitoring data, ammonia-N concentrations near the upstream agricultural area are most critical and require greatest reductions. During a small August 1994 storm (precipitation of 0.7 inch and average intensity of 0.14 inch per hour [NCDC 1989 through 1999]), ammonia-N was detected at concentrations as high as 1 mg/L in the upstream segment of the creek. The reductions in TSS and ammonia-N loads needed to meet state guidelines and improve the aquatic life of the listed segment of Cedar Creek are summarized in Table 5-3.

FIGURE 5-1

EFFECT OF SOD REDUCTIONS ON DO CONCENTRATIONS USING CALIBRATED QUAL2E MODEL DURING BASE FLOW

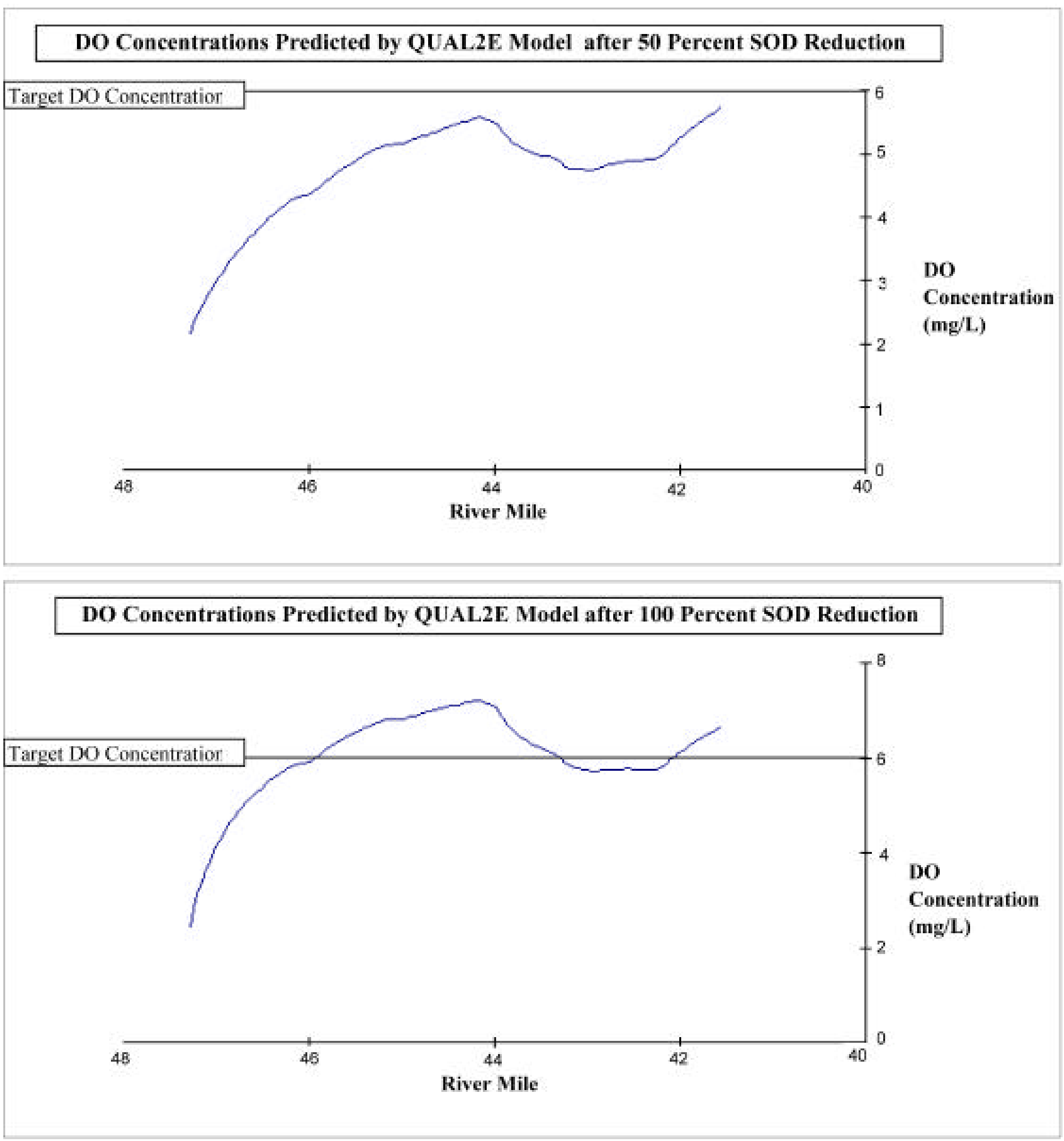
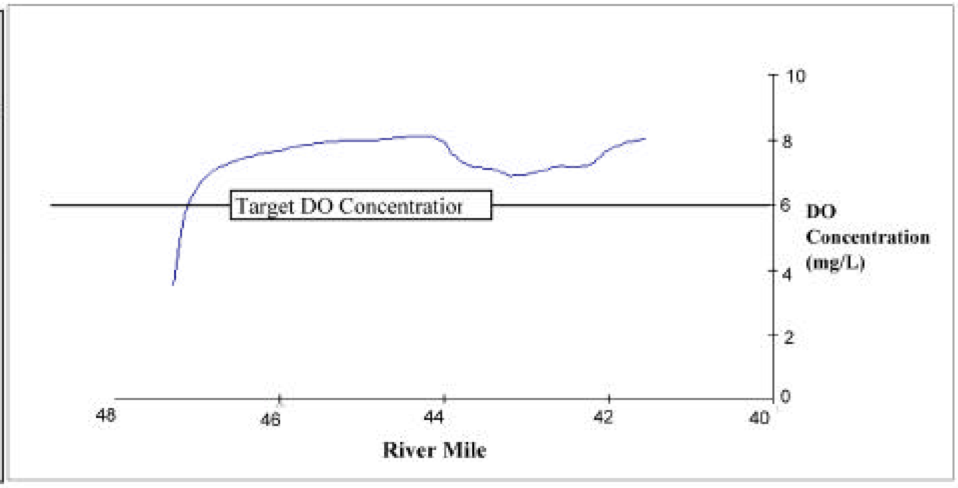


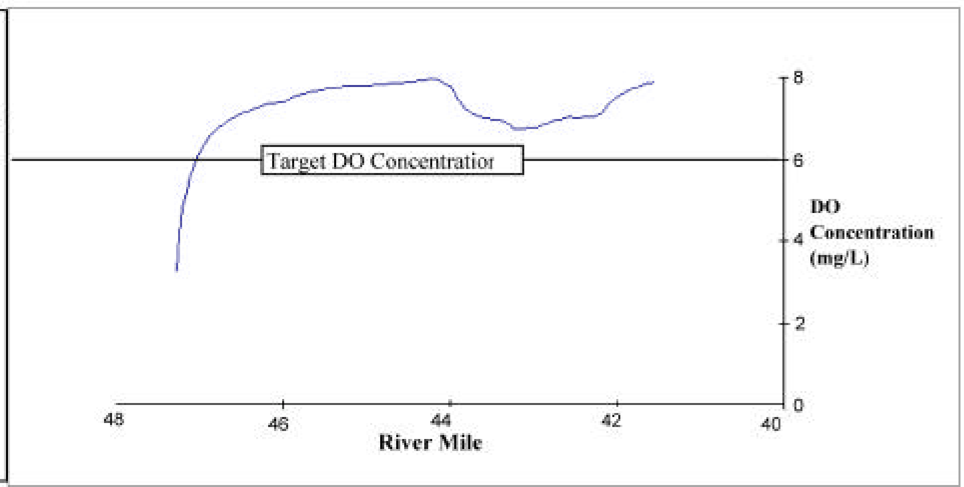
FIGURE 5-2

EFFECTS OF INCREASING REAERATION ON DO CONCENTRATIONS USING CALIBRATED QUAL2E MODEL DURING BASE FLOW WITH 50 PERCENT SOD REDUCTIONS

DO concentrations predicted by QUAL2E model after reaeration coefficients incresed to 22/day in the natural channel and 20/day in the concrete channel



DO concentrations predicted by QUAL2E model after reaeration coefficients incresed to 20/day in the natural channel and 18/day in the concrete channel



DO concentrations predicted by QUAL2E model after reaeration coefficients incresed to 16/day in the natural channel and 14/day in the concrete channel

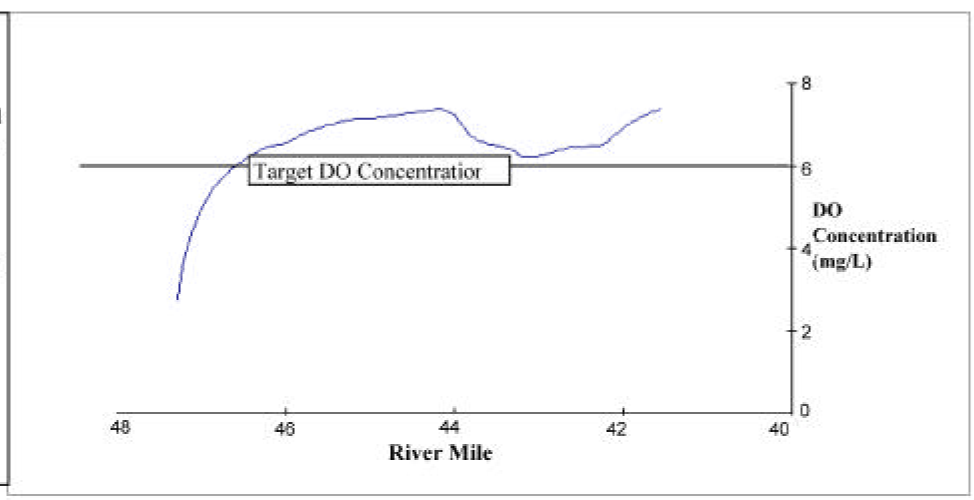
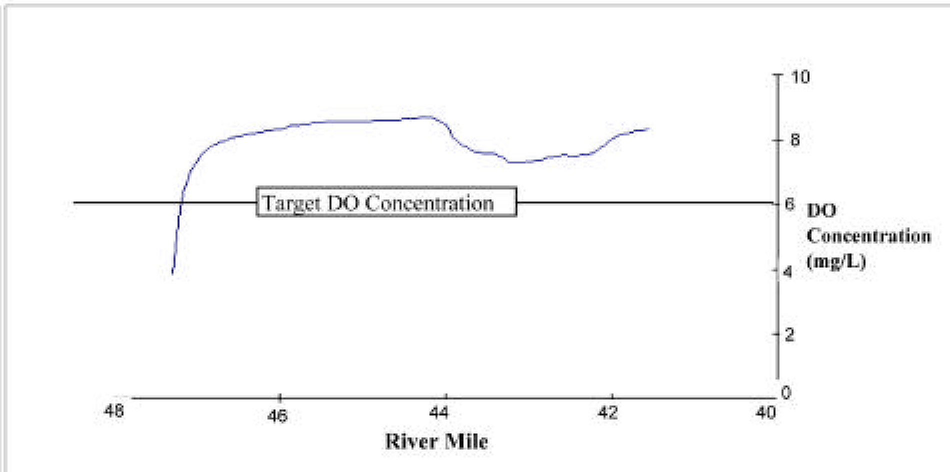


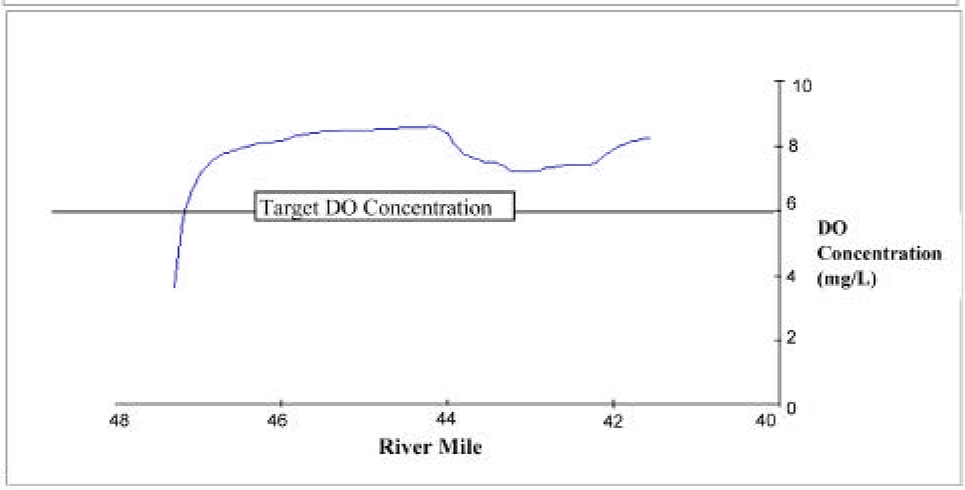
FIGURE 5-3

EFFECT OF INCREASING REAERATION ON DO CONCENTRATIONS USING CALIBRATED QUAL2E MODEL DURING BASE FLOW WITH 100 PERCENT SOD REDUCTION

DO concentrations predicted by QUAL2E model after reaeration coefficients incresed to 22/day in the natural channel and 20/day in the concrete channel



DO concentrations predicted by QUAL2E model after reaeration coefficients incresed to 20/day in the natural channel and 18/day in the concrete channel



DO concentrations predicted by QUAL2E model after reaeration coefficients incresed to 16/day in the natural channel and 14/day in the concrete channel

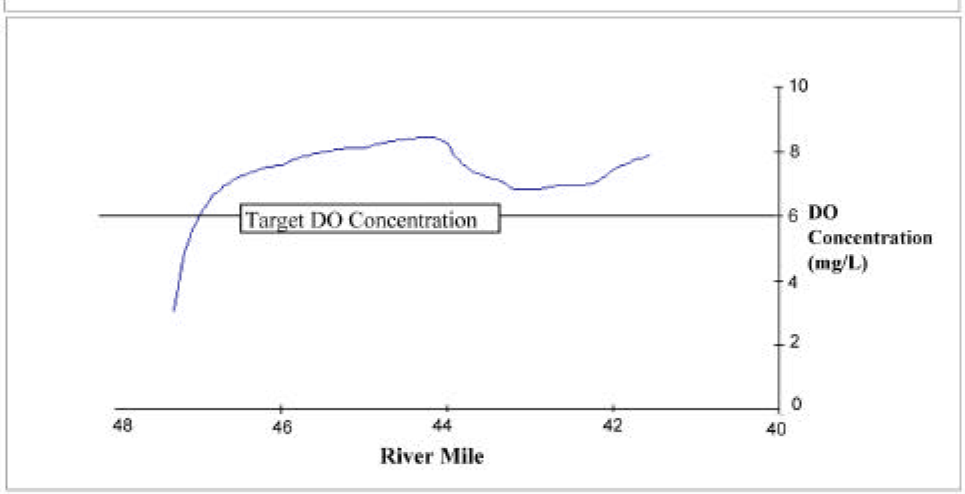


TABLE 5-3

SEASONAL LOAD REDUCTIONS

Source	Predicted Load (lb)	Maximum Allowable Load[a] (lb)	Load Reduction (lb)	Percent Reduction
Ammonia-N				
Agricultural Area	27	13.5	13.5	50
Urban Area	279	218	61	22
TSS				
Agricultural Area	67,800[b]	5,000	62,800	93
Urban Area	826,200[b]	140,450	685,750	83

Notes:

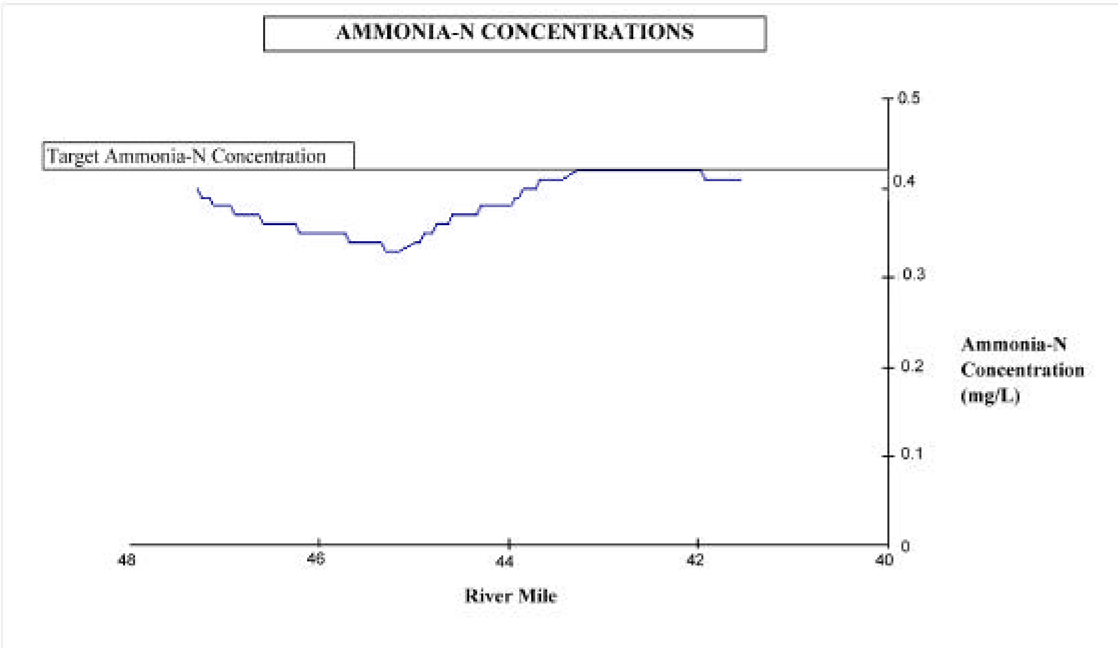
lb Pound
TSS Total suspended solids
a Does not include a margin of safety
b The load allocations do not represent 'sediment yields,' they refer specifically to TSS. TSS and 'sediment yields' may be correlated but are not equivalent. Total sediment loads carried by a stream can be many times TSS loads, and may be composed of sediment loads from both land erosion and stream channel erosion, depending on hydraulic and geomorphic factors. The rationale for TSS as a surrogate for siltation is that low TSS indicates reduction of siltation.

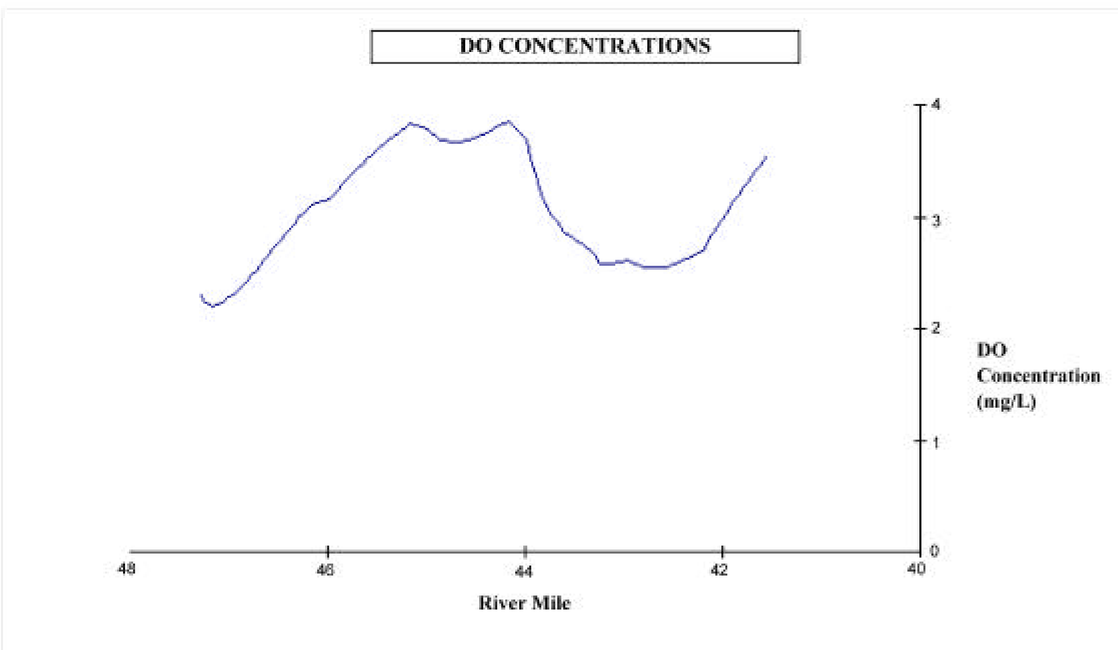
The load reductions needed to achieve compliance were determined by proportionate reductions in predicted EMCs to the target concentrations. For example, if the predicted maximum seasonal EMC for ammonia-N is C_{NH3}, the percent load reduction needed was calculated as (C_{NH3}-Target C_{NH3})/Target C_{NH3}. The target concentration for TSS is 116 mg/L and for ammonia-N is 0.4 mg/L in the agricultural area and 0.5 mg/L in the urban area. The percent load reduction is equal to the percent concentration reduction because the loads are proportional to the average seasonal flow rate, which is assumed to remain constant before and after targets are met.

The QUAL2E model showed that reductions in ammonia-N loads caused increases in DO concentrations, but the increases were not large enough to maintain a DO concentration above 6.0 mg/L. Figure 5-4 shows the ammonia-N and DO concentrations predicted by the calibrated QUAL2E model after target ammonia-N load reductions were applied, without any changes in reaeration or SOD. As shown, the ammonia-N concentrations remain below 0.41 mg/L but the DO concentrations fall below 6.0 mg/L. Even when ammonia-N loads were reduced by 100 percent during simulation of a first-flush event, DO concentrations were predicted to fall below 6.0 mg/L. However, the QUAL2E model predicted that DO concentrations will meet water quality standards if reaeration coefficients are increased and SOD rates are decreased to the same level needed to meet DO standards during base flow.

FIGURE 5-4

AMMONIA-N AND DO CONCENTRATIONS PREDICTED BY QUAL2E MODEL CALIBRATED FOR FIRST-FLUSH EVENT AFTER TARGET AMMONIA-N LOAD REDUCTIONS HAVE BEEN MET





6.0 CONCLUSIONS

Segment ILLD01-LDD-A3 of Cedar Creek was 303(d) listed for nutrient, siltation, and habitat alteration. This modeling effort focused on simulating ammonia-N, DO, and TSS concentrations in the listed segment of Cedar Creek during critical base-flow and first-flush storm events to determine the causes of and solutions to the impairment of the creek.

SWMM was used to predict ammonia-N and TSS loads, and the QUAL2E model was used to predict the instream ammonia-N and DO concentrations. The modeling effort was supported by data collected by the USGS by predicting ammonia-N concentrations above 0.41 mg/L, TSS concentrations above 116 mg/L, and DO concentrations below 5.0 mg/L during storm events; and DO concentrations below 5.0 mg/L during base flow. The models were then able to determine that ammonia-N loads need to be reduced by 50 percent in the agricultural area and 22 percent in the urban area; TSS loads need to be reduced by 93 percent in the agricultural area and 83 percent in the urban area; and reaeration coefficients need to be increased up to 22/day (base e) depending on the feasibility of SOD reductions. To achieve these reductions, various best management practices have been proposed that would result in compliance all along the listed segment, with the exception of compliance with DO water quality standards in the headwaters. These best management practices are described in the TMDL document.

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ATTACHMENT A

SWMM CALIBRATION OUTPUTS
August 26, 1986 Storm

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```
1       **************************************************
     *  U.S. Environmental Protection Agency       *
     *  Storm Water Management Model  (SWMM)       *
     *             Version 4.4GU                   *
     *                                             *
     *             CDM/OSU Beta                    *
     *      Release Date - November 23, 1999       *
     * Camp Dresser & McKee and Oregon State Univ. *
     *        Chuck Moore and Wayne Huber          *
     *  Compiled using Digital Visual Fortran 6.0  *
     **************************************************

                 Developed by

     **************************************************
     *           Metcalf & Eddy, Inc.              *
     *           University of Florida             *
     *      Water Resources Engineers, Inc.        *
     *   (Now Camp, Dresser and McKee, Inc.)       *
     *           September 1970                    *
     **************************************************

          Distributed and Maintained by

     **************************************************
     *     U.S. Environmental Protection Agency    *
     * Center for Exposure Assessment Modeling (CEAM)*
     *  Athens Environmental Research Laboratory   *
     *          960 College Station Road           *
     *          Athens, GA   30605-2720            *
     **************************************************

     **************************************************
     *    This is a new release of SWMM.  If any   *
```

```
  *   problems occur executing this model    *
  *   system, contact Mr. Frank Stancil,     *
  *   U.S. Environmental Protection Agency.  *
  *   706/355-8328 (voice)                   *
  *   e-mail: stancil@athens.ath.epa.gov     *
  *   Or contact Wayne C. Huber at Oregon St. U.*
  *   541/737-6150 or wayne.huber@orst.edu   *
  *   Or Michael F. Schmidt at Camp Dresser &  *
  *   McKee (904) 281-0170 SCHMIDTMF@CDM.COM   *
  ************************************************

  ************************************************
  * This is an implementation of EPA SWMM 4.4GU  *
  * "Nature is full of infinite causes which     *
  *  have never occurred in experience" da Vinci *
  ************************************************


##########################################
#     File names by SWMM Block         #
#      JIN  -> Input to a Block        #
#     JOUT  -> Output from a Block     #
##########################################

  JIN for Block #    1 File #    0  JIN.UF
 JOUT for Block #    1 File #    9  PCTmp1.int

##########################################
# Scratch file names for this simulation. #
##########################################

NSCRAT #    1 File #   21  SCRT1.UF
NSCRAT #    2 File #   22  SCRT2.UF
NSCRAT #    3 File #   23  SCRT3.UF
```

NSCRAT # 4 File # 24 SCRT4.UF
NSCRAT # 5 File # 25 SCRT5.UF
NSCRAT # 6 File # 26 SCRT6.UF
NSCRAT # 7 File # 27 SCRT7.UF
NSCRAT # 8 File # 28 SCRT8.UF

****
* Parameter Values on the Tapes Common Block *
****

Number of Subcatchments in the Runoff Block (NW)...... 1000
Number of Channel/Pipes in the Runoff Block (NG)...... 1000
Number of Connections to Runoff Channels/Inlets (NCP). 6
Number of Water Quality Constituents (MQUAL).......... 20
Number of Runoff Land Uses per Subcatchment (NLU)..... 20
Number of Groundwater Subcatchments in Runoff (NGW)... 100
Number of Interface Locations for all Blocks (NIE).... 1000
Number of Elements in the Transport Block (NET)....... 500
Number of Storage Junctions in Transport (NTSE)....... 100
Number of Transport interface input locations (NTHI).. 500
Number of Transport interface output locations (NTHO). 500
Number of Transport input locations on R lines (NTHR). 80
Number of Transport printed output locations (NTOA)... 80
Number of Tabular Flow Splitters in Transport (NTSP).. 50
Number of Elements in the Extran Block (NEE).......... 4000
Number of Pumps in Extran (NEP)....................... 75
Number of Orifices in Extran (NEO).................... 200
Number of Tide Gates/Free Outfalls in Extran (NTG).... 200
Number of Extran Weirs (NEW).......................... 400
Number of Extran Printout Locations (NPO)............. 150
Number of Tide Elements in Extran (NTE)............... 50
Number of Natural Channels (NNC)...................... 1200
Number of Storage Junctions in Extran (NVSE).......... 1000
Number of Time History Data Points in Extran (NTVAL).. 500

Number of Data Points for Variable Storage Elements
in the Extran Block (NVST).......................... 25
Number of Input Hydrographs in Extran (NEH)........... 500
Number of Allowable Channel Connections to
Junctions in the Extran Block (NCHN)................ 15
Number Rain Gages in Rain and Runoff (MAXRG).......... 200
Number PRATE/VRATE Points for Extran Pump
Input (MAXPRA)...................................... 10
Number of Variable Orifices in Extran (NVORF)......... 50
Number of Variable Orifice Data Points (NVOTIM)....... 50
Number of Allowable Precip. Values/yr in Rain (LIMRN). 5000
Number of Storm Events for Rain Analysis (LSTORM).....20000
Number of Plugs for Plug-flow in S/T (NPLUG).......... 3000
Number Conduits for Extran Results to ASCII
File (MXFLOW)...................................... 400

```
###################################################
# Entry made to the Runoff Block, last updated by #
# Oregon State University, CDM, and XP Software,  #
# October 1997.                                   #
###################################################
# "And wherever water goes, amoebae go along for  #
#  the ride"                    Tom Robbins       #
###################################################
```

CEDAR CREEK TMDL MODEL DEVELOPMENT

RUNOFF MODULE AUGUST 26, 1986 EVENT

Snowmelt parameter - ISNOW....................... 0

Number of rain gages - NRGAG..................... 1

Horton infiltration equation used - INFILM....... 0

Quality is simulated - KWALTY.................... 1
Read evaporation data on line(s) F1 (F2) - IVAP.. 1

Hour of day at start of storm - NHR............. 0

Minute of hour at start of storm - NMN........... 0

Time TZERO at start of storm (hours)............. 0.000

Use U.S. Customary units for most I/O - METRIC... 0

Runoff input print control... 0

Runoff graph plot control.... 1

Runoff output print control.. 1

Limit number of groundwater convergence messages to 10000 (if simulated)

Month, day, year of start of storm is: 8/26/1986

Wet time step length (seconds)....... 300.

Dry time step length (seconds)....... 3600.

Wet/Dry time step length (seconds)... 3600.

Simulation length is...... 96.0 Hours

Percent of impervious area with zero detention depth 25.0

Horton infiltration model being used
Rate forregeneration of infiltration = REGEN * DECAY
DECAY is read in for each subcatchment
REGEN = ... 0.01000
1

Rainfall from E3 Data Group

KTYPE - Rainfall input type.............. 1
NHISTO - Total number of rainfall values.. 20
KINC - Rainfall values (pairs) per line. 1
KPRINT - Print rainfall (0-Yes,1-No)...... 1
KTIME - Precipitation time units
0 --> Minutes 1 --> Hours............ 0
KPREP - Precipitation unit type
0 --> Intensity 1 --> Volume.......... 1
KTHIS - Variable rainfall intervals
0 --> No, > 1 --> Yes................. 0
THISTO - Rainfall time interval........... 11.00
TZRAIN - Starting time (KTIME units)...... 0.00

****
* Rainfall input summary from Runoff *
****

Total rainfall for gage # 1 is 0.4410 inches

#############################
Data Group F1

Evaporation Rate (in/day)
#############################

JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
0.05	0.05	0.05	0.06	0.06	0.10	0.15	0.20	0.25	0.20	0.10	0.05

****
* No Channel or Pipe Network *
****

1

****
* S U B C A T C H M E N T D A T A *
****

	SUBCATCH-MENT NO.	CHANNEL OR INLET	WIDTH (FT)	AREA (AC)	PERCENT IMPERV.	SLOPE (FT/FT)	RESISTANCE FACTOR IMPERV.	RESISTANCE FACTOR PERV.	DEPRES. STORAGE(IN) IMPERV.	DEPRES. STORAGE(IN) PERV.	INFILTRATION RATE(IN/HR) MAXIMUM	INFILTRATION RATE(IN/HR) MINIMUM	DECAY RATE (1/SEC)	GAGE NO.
1	100	10000	1200.00	1152.00	3.00	0.0150	0.100	0.250	0.200	0.400	1.60	0.80	0.00090	1
2	200	20000	4000.00	6281.00	17.00	0.0150	0.100	0.250	0.200	0.400	1.60	0.80	0.00200	1

TOTAL NUMBER OF SUBCATCHMENTS... 2
TOTAL TRIBUTARY AREA (ACRES).... 7433.00
IMPERVIOUS AREA (ACRES)......... 1102.33
PERVIOUS AREA (ACRES)........... 6330.67
TOTAL WIDTH (FEET).............. 5200.00
PERCENT IMPERVIOUSNESS.......... 14.83

```
1
 ***********************************************************
 *     Arrangement of Subcatchments and Channel/Pipes    *
 ***********************************************************


    INLET
    10000     No Tributary Channel/Pipes
              Tributary Subareas........        100
    20000     No Tributary Channel/Pipes
              Tributary Subareas........        200


 *************************************************************
 * Hydrographs will be stored for the following   2 INLETS *
 *************************************************************
       10000     20000

1
 #####################################################
 #           Quality Simulation               #
 #####################################################
 #     General Quality Control Data Groups       #
 #####################################################

  Description                    Variable      Value
  -----------                    --------      -----

  Number of quality constituents.....   NQS.......        4

  Number of land uses................  JLAND.......        2

  Standard catchbasin volume.........  CBVOL.......     60.00 cubic feet
```

Erosion is not simulated......... IROS........ 0

DRY DAYS PRIOR TO START OF STORM... DRYDAY....... 5.00 DAYS

DRY DAYS REQUIRED TO RECHARGE
CATCHBASIN CONCENTRATION TO
INITIAL VALUES..................... DRYBSN....... 1.00 DAYS

DUST AND DIRT
STREET SWEEPING EFFICIENCY......... REFFDD....... 0.500

DAY OF YEAR ON WHICH STREET
SWEEPING BEGINS.................... KLNBGN....... 60

DAY OF YEAR ON WHICH STREET
SWEEPING ENDS...................... KLNEND....... 334

###
Land use data on data group J2
###

LAND USE (LNAME)	BUILDUP EQUATION TYPE (METHOD)	FUNCTIONAL DEPENDENCE OF BUILDUP PARAMETER(JACGUT)	LIMITING BUILDUP QUANTITY (DDLIM)	BUILDUP POWER (DDPOW)	BUILDUP COEFF. (DDFACT)	CLEANING INTERVAL IN DAYS (CLFREQ)	AVAIL. FACTOR FRACTION (AVSWP)	DAYS SINCE LAST SWEEPING (DSLCL)
Agri	POWER LINEAR(0)	AREA(1)	5.000E+04	0.000	0.000	0.000	0.000	0.000
Urban	POWER LINEAR(0)	AREA(1)	5.000E+04	0.000	0.000	0.000	0.000	0.000

1
##
Constituent data on data group J3

##

	NH3-N	BOD	TSS	P
	--------	--------	--------	--------
Constituent units........	mg/l	mg/l	mg/l	mg/l
Type of units............	0	0	0	0
KALC....................	4	4	4	4
Type of buildup calc.....	NO BUILDUP(4)	NO BUILDUP(4)	NO BUILDUP(4)	NO BUILDUP(4)
KWASH...................	2	2	1	2
Type of washoff calc.....	RATING CURVE UL(2)	RATING CURVE UL(2)	RATG CURVE NO UL(1)	RATING CURVE UL(2)
KACGUT..................	0	0	0	0
Dependence of buildup....	CHAN. LENGTH(0)	CHAN. LENGTH(0)	CHAN. LENGTH(0)	CHAN. LENGTH(0)
LINKUP..................	0	0	0	0
Linkage to snowmelt......	NO SNOW LINKAGE	NO SNOW LINKAGE	NO SNOW LINKAGE	NO SNOW LINKAGE
Buildup param 1 (QFACT1).	0.000	0.000	0.000	0.000
Buildup param 2 (QFACT2).	0.000	0.000	0.000	0.000
Buildup param 3 (QFACT3).	0.000	0.000	0.000	0.000
Buildup param 4 (QFACT4).	0.000	0.000	0.000	0.000
Buildup param 5 (QFACT5).	0.000	0.000	0.000	0.000
Washoff power (WASHPO)...	0.830	0.800	1.400	0.800
Washoff coef. (RCOEF)....	9.000	280.000	11250.000	10.000
Init catchb conc (CBFACT)	0.010	0.010	0.010	0.010
Precip. conc. (CONCRN)...	0.000	0.000	0.000	0.000
Street sweep effic (REFF)	0.580	0.350	0.400	0.400
Land use number..........	1	1	1	1

	NH3-N	BOD	TSS	P
	--------	--------	--------	--------
Constituent units........	mg/l	mg/l	mg/l	mg/l
Type of units............	0	0	0	0
KALC....................	4	4	4	4
Type of buildup calc.....	NO BUILDUP(4)	NO BUILDUP(4)	NO BUILDUP(4)	NO BUILDUP(4)
KWASH...................	2	2	1	2

Type of washoff calc.....	RATING CURVE UL(2)	RATING CURVE UL(2)	RATG CURVE NO UL(1)	RATING CURVE UL(2)
KACGUT..................	0	0	0	0
Dependence of buildup....	CHAN. LENGTH(0)	CHAN. LENGTH(0)	CHAN. LENGTH(0)	CHAN. LENGTH(0)
LINKUP..................	0	0	0	0
Linkage to snowmelt......	NO SNOW LINKAGE	NO SNOW LINKAGE	NO SNOW LINKAGE	NO SNOW LINKAGE
Buildup param 1 (QFACT1).	0.000	0.000	0.000	0.000
Buildup param 2 (QFACT2).	0.000	0.000	0.000	0.000
Buildup param 3 (QFACT3).	0.000	0.000	0.000	0.000
Buildup param 4 (QFACT4).	0.000	0.000	0.000	0.000
Buildup param 5 (QFACT5).	0.000	0.000	0.000	0.000
Washoff power (WASHPO)...	0.830	0.900	1.400	0.900
Washoff coef. (RCOEF)....	9.000	800.000	1250.000	9.000
Init catchb conc (CBFACT)	0.010	0.010	0.010	0.010
Precip. conc. (CONCRN)...	0.000	0.000	0.000	0.000
Street sweep effic (REFF)	0.580	0.350	0.400	0.400
Land use number..........	2	2	2	2

****
* Subcatchment surface quality on data group L1 *
****

No.	Land Usage	Land Use No.	Total Gutter Length 10**2ft	Number of Catch- Basins	Input Loading load/ac NH3-N	Input Loading load/ac BOD	Input Loading load/ac TSS	Input Loading load/ac P
1	100 Agri	1	0.00	1.00	5.0E-02	4.0E-01	5.0E-02	3.0E+01
2	200 Urban	2	0.00	1.00	5.0E-02	4.0E-01	5.0E-02	4.5E+01
Totals (Loads in lb or other)			0.00	2.00	3.7E+02	3.0E+03	3.7E+02	3.2E+05

```
**********************************************************
*  Subcatchment land use fractions on data group L2   *
**********************************************************

        FRACTION FOR LAND USE NUMBER:
  CATCHMENT     1       2
NO.     NAME  Agri     Urban
 1     100    0.950    0.050
 2     200    0.150    0.850

  ***********************
  *   DATA GROUP M1   *
  ***********************


TOTAL NUMBER OF PRINTED GUTTERS/INLETS...NPRNT..       2
NUMBER OF TIME STEPS BETWEEN PRINTINGS..INTERV..       1
STARTING AND STOPPING PRINTOUT DATES...........

  ***********************
  *   DATA GROUP M3   *
  ***********************

CHANNEL/INLET PRINT DATA GROUPS......  10000  20000



*****************************************************
*  Precipitation Interface File Summary          *
*  Number of precipitation station....       1   *
*****************************************************

Location Station Number
-------- --------------
```

1. 1

1
```
************************************************
* Summary of Quantity and Quality results for *
*           1986                *
************************************************

   Month    Inlet   Rain   Flow    NH3-N     BOD      TSS      P
            Inch   Inch  Pounds   Pounds   Pounds   Pounds
---  ---------- -------- -------- --------- --------- --------- --------- ---------
August         10000  0.44100  0.00078 0.442      15.3      494.     0.483
Year    10000  0.44100  0.00078 0.442      15.3      494.     0.483
August         20000  0.44100  0.01163  5.11       436.     0.250E+04  5.66
Year     20000  0.44100  0.01163  5.11       436.     0.250E+04  5.66

*************************************************
*      End of time step DO-loop in Runoff      *
*************************************************

Final Date (Mo/Day/Year)  =              8/30/1986
Total number of time steps =                  154
Final Julian Date  =                    1986242
Final time of day  =                      0. seconds.
Final running time =                    96.0000   hours.
Final time of day  =                    0.00   hours.
Final running time =                    4.0000    days.

***************************************************
*     Extrapolation Summary for Watersheds        *
* # Steps ==> Total Number of Extrapolated Steps *
* # Calls ==> Total Number of OVERLND Calls      *
***************************************************
```

Subcatch	# Steps	# Calls	Subcatch	# Steps	# Calls	Subcatch	# Steps	# Calls
100	491	125	200	462	154			

1

****

*   Continuity Check for Surface Water   *

****

	cubic feet	Inches over Total Basin
Total Precipitation (Rain plus Snow)	1.189897E+07	0.441
Total Infiltration	9.432150E+06	0.350
Total Evaporation	2.094425E+06	0.078
Surface Runoff from Watersheds	3.347629E+05	0.012
Total Water remaining in Surface Storage	0.000000E+00	0.000
Infiltration over the Pervious Area...	9.432150E+06	0.410

Infiltration + Evaporation + Surface Runoff + Snow removal + Water remaining in Surface Storage + Water remaining in Snow Cover.........	1.186134E+07	0.440
Total Precipitation + Initial Storage.	1.189897E+07	0.441

The error in continuity is calculated as

****

* Precipitation + Initial Snow Cover *
*   - Infiltration -   *
*Evaporation - Snow removal -   *
*Surface Runoff from Watersheds -   *
*Water in Surface Storage -   *
*Water remaining in Snow Cover   *
----
* Precipitation + Initial Snow Cover *

```
****************************************
Error.................................   0.316 Percent


***********************************************
*      Continuity Check for Channel/Pipes   *
***********************************************
                                              Inches over
                                    cubic feet    Total Basin
Initial Channel/Pipe Storage................   0.000000E+00    0.000
Final Channel/Pipe Storage..................   0.000000E+00    0.000
Surface Runoff from Watersheds.............    3.347629E+05    0.012
Groundwater Subsurface Inflow..............    0.000000E+00    0.000
Evaporation Loss from Channels.............    0.000000E+00    0.000
Channel/Pipe/Inlet Outflow.................   3.347629E+05    0.012
Initial Storage + Inflow...................   3.347629E+05    0.012
Final Storage + Outflow....................   3.347629E+05    0.012
*********************************************
* Final Storage + Outflow + Evaporation  - *
* Watershed Runoff - Groundwater Inflow  - *
*    Initial Channel/Pipe Storage        *
*    ---------------------------------   *
*  Final Storage + Outflow  + Evaporation  *
*********************************************
Error......................................   0.000 Percent
1

                SUMMARY STATISTICS FOR SUBCATCHMENTS
                ===================================

                    PERVIOUS AREA     IMPERVIOUS AREA     TOTAL SUBCATCHMENT AREA
                   -------------------  -----------------  -------------------------
                TOTAL    TOTAL       PEAK            PEAK           PEAK    PEAK
      GUTTER           SIMULATED  RUNOFF TOTAL RUNOFF  RUNOFF  RUNOFF     RUNOFF  RUNOFF   UNIT
```

SUBCATCH-	OR INLET	AREA	PERCENT	RAINFALL	DEPTH	LOSSES	RATE	DEPTH	RATE	DEPTH	RATE	RUNOFF
MENT NO.	NO.	(AC)	IMPER.	(IN)	(IN)	(IN)	(CFS)	(IN)	(CFS)	(IN)	(CFS)	(IN/HR)
100	10000	1152.00	3.0	0.44	0.000	0.441	0.00	0.168	1.72	0.005	1.72	0.001
200	20000	6281.00	17.0	0.44	0.000	0.441	0.00	0.081	11.05	0.014	11.05	0.002

*** NOTE *** IMPERVIOUS AREA STATISTICS AGGREGATE IMPERVIOUS AREAS WITH AND WITHOUT DEPRESSION STORAGE

SUMMARY STATISTICS FOR CHANNEL/PIPES
==

CHANNEL NUMBER	FULL FLOW (CFS)	FULL VELOCITY (FPS)	FULL DEPTH (FT)	MAXIMUM COMPUTED INFLOW (CFS)	MAXIMUM COMPUTED OUTFLOW (CFS)	MAXIMUM COMPUTED DEPTH (FT)	MAXIMUM COMPUTED VELOCITY (FPS)	TIME OF OCCURRENCE DAY	HR.	LENGTH OF SURCHARGE (HOUR)	MAXIMUM SURCHARGE VOLUME (AC-FT)	RATIO OF MAX. TO FULL FLOW	RATIO OF MAX. DEPTH TO FULL DEPTH
20000				11.00				8/26/1986	3.85				
10000				1.61				8/26/1986	2.02				

TOTAL NUMBER OF CHANNELS/PIPES = 2

*** NOTE *** THE MAXIMUM FLOWS AND DEPTHS ARE CALCULATED AT THE END OF THE TIME INTERVAL

1

```
#####################################################
#          Runoff Quality Summary Page          #
# If NDIM = 0 Units for:   loads    mass rates      #
#          METRIC = 1    lb       lb/sec       #
#          METRIC = 2    kg       kg/sec       #
# If NDIM = 1 Loads are in units of quantity       #
#          and mass rates are quantity/sec      #
# If NDIM = 2 loads are in units of concentration   #
```

```
#        times volume and mass rates have units#
#        of concentration times volume/second  #
##################################################

                  NH3-N     BOD      TSS       P
                  mg/l     mg/l     mg/l     mg/l
                -------- -------- -------- --------
Inputs
------
 1. INITIAL SURFACE LOAD........  3.72E+02  2.97E+03  3.72E+02  3.17E+05
 2. TOTAL SURFACE BUILDUP.......  3.72E+02  2.97E+03  3.72E+02  3.17E+05
 3. INITIAL CATCHBASIN LOAD.....  7.49E-05  7.49E-05  7.49E-05  7.49E-05
 4. TOTAL CATCHBASIN LOAD.......  7.49E-05  7.49E-05  7.49E-05  7.49E-05
 5. TOTAL CATCHBASIN AND
    SURFACE BUILDUP (2+4).......  3.72E+02  2.97E+03  3.72E+02  3.17E+05

Remaining Loads
---------------
 6. LOAD REMAINING ON SURFACE...  3.66E+02  2.47E+03  3.72E+02  3.17E+05
 7. REMAINING IN CATCHBASINS....  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 8. REMAINING IN CHANNEL/PIPES..  0.00E+00  0.00E+00  0.00E+00  0.00E+00

Removals
--------
 9. STREET SWEEPING REMOVAL.....  0.00E+00  0.00E+00  0.00E+00  0.00E+00
10. NET SURFACE BUILDUP (2-9)...  3.72E+02  2.97E+03  3.72E+02  3.17E+05
11. SURFACE WASHOFF.............  5.55E+00  4.52E+02  3.00E+03  6.14E+00
12. CATCHBASIN WASHOFF..........  7.49E-05  7.49E-05  7.49E-05  7.49E-05
13. TOTAL WASHOFF (11+12).......  5.55E+00  4.52E+02  3.00E+03  6.14E+00
14. INSOLUBLE WASHOFF...........  0.00E+00  0.00E+00  0.00E+00  0.00E+00
15. PRECIPITATION...............  0.00E+00  0.00E+00  0.00E+00  0.00E+00
16. TOTAL GROUNDWATER LOAD......  0.00E+00  0.00E+00  0.00E+00  0.00E+00
16a.TOTAL I/I LOAD..............  0.00E+00  0.00E+00  0.00E+00  0.00E+00
17. TTL SUBC LD(13+14+15+16+16a)  5.55E+00  4.52E+02  3.00E+03  6.14E+00
```

18. TOTAL LOAD TO INLETS........ 5.55E+00 4.52E+02 3.00E+03 6.14E+00
19. FLOW WT'D AVE.CONCENTRATION
    (INLET LOAD/TOTAL FLOW)..... 2.66E-01 2.16E+01 1.43E+02 2.94E-01

Percentages
----
20. STREET SWEEPING (9/2)....... 0.000 0.000 0.000 0.000
21. SURFACE WASHOFF (11/2)...... 1.493 15.187 806.327 0.002
22. NET SURFACE WASHOFF(11/10).. 1.493 15.187 806.327 0.002
23. WASHOFF/SUBCAT LOAD(11/17).. 99.999 100.000 100.000 99.999
24. SURFACE WASHOFF/INLET LOAD
    (11/18).................... 99.999 100.000 100.000 99.999
25. CATCHBASIN WASHOFF/
    SUBCATCHMENT LOAD (12/17)... 0.001 0.000 0.000 0.001
26. CATCHBASIN WASHOFF/
    INLET LOAD (12/18).......... 0.001 0.000 0.000 0.001
27. INSOLUBLE FRACTION/
    SUBCATCHMENT LOAD (14/17)... 0.000 0.000 0.000 0.000
28. INSOLUBLE FRACTION/
    INLET LOAD (14/18).......... 0.000 0.000 0.000 0.000
29. PRECIPITATION/
    SUBCATCHMENT LOAD (15/17)... 0.000 0.000 0.000 0.000
30. PRECIPITATION/
    INLET LOAD (15/18).......... 0.000 0.000 0.000 0.000
31. GROUNDWATER LOAD/
    SUBCATCHMENT LOAD (16/17)... 0.000 0.000 0.000 0.000
32. GROUNDWATER LOAD/
    INLET LOAD (16/18).......... 0.000 0.000 0.000 0.000

32a.INFILTRATION/INFLOW LOAD/
    SUBCATCHMENT LOAD (16a/17).. 0.000 0.000 0.000 0.000

32b.INFILTRATION/INFLOW LOAD/
    INLET LOAD (16a/18)......... 0.000 0.000 0.000 0.000

33. INLET LOAD SUMMATION ERROR
    (18+8-17)/17................ 0.000 0.000 0.000 0.000

CAUTION. Due to method of quality routing (Users Manual, Appendix IX)
quality routing through channel/pipes is sensitive to the time step.
Large "Inlet Load Summation Errors" may result.
These can be reduced by adjusting the time step(s).
Note: surface accumulation during dry time steps at end of simulation is
not included in totals. Buildup is only performed at beginning of
wet steps or for street cleaning.

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****
* Summary of Quantity and Quality Results at *
* Location 10000 INFlow in cfs. *
* Values are instantaneous at indicated time step *
****

CEDAR CREEK TMDL MODEL DEVELOPMENT
RUNOFF MODULE AUGUST 26, 1986 EVENT

Date Mo/Da/Year	Time Hr:Min	Flow cfs	NH3-N mg/l	BOD mg/l	TSS mg/l	P mg/l
8/26/1986	0 14	0.016	6.774E-01	2.464E+01	7.071E+01	8.167E-01
8/26/1986	0 18	0.050	5.583E-01	1.986E+01	1.119E+02	6.534E-01
8/26/1986	0 22	0.098	4.982E-01	1.754E+01	1.461E+02	5.734E-01
8/26/1986	0 25	0.161	4.565E-01	1.598E+01	1.784E+02	5.192E-01
8/26/1986	0 29	0.234	4.265E-01	1.490E+01	2.073E+02	4.808E-01
8/26/1986	0 33	0.316	4.038E-01	1.410E+01	2.338E+02	4.520E-01
8/26/1986	0 36	0.362	3.937E-01	1.374E+01	2.470E+02	4.393E-01
8/26/1986	0 40	0.410	3.854E-01	1.343E+01	2.595E+02	4.288E-01
8/26/1986	0 44	0.459	3.782E-01	1.316E+01	2.714E+02	4.196E-01
8/26/1986	0 47	0.503	3.723E-01	1.294E+01	2.816E+02	4.121E-01
8/26/1986	0 51	0.561	3.654E-01	1.268E+01	2.942E+02	4.034E-01
8/26/1986	0 55	0.644	3.570E-01	1.236E+01	3.108E+02	3.928E-01

8/26/1986	0	58	0.727	3.497E-01	1.209E+01	3.262E+02	3.837E-01
8/26/1986	1	2	0.820	3.426E-01	1.183E+01	3.423E+02	3.748E-01
8/26/1986	1	6	0.921	3.359E-01	1.158E+01	3.587E+02	3.664E-01
8/26/1986	1	9	0.993	3.316E-01	1.142E+01	3.697E+02	3.611E-01
8/26/1986	1	13	1.068	3.275E-01	1.127E+01	3.806E+02	3.560E-01
8/26/1986	1	17	1.146	3.236E-01	1.112E+01	3.914E+02	3.512E-01
8/26/1986	1	20	1.208	3.208E-01	1.102E+01	3.997E+02	3.477E-01
8/26/1986	1	24	1.270	3.180E-01	1.092E+01	4.078E+02	3.443E-01
8/26/1986	1	28	1.333	3.154E-01	1.082E+01	4.158E+02	3.410E-01
8/26/1986	1	31	1.372	3.139E-01	1.076E+01	4.207E+02	3.391E-01
8/26/1986	1	35	1.412	3.124E-01	1.071E+01	4.255E+02	3.373E-01
8/26/1986	1	39	1.451	3.109E-01	1.065E+01	4.302E+02	3.355E-01
8/26/1986	1	42	1.491	3.095E-01	1.060E+01	4.348E+02	3.337E-01
8/26/1986	1	46	1.530	3.081E-01	1.055E+01	4.394E+02	3.321E-01
8/26/1986	1	50	1.569	3.068E-01	1.050E+01	4.438E+02	3.304E-01
8/26/1986	1	53	1.581	3.064E-01	1.049E+01	4.452E+02	3.300E-01
8/26/1986	1	57	1.593	3.060E-01	1.047E+01	4.466E+02	3.295E-01
8/26/1986	2	1	1.605	3.056E-01	1.046E+01	4.479E+02	3.290E-01
8/26/1986	2	4	1.601	3.057E-01	1.046E+01	4.475E+02	3.291E-01
8/26/1986	2	8	1.598	3.059E-01	1.047E+01	4.470E+02	3.293E-01
8/26/1986	2	12	1.594	3.060E-01	1.047E+01	4.467E+02	3.294E-01
8/26/1986	2	15	1.586	3.063E-01	1.048E+01	4.457E+02	3.298E-01
8/26/1986	2	19	1.578	3.065E-01	1.049E+01	4.448E+02	3.301E-01
8/26/1986	2	23	1.570	3.068E-01	1.050E+01	4.440E+02	3.304E-01
8/26/1986	2	26	1.563	3.070E-01	1.051E+01	4.432E+02	3.307E-01
8/26/1986	2	30	1.557	3.072E-01	1.052E+01	4.424E+02	3.310E-01
8/26/1986	2	34	1.550	3.074E-01	1.052E+01	4.417E+02	3.312E-01
8/26/1986	2	37	1.544	3.076E-01	1.053E+01	4.410E+02	3.315E-01
8/26/1986	2	41	1.538	3.078E-01	1.054E+01	4.403E+02	3.317E-01
8/26/1986	2	45	1.533	3.080E-01	1.055E+01	4.397E+02	3.319E-01
8/26/1986	2	48	1.528	3.082E-01	1.055E+01	4.391E+02	3.321E-01
8/26/1986	2	52	1.523	3.084E-01	1.056E+01	4.386E+02	3.324E-01
8/26/1986	2	56	1.518	3.085E-01	1.056E+01	4.380E+02	3.325E-01
8/26/1986	2	59	1.514	3.087E-01	1.057E+01	4.375E+02	3.327E-01

8/26/1986	3	3	1.510	3.088E-01	1.058E+01	4.371E+02	3.329E-01
8/26/1986	3	7	1.506	3.090E-01	1.058E+01	4.366E+02	3.331E-01
8/26/1986	3	10	1.491	3.095E-01	1.060E+01	4.349E+02	3.337E-01
8/26/1986	3	14	1.478	3.100E-01	1.062E+01	4.333E+02	3.343E-01
8/26/1986	3	18	1.464	3.104E-01	1.063E+01	4.317E+02	3.349E-01

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****
* Summary of Quantity and Quality Results at *
* Location 10000 INFlow in cfs. *
* Values are instantaneous at indicated time step *
****

CEDAR CREEK TMDL MODEL DEVELOPMENT
RUNOFF MODULE AUGUST 26, 1986 EVENT

Date Mo/Da/Year	Time Hr:Min		Flow cfs	NH3-N mg/l	BOD mg/l	TSS mg/l	P mg/l
8/26/1986	3	21	1.446	3.111E-01	1.066E+01	4.295E+02	3.357E-01
8/26/1986	3	25	1.428	3.118E-01	1.068E+01	4.275E+02	3.365E-01
8/26/1986	3	29	1.411	3.124E-01	1.071E+01	4.254E+02	3.373E-01
8/26/1986	3	32	1.385	3.134E-01	1.074E+01	4.222E+02	3.386E-01
8/26/1986	3	36	1.359	3.144E-01	1.078E+01	4.190E+02	3.398E-01
8/26/1986	3	40	1.334	3.154E-01	1.082E+01	4.159E+02	3.410E-01
8/26/1986	3	43	1.310	3.164E-01	1.085E+01	4.129E+02	3.422E-01
8/26/1986	3	47	1.287	3.173E-01	1.089E+01	4.100E+02	3.434E-01
8/26/1986	3	51	1.264	3.183E-01	1.092E+01	4.071E+02	3.446E-01
8/26/1986	4	51	0.751	3.478E-01	1.202E+01	3.305E+02	3.813E-01
8/26/1986	5	51	0.460	3.779E-01	1.315E+01	2.717E+02	4.193E-01
8/26/1986	6	51	0.283	4.104E-01	1.438E+01	2.238E+02	4.608E-01
8/26/1986	7	51	0.170	4.477E-01	1.581E+01	1.824E+02	5.091E-01
8/26/1986	8	51	0.095	4.941E-01	1.761E+01	1.446E+02	5.700E-01
8/26/1986	9	51	0.046	5.592E-01	2.018E+01	1.081E+02	6.572E-01

```
  8/26/1986  10   51      0.015 6.739E-01 2.480E+01 6.969E+01 8.147E-01
  8/26/1986  11   51      0.002 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 ---------- -------    ------- -------- -------- -------- --------
Flow wtd means.....    0.0608 3.372E-01 1.164E+01 3.771E+02 3.687E-01
Flow wtd std devs..    0.2569 5.047E-02 1.911E+00 8.851E+01 6.441E-02
Maximum value......     1.605 6.774E-01 2.480E+01 4.479E+02 8.167E-01
Minimum value......     0.000 0.000E+00 0.000E+00 0.000E+00 0.000E+00
Total loads........ 2.102E+04 4.423E-01 1.527E+01 4.947E+02 4.837E-01
                       Cub-Ft    POUNDS    POUNDS    POUNDS    POUNDS

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 ****************************************************
 *  Summary of Quantity and Quality Results at      *
 *  Location      20000  INFlow in cfs.             *
 *  Values are instantaneous at indicated time step *
 ****************************************************

  CEDAR CREEK TMDL MODEL DEVELOPMENT
  RUNOFF MODULE AUGUST 26, 1986 EVENT

    Date    Time       Flow     NH3-N     BOD       TSS        P
 Mo/Da/Year  Hr:Min      cfs     mg/l      mg/l      mg/l      mg/l
 ---------- -------    ------- -------- -------- -------- --------
  8/26/1986   0   14      0.053 5.737E-01 3.666E+01 1.951E+01 5.153E-01
  8/26/1986   0   18      0.169 4.714E-01 3.228E+01 3.096E+01 4.451E-01
  8/26/1986   0   22      0.331 4.180E-01 2.999E+01 4.055E+01 4.067E-01
  8/26/1986   0   25      0.550 3.809E-01 2.837E+01 4.969E+01 3.794E-01
  8/26/1986   0   29      0.811 3.562E-01 2.720E+01 5.803E+01 3.613E-01
  8/26/1986   0   33      1.110 3.377E-01 2.629E+01 6.580E+01 3.477E-01
  8/26/1986   0   36      1.298 3.288E-01 2.585E+01 7.004E+01 3.412E-01
  8/26/1986   0   40      1.496 3.210E-01 2.546E+01 7.414E+01 3.354E-01
  8/26/1986   0   44      1.705 3.139E-01 2.510E+01 7.812E+01 3.301E-01
  8/26/1986   0   47      1.908 3.080E-01 2.480E+01 8.171E+01 3.256E-01
  8/26/1986   0   51      2.164 3.015E-01 2.447E+01 8.593E+01 3.207E-01
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8/26/1986	0	55	2.510	2.940E-01	2.408E+01	9.117E+01	3.150E-01
8/26/1986	0	58	2.864	2.874E-01	2.374E+01	9.612E+01	3.101E-01
8/26/1986	1	2	3.263	2.811E-01	2.341E+01	1.013E+02	3.052E-01
8/26/1986	1	6	3.701	2.752E-01	2.310E+01	1.065E+02	3.007E-01
8/26/1986	1	9	4.046	2.711E-01	2.288E+01	1.104E+02	2.975E-01
8/26/1986	1	13	4.409	2.671E-01	2.267E+01	1.142E+02	2.944E-01
8/26/1986	1	17	4.790	2.634E-01	2.247E+01	1.181E+02	2.915E-01
8/26/1986	1	20	5.122	2.604E-01	2.231E+01	1.213E+02	2.892E-01
8/26/1986	1	24	5.465	2.575E-01	2.215E+01	1.245E+02	2.870E-01
8/26/1986	1	28	5.819	2.548E-01	2.200E+01	1.276E+02	2.848E-01
8/26/1986	1	31	6.093	2.528E-01	2.190E+01	1.300E+02	2.833E-01
8/26/1986	1	35	6.372	2.509E-01	2.179E+01	1.324E+02	2.818E-01
8/26/1986	1	39	6.657	2.490E-01	2.169E+01	1.347E+02	2.803E-01
8/26/1986	1	42	6.947	2.472E-01	2.159E+01	1.370E+02	2.789E-01
8/26/1986	1	46	7.243	2.455E-01	2.149E+01	1.393E+02	2.775E-01
8/26/1986	1	50	7.544	2.438E-01	2.140E+01	1.416E+02	2.762E-01
8/26/1986	1	53	7.746	2.427E-01	2.134E+01	1.431E+02	2.753E-01
8/26/1986	1	57	7.951	2.416E-01	2.128E+01	1.446E+02	2.745E-01
8/26/1986	2	1	8.158	2.406E-01	2.122E+01	1.461E+02	2.736E-01
8/26/1986	2	4	8.302	2.399E-01	2.118E+01	1.471E+02	2.731E-01
8/26/1986	2	8	8.447	2.392E-01	2.114E+01	1.482E+02	2.725E-01
8/26/1986	2	12	8.594	2.385E-01	2.111E+01	1.492E+02	2.720E-01
8/26/1986	2	15	8.719	2.379E-01	2.107E+01	1.500E+02	2.715E-01
8/26/1986	2	19	8.844	2.373E-01	2.104E+01	1.509E+02	2.710E-01
8/26/1986	2	23	8.970	2.367E-01	2.101E+01	1.518E+02	2.706E-01
8/26/1986	2	26	9.096	2.362E-01	2.098E+01	1.526E+02	2.701E-01
8/26/1986	2	30	9.223	2.356E-01	2.095E+01	1.535E+02	2.697E-01
8/26/1986	2	34	9.350	2.351E-01	2.092E+01	1.543E+02	2.692E-01
8/26/1986	2	37	9.478	2.345E-01	2.089E+01	1.551E+02	2.688E-01
8/26/1986	2	41	9.606	2.340E-01	2.086E+01	1.560E+02	2.684E-01
8/26/1986	2	45	9.735	2.335E-01	2.083E+01	1.568E+02	2.680E-01
8/26/1986	2	48	9.863	2.329E-01	2.080E+01	1.576E+02	2.675E-01
8/26/1986	2	52	9.993	2.324E-01	2.077E+01	1.585E+02	2.671E-01
8/26/1986	2	56	10.122	2.319E-01	2.074E+01	1.593E+02	2.667E-01

8/26/1986	2	59	10.252	2.314E-01	2.071E+01	1.601E+02	2.663E-01
8/26/1986	3	3	10.382	2.309E-01	2.068E+01	1.609E+02	2.659E-01
8/26/1986	3	7	10.512	2.304E-01	2.066E+01	1.617E+02	2.655E-01
8/26/1986	3	10	10.595	2.301E-01	2.064E+01	1.622E+02	2.653E-01
8/26/1986	3	14	10.678	2.298E-01	2.062E+01	1.627E+02	2.650E-01
8/26/1986	3	18	10.761	2.295E-01	2.061E+01	1.632E+02	2.648E-01

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* Summary of Quantity and Quality Results at *
* Location 20000 INFlow in cfs. *
* Values are instantaneous at indicated time step *

****

CEDAR CREEK TMDL MODEL DEVELOPMENT
RUNOFF MODULE AUGUST 26, 1986 EVENT

Date Mo/Da/Year	Time Hr:Min		Flow cfs	NH3-N mg/l	BOD mg/l	TSS mg/l	P mg/l
8/26/1986	3	21	10.820	2.293E-01	2.059E+01	1.636E+02	2.646E-01
8/26/1986	3	25	10.879	2.291E-01	2.058E+01	1.639E+02	2.645E-01
8/26/1986	3	29	10.937	2.289E-01	2.057E+01	1.643E+02	2.643E-01
8/26/1986	3	32	10.948	2.289E-01	2.057E+01	1.643E+02	2.643E-01
8/26/1986	3	36	10.958	2.288E-01	2.057E+01	1.644E+02	2.642E-01
8/26/1986	3	40	10.968	2.288E-01	2.056E+01	1.645E+02	2.642E-01
8/26/1986	3	43	10.978	2.287E-01	2.056E+01	1.645E+02	2.642E-01
8/26/1986	3	47	10.988	2.287E-01	2.056E+01	1.646E+02	2.642E-01
8/26/1986	3	51	10.998	2.287E-01	2.056E+01	1.646E+02	2.641E-01
8/26/1986	4	51	9.652	2.338E-01	2.085E+01	1.563E+02	2.682E-01
8/26/1986	5	51	8.462	2.391E-01	2.114E+01	1.483E+02	2.724E-01
8/26/1986	6	51	7.406	2.446E-01	2.144E+01	1.406E+02	2.768E-01
8/26/1986	7	51	6.468	2.503E-01	2.176E+01	1.331E+02	2.813E-01
8/26/1986	8	51	5.631	2.562E-01	2.208E+01	1.260E+02	2.860E-01

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  8/26/1986   9   51     4.883 2.625E-01 2.242E+01 1.190E+02 2.909E-01
  8/26/1986  10   51     4.215 2.692E-01 2.278E+01 1.122E+02 2.960E-01
  8/26/1986  11   51     3.618 2.763E-01 2.315E+01 1.055E+02 3.015E-01
  8/26/1986  12   51     3.083 2.839E-01 2.355E+01 9.900E+01 3.073E-01
  8/26/1986  13   51     2.606 2.921E-01 2.398E+01 9.256E+01 3.136E-01
  8/26/1986  14   51     2.180 3.011E-01 2.445E+01 8.618E+01 3.204E-01
  8/26/1986  15   51     1.801 3.110E-01 2.495E+01 7.985E+01 3.279E-01
  8/26/1986  16   51     1.466 3.221E-01 2.551E+01 7.354E+01 3.362E-01
  8/26/1986  17   51     1.173 3.346E-01 2.614E+01 6.725E+01 3.454E-01
  8/26/1986  18   51     0.918 3.488E-01 2.684E+01 6.097E+01 3.559E-01
  8/26/1986  19   51     0.701 3.651E-01 2.763E+01 5.474E+01 3.678E-01
  8/26/1986  20   51     0.523 3.839E-01 2.853E+01 4.867E+01 3.814E-01
  8/26/1986  21   51     0.385 4.043E-01 2.949E+01 4.308E+01 3.960E-01
  8/26/1986  22   51     0.297 4.224E-01 3.033E+01 3.885E+01 4.089E-01
  8/26/1986  23   51     0.229 4.416E-01 3.121E+01 3.500E+01 4.224E-01
  8/27/1986   0   51     0.169 4.648E-01 3.226E+01 3.102E+01 4.386E-01
  8/27/1986   1   51     0.118 4.941E-01 3.355E+01 2.688E+01 4.588E-01
  8/27/1986   2   51     0.076 5.331E-01 3.525E+01 2.247E+01 4.855E-01
  8/27/1986   3   51     0.041 5.905E-01 3.767E+01 1.767E+01 5.241E-01
  8/27/1986   4   51     0.016 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  8/27/1986   5   51     0.002 0.000E+00 0.000E+00 0.000E+00 0.000E+00
 ---------- -------    ------- -------- -------- -------- --------
Flow wtd means.....    0.9078 2.609E-01 2.229E+01 1.278E+02 2.892E-01
Flow wtd std devs..    2.2378 3.820E-02 1.973E+00 3.014E+01 2.897E-02
Maximum value......    10.998 5.905E-01 3.767E+01 1.646E+02 5.241E-01
Minimum value......     0.000 0.000E+00 0.000E+00 0.000E+00 0.000E+00
Total loads........ 3.137E+05 5.110E+00 4.365E+02 2.504E+03 5.664E+00
                       Cub-Ft    POUNDS    POUNDS    POUNDS    POUNDS

 ===> Runoff simulation ended normally.

 ===> SWMM 4.4GU  simulation ended normally.
    Always check output file for possible warning messages.
```

```
===> Your input file was named : PCTmp1.dat
===> Your output file was named: PCTmp1.out

*******************************************************
*      SWMM 4.4GU  Simulation Date and Time Summary  *
*******************************************************
* Starting Date... March      16, 2001              *
*         Time...        14:53:35.130            *
*   Ending Date... March      16, 2001              *
*         Time...        14:53:37.110            *
*  Elapsed Time...            0.033 minutes.       *
*  Elapsed Time...            1.982 seconds.       *
*******************************************************
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ATTACHMENT B

QUAL2E MODEL CALIBRATION OUTPUTS
For July 10, 1985 (Base Flow)
And August 26, 1986 (First Flush)

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JULY 10, 1985- BASE FLOW * * * QUAL-2E STREAM QUALITY ROUTING MODEL * * *
Version 3.21 - Feb. 1995

$$$ (PROBLEM TITLES) $$$

CARD TYPE		QUAL-2E PROGRAM TITLES
TITLE01		Base Flow (Calibration)
TITLE02		
TITLE03	NO	CONSERVATIVE MINERAL I
TITLE04	NO	CONSERVATIVE MINERAL II
TITLE05	NO	CONSERVATIVE MINERAL III
TITLE06	NO	TEMPERATURE
TITLE07	YES	BIOCHEMICAL OXYGEN DEMAND
TITLE08	YES	ALGAE AS CHL-A IN UG/L
TITLE09	YES	PHOSPHORUS CYCLE AS P IN MG/L
TITLE10		(ORGANIC-P; DISSOLVED-P)
TITLE11	YES	NITROGEN CYCLE AS N IN MG/L
TITLE12		(ORGANIC-N; AMMONIA-N; NITRITE-N;' NITRATE-N)
TITLE13	YES	DISSOLVED OXYGEN IN MG/L
TITLE14	NO	FECAL COLIFORM IN NO./100 ML
TITLE15	NO	ARBITRARY NON-CONSERVATIVE
ENDTITLE		

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE		CARD TYPE	
LIST DATA INPUT	0.00000		0.00000
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 =	10.00000	NUMBER OF JUNCTIONS =	0.00000
NUM OF HEADWATERS =	1.00000	NUMBER OF POINT LOADS =	0.00000
TIME STEP (HOURS) =	1.00000	LNTH. COMP. ELEMENT (DX)=	0.05000
MAXIMUM ROUTE TIME (HRS)=	30.00000	TIME INC. FOR RPT2 (HRS)=	1.00000

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LATITUDE OF BASIN (DEG) =  40.00000          LONGITUDE OF BASIN (DEG)=  90.00000
STANDARD MARIDIAN (DEG) =  90.00000          DAY OF YEAR START TIME  = 228.00000
EVAP. COEF.,(AE)        =   0.00130          EVAP. COEF.,(BE)        =   0.00016
ELEV. OF BASIN (ELEV)   = 771.00000          DUST ATTENUATION COEF.  =   0.06000
ENDATA1                     0.00000                                      0.00000

 $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE                                            CARD TYPE
O UPTAKE BY NH3 OXID(MG O/MG N)=    3.4300           O UPTAKE BY NO2 OXID(MG O/MG N)=    1.1400
O PROD  BY ALGAE (MG O/MG A)   =    1.6000           O UPTAKE BY ALGAE (MG O/MG A)  =    2.0000
N CONTENT OF ALGAE (MG N/MG A) =    0.0850           P CONTENT OF ALGAE (MG O/MG A) =    0.0140
ALG MAX SPEC GROWTH RATE(1/DAY)=    2.5000           ALGAE RESPIRATION RATE (1/DAY) =    0.5000
N HALF SATURATION CONST (MG/L) =    0.2000           P HALF SATURATION CONST (MG/L) =    0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0008           NLIN SHADE(1/FT-(UGCHA/L)**2/3)=    0.0000
LIGHT FUNCTION OPTION (LFNOPT) =    1.0000           LIGHT SAT'N COEF (BTU/FT2-MIN) =    0.1100
DAILY AVERAGING OPTION (LAVOPT)=    2.0000           LIGHT AVERAGING FACTOR (AFACT) =    0.9200
NUMBER OF DAYLIGHT HOURS (DLH) =   14.0000           TOTAL DAILY SOLR RAD (BTU/FT-2)= 1300.0000
ALGY GROWTH CALC OPTION(LGROPT)=    2.0000           ALGAL PREF FOR NH3-N (PREFN)   =    0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4400           NITRIFICATION INHIBITION COEF  =   10.0000
ENDATA1A                            0.0000                                               0.0000

 $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE     RATE CODE     THETA VALUE

THETA( 1)      BOD DECA        1.047     DFLT
THETA( 2)      BOD SETT        1.024     DFLT
THETA( 3)      OXY TRAN        1.024     DFLT
THETA( 4)      SOD RATE        1.060     DFLT
THETA( 5)      ORGN DEC        1.047     DFLT
THETA( 6)      ORGN SET        1.024     DFLT
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
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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         47.3    TO           47.0
STREAM REACH     2.0  RCH=              2   FROM         47.0    TO           46.0
STREAM REACH     3.0  RCH=              3   FROM         46.0    TO           45.0
STREAM REACH     4.0  RCH=              4   FROM         45.0    TO           44.0
STREAM REACH     5.0  RCH=              5   FROM         44.0    TO           43.3
STREAM REACH     6.0  RCH=              6   FROM         43.3    TO           43.2
STREAM REACH     7.0  RCH=              7   FROM         43.2    TO           42.9
STREAM REACH     8.0  RCH=              8   FROM         42.9    TO           42.5
STREAM REACH     9.0  RCH=              9   FROM         42.5    TO           42.2
STREAM REACH    10.0  RCH=             10   FROM         42.2    TO           41.4
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.        7.          1.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        2.       20.          2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD        3.       20.          2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD        4.       20.          2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD        5.       14.          2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
FLAG FIELD        6.        2.          2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        7.        6.          2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        8.        8.          2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        9.        6.          2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD       10.       16.          2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.0.0.0.0.
ENDATA4           0.        0.          0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
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$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEF-DSPN	SS1	SS2	WIDTH	SLOPE	CMANN
HYDRAULICS	1.	26.00	6.000	6.000	1.000	0.002	0.033
HYDRAULICS	2.	26.00	6.000	6.000	1.500	0.002	0.033
HYDRAULICS	3.	26.00	6.000	6.000	2.000	0.002	0.033
HYDRAULICS	4.	26.00	6.000	6.000	3.000	0.002	0.033
HYDRAULICS	5.	18.00	6.000	6.000	3.000	0.002	0.033
HYDRAULICS	6.	18.00	0.000	6.000	3.000	0.002	0.033
HYDRAULICS	7.	18.00	6.000	6.000	3.000	0.002	0.033
HYDRAULICS	8.	18.00	0.000	6.000	3.000	0.002	0.033
HYDRAULICS	9.	18.00	6.000	6.000	3.000	0.002	0.033
HYDRAULICS	10.	66.00	2.000	2.000	4.000	0.002	0.033
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.	771.00	0.06	0.25	79.00	79.00	30.00	0.00	1.00
TEMP/LCD	2.	771.00	0.06	0.25	79.00	79.00	30.00	0.00	1.00
TEMP/LCD	3.	771.00	0.06	0.25	79.00	79.00	30.00	0.00	1.00
TEMP/LCD	4.	771.00	0.06	0.25	79.00	79.00	30.00	0.00	1.00
TEMP/LCD	5.	771.00	0.06	0.25	79.00	79.00	30.00	0.00	1.00
TEMP/LCD	6.	771.00	0.06	0.25	79.00	79.00	30.00	0.00	1.00
TEMP/LCD	7.	771.00	0.06	0.25	79.00	79.00	30.00	0.00	1.00
TEMP/LCD	8.	771.00	0.06	0.25	79.00	79.00	30.00	0.00	1.00
TEMP/LCD	9.	771.00	0.06	0.25	79.00	79.00	30.00	0.00	1.00
TEMP/LCD	10.	771.00	0.06	0.25	79.00	79.00	30.00	0.00	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	EXPQK2 OR SLOPE FOR OPT 8
REACT COEF	1.	0.13	1.00	0.210	1.	10.00	0.000		0.00000
REACT COEF	2.	0.13	1.00	0.210	1.	10.00	0.000		0.00000
REACT COEF	3.	0.13	1.00	0.210	1.	10.00	0.000		0.00000
REACT COEF	4.	0.13	1.00	0.210	1.	10.00	0.000		0.00000
REACT COEF	5.	0.13	1.00	0.140	1.	8.00	0.000		0.00000

REACT COEF	6.	0.13	1.00	0.140	1.	8.00	0.000	0.00000
REACT COEF	7.	0.13	1.00	0.140	1.	8.00	0.000	0.00000
REACT COEF	8.	0.13	1.00	0.140	1.	8.00	0.000	0.00000
REACT COEF	9.	0.13	1.00	0.140	1.	8.00	0.000	0.00000
REACT COEF	10.	0.13	1.00	0.230	1.	10.00	0.000	0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000	0.00000

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

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	2.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	3.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	4.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	5.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	6.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	7.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	8.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	9.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	10.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	2.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	3.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	4.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	5.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	6.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	7.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	8.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	9.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	10.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI

INITIAL COND-1	1.	73.00	7.00	11.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	2.	73.00	7.00	11.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	3.	73.00	7.00	11.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	4.	73.00	7.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	5.	77.00	7.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	6.	77.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	7.	77.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	8.	77.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	9.	77.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	10.	77.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.00	1.00	0.20	0.00	7.00	0.00	0.12
INITIAL COND-2	2.	2.00	1.00	0.20	0.00	7.00	0.00	0.12
INITIAL COND-2	3.	2.00	1.00	0.20	0.00	7.00	0.00	0.12
INITIAL COND-2	4.	2.00	1.00	0.10	0.00	7.00	0.00	0.12
INITIAL COND-2	5.	4.00	0.70	0.10	0.00	4.00	0.00	0.07
INITIAL COND-2	6.	4.00	0.70	0.10	0.00	4.00	0.00	0.07
INITIAL COND-2	7.	4.00	0.70	0.10	0.00	4.00	0.00	0.07
INITIAL COND-2	8.	4.00	0.70	0.20	0.00	4.00	0.00	0.07
INITIAL COND-2	9.	4.00	0.70	0.20	0.00	0.50	0.00	0.07
INITIAL COND-2	10.	4.00	0.70	0.20	0.00	0.50	0.00	0.07
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.	0.075	73.00	2.00	12.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.200	73.00	2.00	12.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.150	73.00	2.00	10.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	4.	0.165	73.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	5.	0.390	77.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	6.	0.120	77.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.240	77.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	8.	0.240	77.00	2.00	12.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	9.	0.240	77.00	2.00	12.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	10.	0.120	77.00	2.00	12.00	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INCR INFLOW-2	1.	3.00	1.30	0.40	0.00	7.00	0.00	0.12
INCR INFLOW-2	2.	3.00	1.30	0.40	0.00	7.00	0.00	0.12
INCR INFLOW-2	3.	3.00	1.30	0.40	0.00	7.00	0.00	0.12
INCR INFLOW-2	4.	2.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	5.	2.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	6.	2.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	7.	2.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	8.	6.00	1.20	0.50	0.00	0.00	0.00	0.00
INCR INFLOW-2	9.	6.00	1.20	0.50	0.00	0.00	0.00	0.12
INCR INFLOW-2	10.	6.00	1.20	0.50	0.00	0.00	0.00	0.12
ENDATA8A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT	UPSTRM	JUNCTION	TRIB
ENDATA9	0.	0.	0.	0.

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

CARD TYPE	HDWTR ORDER	NAME		FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
HEADWTR-1	1.		1	0.08	73.00	2.00	12.00	0.00	0.00	0.00
ENDATA10	0.			0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	0.00	0.00	3.00	1.20	0.40	0.00	7.00	0.00	0.12
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

```
ENDATA11       0.                      0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00

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

              POINT
CARD TYPE      LOAD     ANC     COLI    CHL-A    ORG-N    NH3-N    NO2-N    N03-N    ORG-P    DIS-P
              ORDER
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
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STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:
-----------------------------------------------------------------------------

                                                        NUMBER OF
           VARIABLE              ITERATION            NONCONVERGENT
                                                        ELEMENTS

 ALGAE GROWTH RATE                  1                  72
 ALGAE GROWTH RATE                  2                  72
 ALGAE GROWTH RATE                  3                  68
 ALGAE GROWTH RATE                  4                  58
 ALGAE GROWTH RATE                  5                  37
 ALGAE GROWTH RATE                  6                   0
 ALGAE GROWTH RATE                  7                   0


SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:
-------------------------------------------------------

      1. LIGHT AVERAGING OPTION.   LAVOPT= 2

          METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

          SOURCE OF SOLAR VALUES:   DATA TYPE 1A
              DAILY NET SOLAR RADIATION:  1300.000 BTU/FT-2 (  352.782 LANGLEYS)
              NUMBER OF DAYLIGHT HOURS:  0.0
              PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): N/A
              MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.920


      2. LIGHT FUNCTION OPTION:   LFNOPT= 1

          HALF SATURATION METHOD, WITH HALF SATURATION COEF =  0.030 LANGLEYS/MIN


      3. GROWTH ATTENUATION OPTION FOR NUTRIENTS.   LGROPT= 2

          MINIMUM OF NITROGEN, PHOSPHORUS:   FL*MIN(FN,FP)
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STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 1

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

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC 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	47.35	47.30	0.09	0.00	0.01	0.394	0.008	0.125	1.748	0.06	0.66	0.22	0.23
2	1	2	47.30	47.25	0.10	0.00	0.01	0.407	0.008	0.132	1.793	0.06	0.69	0.24	0.25
3	1	3	47.25	47.20	0.11	0.00	0.01	0.419	0.007	0.139	1.836	0.07	0.71	0.26	0.27
4	1	4	47.20	47.15	0.12	0.00	0.01	0.430	0.007	0.146	1.876	0.07	0.73	0.27	0.28
5	1	5	47.15	47.10	0.13	0.00	0.01	0.440	0.007	0.152	1.915	0.08	0.75	0.29	0.30
6	1	6	47.10	47.05	0.14	0.00	0.01	0.450	0.007	0.159	1.952	0.08	0.77	0.31	0.32
7	1	7	47.05	47.00	0.15	0.00	0.01	0.459	0.007	0.164	1.987	0.09	0.79	0.33	0.33
8	2	1	47.00	46.95	0.16	0.00	0.01	0.454	0.007	0.148	2.387	0.09	0.87	0.35	0.30
9	2	2	46.95	46.90	0.17	0.00	0.01	0.462	0.007	0.152	2.415	0.10	0.89	0.37	0.32
10	2	3	46.90	46.85	0.18	0.00	0.01	0.469	0.007	0.157	2.442	0.10	0.90	0.38	0.33
11	2	4	46.85	46.80	0.19	0.00	0.01	0.476	0.006	0.162	2.469	0.11	0.91	0.40	0.34
12	2	5	46.80	46.75	0.20	0.00	0.01	0.483	0.006	0.166	2.495	0.11	0.93	0.41	0.35

13	2	6	46.75	46.70	0.21	0.00	0.01	0.490	0.006	0.170	2.520	0.11	0.94	0.43	0.37
14	2	7	46.70	46.65	0.22	0.00	0.01	0.497	0.006	0.174	2.545	0.12	0.96	0.44	0.38
15	2	8	46.65	46.60	0.23	0.00	0.01	0.503	0.006	0.178	2.569	0.12	0.97	0.46	0.39
16	2	9	46.60	46.55	0.24	0.00	0.01	0.509	0.006	0.182	2.592	0.12	0.98	0.47	0.40
17	2	10	46.55	46.50	0.25	0.00	0.01	0.514	0.006	0.186	2.617	0.13	0.99	0.49	0.41
18	2	11	46.50	46.45	0.26	0.00	0.01	0.520	0.006	0.190	2.639	0.13	1.00	0.50	0.43
19	2	12	46.45	46.40	0.27	0.00	0.01	0.525	0.006	0.193	2.660	0.14	1.02	0.51	0.44
20	2	13	46.40	46.35	0.28	0.00	0.01	0.531	0.006	0.197	2.681	0.14	1.03	0.53	0.45
21	2	14	46.35	46.30	0.29	0.00	0.01	0.536	0.006	0.200	2.702	0.14	1.04	0.54	0.46
22	2	15	46.30	46.25	0.30	0.00	0.01	0.541	0.006	0.204	2.723	0.15	1.05	0.55	0.47
23	2	16	46.25	46.20	0.31	0.00	0.01	0.546	0.006	0.207	2.743	0.15	1.06	0.57	0.48
24	2	17	46.20	46.15	0.32	0.00	0.01	0.551	0.006	0.210	2.762	0.15	1.07	0.58	0.49
25	2	18	46.15	46.10	0.33	0.00	0.01	0.556	0.006	0.214	2.782	0.16	1.08	0.59	0.50
26	2	19	46.10	46.05	0.34	0.00	0.01	0.560	0.005	0.217	2.801	0.16	1.09	0.61	0.51
27	2	20	46.05	46.00	0.35	0.00	0.01	0.565	0.005	0.220	2.820	0.16	1.10	0.62	0.52
28	3	1	46.00	45.95	0.36	0.00	0.01	0.555	0.006	0.201	3.205	0.17	1.17	0.64	0.48
29	3	2	45.95	45.90	0.36	0.00	0.01	0.559	0.005	0.203	3.218	0.17	1.18	0.65	0.49
30	3	3	45.90	45.85	0.37	0.00	0.01	0.562	0.005	0.205	3.231	0.18	1.19	0.66	0.49
31	3	4	45.85	45.80	0.38	0.00	0.01	0.565	0.005	0.207	3.244	0.18	1.19	0.67	0.50

32	3	5	45.80	45.75	0.39	0.00	0.01	0.568	0.005	0.209	3.257	0.18	1.20	0.68	0.51
33	3	6	45.75	45.70	0.39	0.00	0.01	0.571	0.005	0.211	3.269	0.18	1.21	0.69	0.51
34	3	7	45.70	45.65	0.40	0.00	0.01	0.574	0.005	0.214	3.281	0.18	1.21	0.70	0.52
35	3	8	45.65	45.60	0.41	0.00	0.01	0.577	0.005	0.216	3.294	0.19	1.22	0.71	0.53
36	3	9	45.60	45.55	0.42	0.00	0.01	0.580	0.005	0.218	3.306	0.19	1.23	0.72	0.53
37	3	10	45.55	45.50	0.42	0.00	0.01	0.583	0.005	0.220	3.318	0.19	1.23	0.73	0.54
38	3	11	45.50	45.45	0.43	0.00	0.01	0.586	0.005	0.222	3.330	0.19	1.24	0.74	0.55
39	3	12	45.45	45.40	0.44	0.00	0.01	0.589	0.005	0.224	3.341	0.20	1.25	0.75	0.55
40	3	13	45.40	45.35	0.45	0.00	0.01	0.592	0.005	0.225	3.353	0.20	1.25	0.76	0.56
41	3	14	45.35	45.30	0.45	0.00	0.01	0.595	0.005	0.227	3.364	0.20	1.26	0.77	0.57
42	3	15	45.30	45.25	0.46	0.00	0.01	0.597	0.005	0.229	3.376	0.20	1.26	0.77	0.57

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 2

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

***** 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
43	3	16	45.25	45.20	0.47	0.00	0.01	0.600	0.005	0.231	3.387	0.21	1.27	0.78	0.58
44	3	17	45.20	45.15	0.48	0.00	0.01	0.603	0.005	0.233	3.398	0.21	1.28	0.79	0.59
45	3	18	45.15	45.10	0.48	0.00	0.01	0.605	0.005	0.235	3.410	0.21	1.28	0.80	0.59
46	3	19	45.10	45.05	0.49	0.00	0.01	0.608	0.005	0.237	3.421	0.21	1.29	0.81	0.60
47	3	20	45.05	45.00	0.50	0.00	0.01	0.611	0.005	0.239	3.432	0.22	1.29	0.82	0.61
48	4	1	45.00	44.95	0.51	0.00	0.01	0.588	0.005	0.205	4.228	0.23	1.45	0.87	0.51
49	4	2	44.95	44.90	0.52	0.00	0.01	0.590	0.005	0.206	4.239	0.23	1.45	0.87	0.52
50	4	3	44.90	44.85	0.52	0.00	0.01	0.593	0.005	0.208	4.249	0.23	1.46	0.88	0.53
51	4	4	44.85	44.80	0.53	0.00	0.01	0.596	0.005	0.210	4.260	0.24	1.47	0.89	0.53
52	4	5	44.80	44.75	0.54	0.00	0.01	0.599	0.005	0.212	4.270	0.24	1.47	0.90	0.54
53	4	6	44.75	44.70	0.55	0.00	0.01	0.601	0.005	0.213	4.281	0.24	1.48	0.91	0.54
54	4	7	44.70	44.65	0.56	0.00	0.01	0.604	0.005	0.215	4.291	0.24	1.48	0.92	0.55

55	4	8	44.65	44.60	0.57	0.00	0.01	0.607	0.005	0.217	4.301	0.25	1.49	0.93
0.56														
56	4	9	44.60	44.55	0.57	0.00	0.01	0.609	0.005	0.219	4.311	0.25	1.49	0.94
0.56														
57	4	10	44.55	44.50	0.58	0.00	0.01	0.612	0.005	0.220	4.321	0.25	1.50	0.95
0.57														
58	4	11	44.50	44.45	0.59	0.00	0.01	0.615	0.005	0.222	4.331	0.25	1.50	0.96
0.57														
59	4	12	44.45	44.40	0.60	0.00	0.01	0.617	0.005	0.224	4.341	0.26	1.51	0.97
0.58														
60	4	13	44.40	44.35	0.61	0.00	0.01	0.620	0.005	0.225	4.351	0.26	1.52	0.98
0.59														
61	4	14	44.35	44.30	0.62	0.00	0.01	0.622	0.005	0.227	4.361	0.26	1.52	0.99
0.59														
62	4	15	44.30	44.25	0.62	0.00	0.01	0.625	0.005	0.228	4.371	0.26	1.53	1.00
0.60														
63	4	16	44.25	44.20	0.63	0.00	0.01	0.627	0.005	0.230	4.380	0.27	1.53	1.01
0.60														
64	4	17	44.20	44.15	0.64	0.00	0.01	0.630	0.005	0.232	4.390	0.27	1.54	1.02
0.61														
65	4	18	44.15	44.10	0.65	0.00	0.01	0.632	0.005	0.233	4.400	0.27	1.54	1.03
0.62														
66	4	19	44.10	44.05	0.66	0.00	0.01	0.634	0.005	0.235	4.409	0.27	1.55	1.04
0.62														
67	4	20	44.05	44.00	0.66	0.00	0.01	0.637	0.005	0.236	4.418	0.28	1.55	1.04
0.63														
68	5	1	44.00	43.95	0.69	0.00	0.03	0.644	0.005	0.242	4.450	0.28	1.57	1.08
0.45														
69	5	2	43.95	43.90	0.72	0.00	0.03	0.652	0.005	0.247	4.480	0.29	1.58	1.11
0.46														
70	5	3	43.90	43.85	0.75	0.00	0.03	0.659	0.005	0.252	4.511	0.30	1.60	1.14
0.47														
71	5	4	43.85	43.80	0.78	0.00	0.03	0.666	0.005	0.257	4.540	0.31	1.62	1.17
0.49														
72	5	5	43.80	43.75	0.80	0.00	0.03	0.673	0.005	0.261	4.569	0.32	1.63	1.19
0.50														
73	5	6	43.75	43.70	0.83	0.00	0.03	0.680	0.004	0.266	4.597	0.32	1.65	1.22
0.51														

74	5	7	43.70	43.65	0.86	0.00	0.03	0.686	0.004	0.271	4.625	0.33	1.66	1.25	0.52
75	5	8	43.65	43.60	0.89	0.00	0.03	0.693	0.004	0.275	4.653	0.34	1.68	1.28	0.54
76	5	9	43.60	43.55	0.92	0.00	0.03	0.699	0.004	0.280	4.680	0.35	1.69	1.31	0.55
77	5	10	43.55	43.50	0.94	0.00	0.03	0.705	0.004	0.284	4.706	0.35	1.71	1.34	0.56
78	5	11	43.50	43.45	0.97	0.00	0.03	0.711	0.004	0.289	4.732	0.36	1.72	1.37	0.57
79	5	12	43.45	43.40	1.00	0.00	0.03	0.717	0.004	0.293	4.758	0.37	1.73	1.39	0.58
80	5	13	43.40	43.35	1.03	0.00	0.03	0.722	0.004	0.297	4.783	0.38	1.75	1.42	0.60
81	5	14	43.35	43.30	1.05	0.00	0.03	0.728	0.004	0.301	4.811	0.38	1.76	1.45	0.61
82	6	1	43.30	43.25	1.11	0.00	0.06	0.808	0.004	0.343	4.028	0.36	1.43	1.38	0.75

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 3

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

***** 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
83	6	2	43.25	43.20	1.17	0.00	0.06	0.821	0.004	0.353	4.058	0.38	1.45	1.43	0.78
84	7	1	43.20	43.15	1.21	0.00	0.04	0.758	0.004	0.324	4.947	0.42	1.83	1.60	0.67
85	7	2	43.15	43.10	1.25	0.00	0.04	0.765	0.004	0.330	4.979	0.43	1.85	1.64	0.69
86	7	3	43.10	43.05	1.29	0.00	0.04	0.771	0.004	0.335	5.011	0.44	1.87	1.68	0.70
87	7	4	43.05	43.00	1.33	0.00	0.04	0.778	0.004	0.340	5.043	0.45	1.88	1.72	0.72
88	7	5	43.00	42.95	1.37	0.00	0.04	0.785	0.004	0.345	5.073	0.46	1.90	1.75	0.73
89	7	6	42.95	42.90	1.41	0.00	0.04	0.791	0.004	0.351	5.104	0.47	1.92	1.79	0.75
90	8	1	42.90	42.85	1.44	0.00	0.03	0.873	0.004	0.395	4.186	0.44	1.53	1.66	0.91
91	8	2	42.85	42.80	1.47	0.00	0.03	0.878	0.003	0.400	4.200	0.44	1.54	1.68	0.93
92	8	3	42.80	42.75	1.50	0.00	0.03	0.883	0.003	0.404	4.213	0.45	1.55	1.70	0.94
93	8	4	42.75	42.70	1.53	0.00	0.03	0.888	0.003	0.409	4.226	0.46	1.56	1.73	0.96

94	8	5	42.70	42.65	1.56	0.00	0.03	0.894	0.003	0.413	4.239	0.46	1.56	1.75	0.97
95	8	6	42.65	42.60	1.59	0.00	0.03	0.898	0.003	0.417	4.252	0.47	1.57	1.78	0.98
96	8	7	42.60	42.55	1.62	0.00	0.03	0.903	0.003	0.422	4.265	0.47	1.58	1.80	1.00
97	8	8	42.55	42.50	1.65	0.00	0.03	0.908	0.003	0.426	4.278	0.48	1.59	1.82	1.01
98	9	1	42.50	42.45	1.69	0.00	0.04	0.832	0.004	0.384	5.305	0.54	2.03	2.04	0.85
99	9	2	42.45	42.40	1.73	0.00	0.04	0.837	0.004	0.389	5.332	0.55	2.04	2.07	0.86
100	9	3	42.40	42.35	1.77	0.00	0.04	0.843	0.004	0.393	5.359	0.56	2.05	2.11	0.88
101	9	4	42.35	42.30	1.81	0.00	0.04	0.848	0.004	0.398	5.385	0.57	2.07	2.14	0.89
102	9	5	42.30	42.25	1.85	0.00	0.04	0.853	0.004	0.402	5.412	0.57	2.08	2.17	0.91
103	9	6	42.25	42.20	1.89	0.00	0.04	0.858	0.004	0.406	5.437	0.58	2.10	2.21	0.92
104	10	1	42.20	42.15	1.90	0.00	0.01	0.973	0.003	0.406	4.812	0.52	1.54	1.95	3.82
105	10	2	42.15	42.10	1.91	0.00	0.01	0.975	0.003	0.407	4.814	0.52	1.54	1.96	3.84
106	10	3	42.10	42.05	1.92	0.00	0.01	0.976	0.003	0.408	4.816	0.52	1.54	1.96	3.85
107	10	4	42.05	42.00	1.92	0.00	0.01	0.977	0.003	0.409	4.818	0.52	1.54	1.97	3.86
108	10	5	42.00	41.95	1.93	0.00	0.01	0.978	0.003	0.410	4.820	0.52	1.54	1.98	3.87
109	10	6	41.95	41.90	1.94	0.00	0.01	0.980	0.003	0.411	4.821	0.52	1.54	1.98	3.88
110	10	7	41.90	41.85	1.95	0.00	0.01	0.981	0.003	0.412	4.823	0.52	1.54	1.99	3.90
111	10	8	41.85	41.80	1.95	0.00	0.01	0.982	0.003	0.413	4.825	0.53	1.54	1.99	3.91

112	10	9	41.80	41.75	1.96	0.00	0.01	0.983	0.003	0.413	4.827	0.53	1.54	2.00	3.92
113	10	10	41.75	41.70	1.97	0.00	0.01	0.985	0.003	0.414	4.829	0.53	1.55	2.00	3.93
114	10	11	41.70	41.65	1.98	0.00	0.01	0.986	0.003	0.415	4.831	0.53	1.55	2.01	3.94
115	10	12	41.65	41.60	1.98	0.00	0.01	0.987	0.003	0.416	4.832	0.53	1.55	2.01	3.96
116	10	13	41.60	41.55	1.99	0.00	0.01	0.988	0.003	0.417	4.834	0.53	1.55	2.02	3.97
117	10	14	41.55	41.50	2.00	0.00	0.01	0.989	0.003	0.418	4.836	0.53	1.55	2.02	3.98
118	10	15	41.50	41.45	2.01	0.00	0.01	0.991	0.003	0.419	4.838	0.53	1.55	2.03	3.99
119	10	16	41.45	41.40	2.01	0.00	0.01	0.992	0.003	0.420	4.840	0.54	1.55	2.03	4.00

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 4

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

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

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/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	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	3	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	4	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	5	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	6	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	7	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	3	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	4	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00

2	6	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	7	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	8	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	9	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	10	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	11	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	12	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	13	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	14	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	15	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	16	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	17	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	18	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	19	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	20	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3	1	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	4	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3	5	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	6	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	7	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	8	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	9	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	10	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	11	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	12	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	13	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	14	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	15	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 5

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

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

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/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
3	16	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	17	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	18	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	19	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	20	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	2	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	3	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	5	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	6	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	7	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4	8	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	9	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	10	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	11	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	12	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	13	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	14	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	15	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	16	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	17	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	18	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	19	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	20	8.64	1	10.68	0.15	1.07	0.25	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5	1	8.29	1	10.13	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	2	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	3	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	4	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	5	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5	7	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	8	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	9	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	10	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	11	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	12	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	13	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	14	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	1	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 6

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

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

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/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
6	2	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	1	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	2	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	3	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	4	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	5	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	6	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	2	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	3	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	4	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00

8	5	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	6	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	7	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	8	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	1	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	2	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	3	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	4	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	5	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	6	8.29	1	9.01	0.16	1.13	0.19	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	1	8.29	1	10.13	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	2	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	3	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	4	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	5	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	6	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	7	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	8	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00

10	9	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	10	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	11	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	12	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	13	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	14	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	15	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	16	8.29	1	11.26	0.16	1.13	0.31	0.03	1.13	1.86	0.00	12.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 7

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

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
1	1	73.00	0.00	0.00	0.00	1.74	11.89	1.20	0.40	0.00	7.00	8.60	0.00	0.12	0.12	0.00	0.00	2.83
1	2	73.00	0.00	0.00	0.00	1.56	11.80	1.20	0.39	0.01	7.00	8.60	0.00	0.12	0.12	0.00	0.00	2.70
1	3	73.00	0.00	0.00	0.00	1.45	11.72	1.20	0.39	0.01	7.00	8.60	0.00	0.12	0.12	0.00	0.00	2.60
1	4	73.00	0.00	0.00	0.00	1.38	11.65	1.20	0.39	0.01	7.00	8.60	0.00	0.12	0.12	0.00	0.00	2.52
1	5	73.00	0.00	0.00	0.00	1.34	11.58	1.20	0.38	0.01	7.00	8.60	0.00	0.12	0.12	0.00	0.00	2.45
1	6	73.00	0.00	0.00	0.00	1.32	11.52	1.20	0.38	0.02	7.00	8.60	0.00	0.12	0.12	0.00	0.00	2.40
1	7	73.00	0.00	0.00	0.00	1.32	11.47	1.20	0.38	0.02	7.00	8.60	0.00	0.12	0.12	0.00	0.00	2.35
2	1	73.00	0.00	0.00	0.00	1.29	11.41	1.20	0.38	0.02	7.01	8.60	0.00	0.12	0.12	0.00	0.00	2.29
2	2	73.00	0.00	0.00	0.00	1.29	11.36	1.20	0.37	0.02	7.01	8.60	0.00	0.12	0.12	0.00	0.00	2.24
2	3	73.00	0.00	0.00	0.00	1.30	11.30	1.19	0.37	0.02	7.01	8.59	0.00	0.12	0.12	0.00	0.00	2.19
2	4	73.00	0.00	0.00	0.00	1.32	11.25	1.19	0.37	0.02	7.01	8.59	0.00	0.12	0.12	0.00	0.00	2.15
2	5	73.00	0.00	0.00	0.00	1.35	11.21	1.19	0.37	0.02	7.01	8.59	0.00	0.12	0.12	0.00	0.00	2.11

2	6	73.00	0.00	0.00	0.00	1.38	11.16	1.19	0.37	0.02	7.01	8.59	0.00	0.12	0.12	0.00	0.00	2.08
2	7	73.00	0.00	0.00	0.00	1.41	11.12	1.18	0.36	0.02	7.01	8.58	0.00	0.12	0.12	0.00	0.00	2.05
2	8	73.00	0.00	0.00	0.00	1.45	11.08	1.18	0.36	0.02	7.01	8.58	0.00	0.12	0.12	0.00	0.00	2.03
2	9	73.00	0.00	0.00	0.00	1.49	11.03	1.18	0.36	0.03	7.01	8.58	0.00	0.12	0.12	0.00	0.00	2.01
2	10	73.00	0.00	0.00	0.00	1.53	11.00	1.18	0.36	0.03	7.02	8.58	0.00	0.12	0.12	0.00	0.00	1.98
2	11	73.00	0.00	0.00	0.00	1.58	10.96	1.17	0.36	0.03	7.02	8.57	0.00	0.12	0.12	0.00	0.00	1.97
2	12	73.00	0.00	0.00	0.00	1.62	10.92	1.17	0.36	0.03	7.02	8.57	0.00	0.12	0.12	0.00	0.00	1.95
2	13	73.00	0.00	0.00	0.00	1.66	10.88	1.17	0.35	0.03	7.02	8.57	0.00	0.12	0.12	0.00	0.00	1.93
2	14	73.00	0.00	0.00	0.00	1.71	10.85	1.17	0.35	0.03	7.02	8.57	0.00	0.12	0.12	0.00	0.00	1.92
2	15	73.00	0.00	0.00	0.00	1.76	10.81	1.16	0.35	0.03	7.02	8.56	0.00	0.12	0.12	0.00	0.00	1.90
2	16	73.00	0.00	0.00	0.00	1.80	10.78	1.16	0.35	0.03	7.02	8.56	0.00	0.12	0.12	0.00	0.00	1.89
2	17	73.00	0.00	0.00	0.00	1.85	10.74	1.16	0.35	0.03	7.02	8.56	0.00	0.12	0.12	0.00	0.00	1.88
2	18	73.00	0.00	0.00	0.00	1.89	10.71	1.16	0.35	0.03	7.02	8.56	0.00	0.12	0.12	0.00	0.00	1.86
2	19	73.00	0.00	0.00	0.00	1.94	10.68	1.15	0.35	0.03	7.02	8.55	0.00	0.12	0.12	0.00	0.00	1.85
2	20	73.00	0.00	0.00	0.00	1.98	10.65	1.15	0.35	0.03	7.03	8.55	0.00	0.12	0.12	0.00	0.00	1.84
3	1	73.00	0.00	0.00	0.00	2.01	10.56	1.15	0.34	0.03	7.03	8.55	0.00	0.12	0.12	0.00	0.00	1.82
3	2	73.00	0.00	0.00	0.00	2.05	10.48	1.14	0.34	0.03	7.03	8.54	0.00	0.12	0.12	0.00	0.00	1.80
3	3	73.00	0.00	0.00	0.00	2.09	10.41	1.14	0.34	0.03	7.03	8.54	0.00	0.12	0.12	0.00	0.00	1.78
3	4	73.00	0.00	0.00	0.00	2.12	10.33	1.14	0.34	0.03	7.03	8.54	0.00	0.12	0.12	0.00	0.00	1.76

3	5	73.00	0.00	0.00	0.00	2.16	10.26	1.13	0.34	0.03	7.03	8.53	0.00	0.12	0.12	0.00	0.00
1.74																	
3	6	73.00	0.00	0.00	0.00	2.19	10.19	1.13	0.34	0.03	7.03	8.53	0.00	0.12	0.12	0.00	0.00
1.72																	
3	7	73.00	0.00	0.00	0.00	2.23	10.12	1.13	0.33	0.03	7.03	8.53	0.00	0.12	0.12	0.00	0.00
1.70																	
3	8	73.00	0.00	0.00	0.00	2.26	10.05	1.12	0.33	0.03	7.04	8.52	0.00	0.12	0.12	0.00	0.00
1.69																	
3	9	73.00	0.00	0.00	0.00	2.30	9.99	1.12	0.33	0.03	7.04	8.52	0.00	0.12	0.12	0.00	0.00
1.67																	
3	10	73.00	0.00	0.00	0.00	2.33	9.92	1.12	0.33	0.03	7.04	8.52	0.00	0.12	0.12	0.00	0.00
1.66																	
3	11	73.00	0.00	0.00	0.00	2.36	9.86	1.11	0.33	0.03	7.04	8.52	0.00	0.12	0.12	0.00	0.00
1.65																	
3	12	73.00	0.00	0.00	0.00	2.40	9.80	1.11	0.33	0.03	7.04	8.51	0.00	0.12	0.12	0.00	0.00
1.63																	
3	13	73.00	0.00	0.00	0.00	2.43	9.75	1.11	0.33	0.03	7.04	8.51	0.00	0.12	0.12	0.00	0.00
1.62																	
3	14	73.00	0.00	0.00	0.00	2.46	9.69	1.10	0.33	0.03	7.04	8.51	0.00	0.12	0.12	0.00	0.00
1.61																	
3	15	73.00	0.00	0.00	0.00	2.50	9.64	1.10	0.32	0.03	7.04	8.50	0.00	0.12	0.12	0.00	0.00
1.60																	

STREAM QUALITY SIMULATION — OUTPUT PAGE NUMBER 8

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

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
3	16	73.00	0.00	0.00	0.00	2.53	9.58	1.10	0.32	0.03	7.05	8.50	0.00	0.12	0.12	0.00	0.00	1.59
3	17	73.00	0.00	0.00	0.00	2.56	9.53	1.10	0.32	0.03	7.05	8.50	0.00	0.12	0.12	0.00	0.00	1.58
3	18	73.00	0.00	0.00	0.00	2.59	9.48	1.09	0.32	0.03	7.05	8.49	0.00	0.12	0.12	0.00	0.00	1.57
3	19	73.00	0.00	0.00	0.00	2.62	9.43	1.09	0.32	0.03	7.05	8.49	0.00	0.12	0.12	0.00	0.00	1.56
3	20	73.00	0.00	0.00	0.00	2.65	9.38	1.09	0.32	0.03	7.05	8.49	0.00	0.12	0.12	0.00	0.00	1.55
4	1	73.00	0.00	0.00	0.00	2.66	9.17	1.06	0.31	0.03	6.94	8.35	0.00	0.12	0.12	0.00	0.00	1.52
4	2	73.00	0.00	0.00	0.00	2.68	8.97	1.04	0.30	0.03	6.83	8.21	0.00	0.12	0.12	0.00	0.00	1.49
4	3	73.00	0.00	0.00	0.00	2.69	8.78	1.02	0.30	0.03	6.72	8.07	0.00	0.11	0.11	0.00	0.00	1.46
4	4	73.00	0.00	0.00	0.00	2.71	8.59	1.00	0.29	0.03	6.62	7.94	0.00	0.11	0.11	0.00	0.00	1.44
4	5	73.00	0.00	0.00	0.00	2.73	8.40	0.98	0.28	0.03	6.52	7.81	0.00	0.11	0.11	0.00	0.00	1.41
4	6	73.00	0.00	0.00	0.00	2.75	8.23	0.96	0.28	0.03	6.43	7.69	0.00	0.11	0.11	0.00	0.00	1.39
4	7	73.00	0.00	0.00	0.00	2.77	8.06	0.94	0.27	0.03	6.33	7.57	0.00	0.11	0.11	0.00	0.00	1.37

4	8	73.00	0.00	0.00	0.00	2.79	7.89	0.92	0.26	0.03	6.24	7.46	0.00	0.11	0.11	0.00	0.00	1.35
4	9	73.00	0.00	0.00	0.00	2.82	7.73	0.90	0.26	0.03	6.15	7.35	0.00	0.10	0.10	0.00	0.00	1.33
4	10	73.00	0.00	0.00	0.00	2.84	7.58	0.88	0.25	0.03	6.07	7.24	0.00	0.10	0.10	0.00	0.00	1.31
4	11	73.00	0.00	0.00	0.00	2.86	7.43	0.87	0.25	0.03	5.99	7.13	0.00	0.10	0.10	0.00	0.00	1.29
4	12	73.00	0.00	0.00	0.00	2.88	7.28	0.85	0.24	0.03	5.90	7.03	0.00	0.10	0.10	0.00	0.00	1.27
4	13	73.00	0.00	0.00	0.00	2.91	7.14	0.83	0.24	0.03	5.83	6.93	0.00	0.10	0.10	0.00	0.00	1.26
4	14	73.00	0.00	0.00	0.00	2.93	7.00	0.82	0.23	0.03	5.75	6.83	0.00	0.10	0.10	0.00	0.00	1.24
4	15	73.00	0.00	0.00	0.00	2.96	6.87	0.80	0.23	0.03	5.68	6.74	0.00	0.10	0.10	0.00	0.00	1.23
4	16	73.00	0.00	0.00	0.00	2.98	6.74	0.79	0.22	0.03	5.60	6.65	0.00	0.09	0.09	0.00	0.00	1.21
4	17	73.00	0.00	0.00	0.00	3.00	6.61	0.78	0.22	0.03	5.53	6.56	0.00	0.09	0.09	0.00	0.00	1.20
4	18	73.00	0.00	0.00	0.00	3.03	6.49	0.76	0.21	0.03	5.46	6.47	0.00	0.09	0.09	0.00	0.00	1.18
4	19	73.00	0.00	0.00	0.00	3.05	6.37	0.75	0.21	0.03	5.40	6.38	0.00	0.09	0.09	0.00	0.00	1.17
4	20	73.00	0.00	0.00	0.00	3.08	6.26	0.73	0.21	0.03	5.33	6.30	0.00	0.09	0.09	0.00	0.00	1.16
5	1	77.00	0.00	0.00	0.00	3.09	5.97	0.70	0.20	0.03	5.12	6.04	0.00	0.09	0.09	0.00	0.00	1.17
5	2	77.00	0.00	0.00	0.00	3.09	5.70	0.67	0.19	0.03	4.92	5.81	0.00	0.08	0.08	0.00	0.00	1.18
5	3	77.00	0.00	0.00	0.00	3.09	5.46	0.64	0.18	0.03	4.74	5.59	0.00	0.08	0.08	0.00	0.00	1.19
5	4	77.00	0.00	0.00	0.00	3.09	5.23	0.62	0.17	0.02	4.57	5.38	0.00	0.08	0.08	0.00	0.00	1.19
5	5	77.00	0.00	0.00	0.00	3.10	5.02	0.59	0.16	0.02	4.41	5.19	0.00	0.07	0.07	0.00	0.00	1.20
5	6	77.00	0.00	0.00	0.00	3.11	4.83	0.57	0.16	0.02	4.27	5.02	0.00	0.07	0.07	0.00	0.00	1.21

5	7	77.00	0.00	0.00	0.00	3.12	4.64	0.55	0.15	0.02	4.13	4.85	0.00	0.07	0.07	0.00	0.00
1.21																	
5	8	77.00	0.00	0.00	0.00	3.13	4.47	0.53	0.14	0.02	4.00	4.70	0.00	0.07	0.07	0.00	0.00
1.22																	
5	9	77.00	0.00	0.00	0.00	3.15	4.31	0.51	0.14	0.02	3.88	4.55	0.00	0.07	0.07	0.00	0.00
1.22																	
5	10	77.00	0.00	0.00	0.00	3.17	4.16	0.49	0.13	0.02	3.77	4.41	0.00	0.06	0.06	0.00	0.00
1.23																	
5	11	77.00	0.00	0.00	0.00	3.19	4.02	0.48	0.13	0.02	3.66	4.29	0.00	0.06	0.06	0.00	0.00
1.23																	
5	12	77.00	0.00	0.00	0.00	3.21	3.89	0.46	0.12	0.02	3.56	4.16	0.00	0.06	0.06	0.00	0.00
1.23																	
5	13	77.00	0.00	0.00	0.00	3.23	3.76	0.45	0.12	0.02	3.46	4.05	0.00	0.06	0.06	0.00	0.00
1.24																	
5	14	77.00	0.00	0.00	0.00	3.25	3.64	0.43	0.12	0.02	3.37	3.94	0.00	0.06	0.06	0.00	0.00
1.24																	
6	1	77.00	0.00	0.00	0.00	3.26	3.43	0.41	0.11	0.02	3.19	3.73	0.00	0.05	0.05	0.00	0.00
1.26																	

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 9

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

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
6	2	77.00	0.00	0.00	0.00	3.26	3.24	0.38	0.10	0.02	3.03	3.53	0.00	0.05	0.05	0.00	0.00	1.29
7	1	77.00	0.00	0.00	0.00	3.27	3.12	0.37	0.10	0.02	2.93	3.42	0.00	0.05	0.05	0.00	0.00	1.30
7	2	77.00	0.00	0.00	0.00	3.29	3.00	0.36	0.10	0.01	2.84	3.31	0.00	0.05	0.05	0.00	0.00	1.30
7	3	77.00	0.00	0.00	0.00	3.31	2.90	0.34	0.09	0.01	2.75	3.20	0.00	0.05	0.05	0.00	0.00	1.31
7	4	77.00	0.00	0.00	0.00	3.33	2.80	0.33	0.09	0.01	2.67	3.11	0.00	0.04	0.04	0.00	0.00	1.31
7	5	77.00	0.00	0.00	0.00	3.35	2.70	0.32	0.09	0.01	2.59	3.01	0.00	0.04	0.04	0.00	0.00	1.32
7	6	77.00	0.00	0.00	0.00	3.37	2.61	0.31	0.08	0.01	2.52	2.93	0.00	0.04	0.04	0.00	0.00	1.32
8	1	77.00	0.00	0.00	0.00	3.42	2.79	0.33	0.09	0.01	2.47	2.90	0.00	0.04	0.04	0.00	0.00	1.40
8	2	77.00	0.00	0.00	0.00	3.46	2.97	0.34	0.10	0.01	2.42	2.87	0.00	0.04	0.04	0.00	0.00	1.48
8	3	77.00	0.00	0.00	0.00	3.49	3.13	0.36	0.11	0.01	2.37	2.85	0.00	0.04	0.04	0.00	0.00	1.56
8	4	77.00	0.00	0.00	0.00	3.53	3.29	0.38	0.11	0.01	2.33	2.83	0.00	0.04	0.04	0.00	0.00	1.63

8	5	77.00	0.00	0.00	0.00	3.56	3.44	0.39	0.12	0.01	2.28	2.80	0.00	0.04	0.04	0.00	0.00	1.70
8	6	77.00	0.00	0.00	0.00	3.59	3.59	0.40	0.13	0.01	2.24	2.78	0.00	0.04	0.04	0.00	0.00	1.77
8	7	77.00	0.00	0.00	0.00	3.63	3.73	0.42	0.13	0.01	2.20	2.76	0.00	0.04	0.04	0.00	0.00	1.83
8	8	77.00	0.00	0.00	0.00	3.66	3.86	0.43	0.14	0.01	2.16	2.74	0.00	0.04	0.04	0.00	0.00	1.89
9	1	77.00	0.00	0.00	0.00	3.66	4.04	0.45	0.15	0.01	2.11	2.71	0.00	0.04	0.04	0.00	0.00	1.97
9	2	77.00	0.00	0.00	0.00	3.68	4.20	0.46	0.15	0.01	2.06	2.69	0.00	0.04	0.04	0.00	0.00	2.04
9	3	77.00	0.00	0.00	0.00	3.70	4.36	0.48	0.16	0.01	2.01	2.66	0.00	0.04	0.04	0.00	0.00	2.11
9	4	77.00	0.00	0.00	0.00	3.71	4.50	0.49	0.17	0.01	1.97	2.64	0.00	0.04	0.04	0.00	0.00	2.17
9	5	77.00	0.00	0.00	0.00	3.73	4.64	0.50	0.17	0.01	1.93	2.62	0.00	0.04	0.05	0.00	0.00	2.24
9	6	77.00	0.00	0.00	0.00	3.74	4.78	0.52	0.18	0.01	1.89	2.60	0.00	0.05	0.05	0.00	0.00	2.29
10	1	77.00	0.00	0.00	0.00	3.78	4.78	0.52	0.18	0.01	1.88	2.59	0.00	0.05	0.05	0.00	0.00	2.29
10	2	77.00	0.00	0.00	0.00	3.82	4.79	0.52	0.18	0.01	1.87	2.58	0.00	0.05	0.05	0.00	0.00	2.29
10	3	77.00	0.00	0.00	0.00	3.87	4.80	0.52	0.18	0.02	1.87	2.58	0.00	0.05	0.05	0.00	0.00	2.28
10	4	77.00	0.00	0.00	0.00	3.90	4.81	0.52	0.18	0.02	1.86	2.57	0.00	0.05	0.05	0.00	0.00	2.28
10	5	77.00	0.00	0.00	0.00	3.94	4.82	0.52	0.18	0.02	1.85	2.57	0.00	0.05	0.05	0.00	0.00	2.27
10	6	77.00	0.00	0.00	0.00	3.98	4.83	0.52	0.18	0.02	1.85	2.56	0.00	0.05	0.05	0.00	0.00	2.27
10	7	77.00	0.00	0.00	0.00	4.02	4.84	0.52	0.18	0.02	1.84	2.56	0.00	0.05	0.05	0.00	0.00	2.27
10	8	77.00	0.00	0.00	0.00	4.05	4.84	0.52	0.18	0.02	1.84	2.55	0.00	0.05	0.05	0.00	0.00	2.26

10	9	77.00	0.00	0.00	0.00	4.08	4.85	0.52	0.18	0.02	1.83	2.55	0.00	0.05	0.05	0.00	0.00
2.26																	
10	10	77.00	0.00	0.00	0.00	4.12	4.86	0.52	0.18	0.02	1.82	2.54	0.00	0.05	0.05	0.00	0.00
2.26																	
10	11	77.00	0.00	0.00	0.00	4.15	4.87	0.52	0.18	0.02	1.82	2.54	0.00	0.05	0.05	0.00	0.00
2.26																	
10	12	77.00	0.00	0.00	0.00	4.18	4.88	0.53	0.18	0.02	1.81	2.53	0.00	0.05	0.05	0.00	0.00
2.25																	
10	13	77.00	0.00	0.00	0.00	4.21	4.88	0.53	0.18	0.02	1.80	2.53	0.00	0.05	0.05	0.00	0.00
2.25																	
10	14	77.00	0.00	0.00	0.00	4.24	4.89	0.53	0.18	0.02	1.80	2.52	0.00	0.05	0.05	0.00	0.00
2.25																	
10	15	77.00	0.00	0.00	0.00	4.26	4.90	0.53	0.18	0.02	1.79	2.52	0.00	0.05	0.05	0.00	0.00
2.24																	
10	16	77.00	0.00	0.00	0.00	4.29	4.90	0.53	0.18	0.02	1.79	2.51	0.00	0.05	0.05	0.00	0.00
2.24																	

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 10

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

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

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
1	1	1	2.83	1.07	0.57	1.07	1.50	0.16	0.90	0.34	0.01	0.50	0.97	0.75
2	1	2	2.70	1.07	0.57	1.07	1.50	0.15	0.90	0.33	0.01	0.50	0.97	0.75
3	1	3	2.60	1.07	0.57	1.07	1.50	0.15	0.90	0.33	0.01	0.50	0.97	0.75
4	1	4	2.52	1.07	0.57	1.07	1.50	0.14	0.90	0.33	0.01	0.50	0.97	0.75
5	1	5	2.45	1.07	0.57	1.07	1.50	0.14	0.90	0.33	0.01	0.50	0.97	0.75
6	1	6	2.40	1.07	0.57	1.07	1.50	0.14	0.90	0.33	0.01	0.50	0.97	0.75
7	1	7	2.35	1.07	0.57	1.07	1.50	0.13	0.90	0.33	0.01	0.50	0.97	0.75
8	2	1	2.29	1.07	0.57	1.07	1.50	0.13	0.90	0.33	0.01	0.50	0.97	0.75
9	2	2	2.24	1.07	0.57	1.07	1.50	0.13	0.90	0.32	0.01	0.50	0.97	0.75
10	2	3	2.19	1.07	0.57	1.07	1.50	0.13	0.90	0.32	0.01	0.50	0.97	0.75
11	2	4	2.15	1.07	0.57	1.07	1.50	0.12	0.90	0.32	0.01	0.50	0.97	0.75
12	2	5	2.11	1.07	0.57	1.07	1.50	0.12	0.90	0.32	0.01	0.50	0.97	0.75
13	2	6	2.08	1.07	0.57	1.07	1.50	0.12	0.90	0.32	0.01	0.50	0.97	0.75
14	2	7	2.05	1.07	0.57	1.07	1.50	0.12	0.90	0.32	0.01	0.50	0.97	0.75
15	2	8	2.03	1.07	0.57	1.07	1.50	0.12	0.90	0.32	0.01	0.50	0.97	0.75
16	2	9	2.01	1.07	0.57	1.07	1.50	0.11	0.90	0.32	0.01	0.50	0.97	0.75
17	2	10	1.98	1.07	0.57	1.07	1.50	0.11	0.90	0.32	0.01	0.50	0.97	0.75
18	2	11	1.97	1.07	0.57	1.07	1.50	0.11	0.90	0.31	0.01	0.50	0.97	0.75
19	2	12	1.95	1.07	0.57	1.07	1.50	0.11	0.90	0.31	0.01	0.50	0.97	0.75
20	2	13	1.93	1.07	0.57	1.07	1.50	0.11	0.90	0.31	0.01	0.50	0.97	0.75
21	2	14	1.92	1.07	0.57	1.07	1.50	0.11	0.90	0.31	0.01	0.50	0.97	0.75
22	2	15	1.90	1.07	0.57	1.07	1.50	0.11	0.90	0.31	0.01	0.50	0.97	0.75
23	2	16	1.89	1.07	0.57	1.07	1.50	0.11	0.90	0.31	0.01	0.50	0.97	0.75
24	2	17	1.88	1.07	0.57	1.07	1.50	0.11	0.90	0.31	0.01	0.50	0.97	0.75
25	2	18	1.86	1.07	0.57	1.07	1.50	0.11	0.90	0.31	0.01	0.50	0.97	0.75

26	2	19	1.85	1.07	0.57	1.07	1.50	0.11	0.90	0.31	0.01	0.50	0.97	0.75
27	2	20	1.84	1.07	0.57	1.07	1.50	0.11	0.90	0.31	0.01	0.50	0.97	0.75
28	3	1	1.82	1.07	0.57	1.07	1.50	0.10	0.90	0.31	0.01	0.50	0.97	0.75
29	3	2	1.80	1.07	0.57	1.07	1.50	0.10	0.90	0.30	0.01	0.50	0.97	0.75
30	3	3	1.78	1.07	0.57	1.07	1.50	0.10	0.90	0.30	0.01	0.50	0.97	0.75
31	3	4	1.76	1.07	0.57	1.07	1.50	0.10	0.90	0.30	0.01	0.50	0.97	0.75
32	3	5	1.74	1.07	0.57	1.07	1.50	0.10	0.90	0.30	0.01	0.50	0.97	0.75
33	3	6	1.72	1.07	0.57	1.07	1.50	0.10	0.90	0.30	0.01	0.50	0.97	0.75
34	3	7	1.70	1.07	0.57	1.07	1.50	0.10	0.90	0.30	0.01	0.50	0.97	0.75
35	3	8	1.69	1.07	0.57	1.07	1.50	0.10	0.90	0.30	0.01	0.50	0.97	0.75
36	3	9	1.67	1.07	0.57	1.07	1.50	0.10	0.90	0.30	0.01	0.50	0.97	0.75
37	3	10	1.66	1.07	0.57	1.07	1.50	0.09	0.90	0.30	0.01	0.50	0.97	0.75
38	3	11	1.65	1.07	0.57	1.07	1.50	0.09	0.90	0.30	0.01	0.50	0.97	0.75
39	3	12	1.63	1.07	0.57	1.07	1.50	0.09	0.90	0.30	0.01	0.50	0.97	0.75
40	3	13	1.62	1.07	0.57	1.07	1.50	0.09	0.90	0.29	0.01	0.50	0.97	0.75
41	3	14	1.61	1.07	0.57	1.07	1.50	0.09	0.90	0.29	0.01	0.50	0.97	0.75
42	3	15	1.60	1.07	0.57	1.07	1.50	0.09	0.90	0.29	0.01	0.50	0.97	0.75

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 11

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

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

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
43	3	16	1.59	1.07	0.57	1.07	1.50	0.09	0.90	0.29	0.01	0.50	0.97	0.75
44	3	17	1.58	1.07	0.57	1.07	1.50	0.09	0.90	0.29	0.01	0.50	0.97	0.75
45	3	18	1.57	1.07	0.57	1.07	1.50	0.09	0.90	0.29	0.01	0.50	0.97	0.75
46	3	19	1.56	1.07	0.57	1.07	1.50	0.09	0.90	0.29	0.01	0.50	0.97	0.75
47	3	20	1.55	1.07	0.57	1.07	1.50	0.09	0.90	0.29	0.01	0.50	0.97	0.75
48	4	1	1.52	1.06	0.57	1.07	1.50	0.09	0.90	0.29	0.01	0.50	0.97	0.75
49	4	2	1.49	1.06	0.57	1.07	1.49	0.08	0.90	0.29	0.01	0.50	0.97	0.74
50	4	3	1.46	1.05	0.57	1.07	1.48	0.08	0.90	0.28	0.01	0.50	0.97	0.74
51	4	4	1.44	1.05	0.57	1.07	1.48	0.08	0.90	0.28	0.01	0.50	0.97	0.74
52	4	5	1.41	1.04	0.57	1.07	1.47	0.08	0.90	0.28	0.01	0.50	0.97	0.73
53	4	6	1.39	1.04	0.57	1.07	1.47	0.07	0.90	0.28	0.01	0.50	0.97	0.73
54	4	7	1.37	1.04	0.57	1.07	1.46	0.07	0.90	0.28	0.01	0.50	0.97	0.73
55	4	8	1.35	1.03	0.57	1.07	1.45	0.07	0.90	0.28	0.01	0.50	0.97	0.73
56	4	9	1.33	1.03	0.57	1.07	1.45	0.07	0.90	0.27	0.01	0.50	0.97	0.72
57	4	10	1.31	1.02	0.57	1.07	1.44	0.07	0.90	0.27	0.01	0.50	0.97	0.72
58	4	11	1.29	1.02	0.57	1.07	1.44	0.06	0.90	0.27	0.01	0.50	0.97	0.72
59	4	12	1.27	1.02	0.57	1.07	1.43	0.06	0.90	0.27	0.01	0.50	0.97	0.71
60	4	13	1.26	1.01	0.57	1.07	1.42	0.06	0.90	0.27	0.01	0.50	0.97	0.71
61	4	14	1.24	1.01	0.57	1.07	1.42	0.06	0.90	0.27	0.01	0.50	0.97	0.71
62	4	15	1.23	1.00	0.57	1.07	1.41	0.06	0.90	0.27	0.01	0.50	0.97	0.71
63	4	16	1.21	1.00	0.57	1.07	1.41	0.06	0.90	0.26	0.01	0.50	0.97	0.70
64	4	17	1.20	1.00	0.57	1.07	1.40	0.05	0.90	0.26	0.01	0.50	0.97	0.70
65	4	18	1.18	0.99	0.57	1.07	1.40	0.05	0.90	0.26	0.01	0.50	0.97	0.70
66	4	19	1.17	0.99	0.57	1.07	1.39	0.05	0.90	0.26	0.01	0.50	0.97	0.69
67	4	20	1.16	0.98	0.57	1.07	1.39	0.05	0.90	0.26	0.01	0.50	0.97	0.69

68	5	1	1.17	1.08	0.63	1.13	1.37	0.05	0.90	0.26	0.01	0.50	0.96	0.68
69	5	2	1.18	1.06	0.63	1.13	1.35	0.05	0.90	0.25	0.01	0.50	0.96	0.67
70	5	3	1.19	1.05	0.63	1.13	1.33	0.05	0.90	0.25	0.01	0.50	0.96	0.67
71	5	4	1.19	1.04	0.63	1.13	1.32	0.05	0.90	0.25	0.01	0.50	0.96	0.66
72	5	5	1.20	1.02	0.63	1.13	1.30	0.05	0.90	0.25	0.01	0.50	0.96	0.65
73	5	6	1.21	1.01	0.63	1.13	1.29	0.04	0.90	0.25	0.01	0.50	0.96	0.64
74	5	7	1.21	1.00	0.63	1.13	1.27	0.04	0.90	0.25	0.01	0.50	0.96	0.63
75	5	8	1.22	0.99	0.63	1.13	1.26	0.04	0.90	0.25	0.01	0.50	0.95	0.63
76	5	9	1.22	0.98	0.63	1.13	1.24	0.04	0.90	0.24	0.01	0.50	0.95	0.62
77	5	10	1.23	0.97	0.63	1.13	1.23	0.04	0.90	0.24	0.01	0.50	0.95	0.61
78	5	11	1.23	0.95	0.63	1.13	1.21	0.03	0.90	0.24	0.01	0.50	0.95	0.61
79	5	12	1.23	0.94	0.63	1.13	1.20	0.03	0.90	0.24	0.01	0.50	0.95	0.60
80	5	13	1.24	0.93	0.63	1.13	1.19	0.03	0.90	0.24	0.01	0.50	0.95	0.59
81	5	14	1.24	0.92	0.63	1.13	1.17	0.03	0.90	0.24	0.01	0.50	0.95	0.59
82	6	1	1.26	0.90	0.63	1.13	1.15	0.02	0.90	0.24	0.01	0.50	0.94	0.57

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 12
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995
***** STEADY STATE SIMULATION *****

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
83	6	2	1.29	0.88	0.63	1.13	1.12	0.02	0.90	0.23	0.01	0.50	0.94	0.56
84	7	1	1.30	0.87	0.63	1.13	1.10	0.02	0.90	0.23	0.01	0.50	0.94	0.55
85	7	2	1.30	0.86	0.63	1.13	1.09	0.01	0.90	0.23	0.01	0.50	0.94	0.54
86	7	3	1.31	0.84	0.63	1.13	1.07	0.01	0.90	0.23	0.01	0.50	0.93	0.53
87	7	4	1.31	0.83	0.63	1.13	1.06	0.01	0.90	0.23	0.01	0.50	0.93	0.53
88	7	5	1.32	0.82	0.63	1.13	1.04	0.01	0.90	0.23	0.01	0.50	0.93	0.52
89	7	6	1.32	0.81	0.63	1.13	1.03	0.00	0.90	0.23	0.01	0.50	0.93	0.51
90	8	1	1.40	0.80	0.63	1.13	1.02	0.00	0.90	0.25	0.01	0.50	0.93	0.51
91	8	2	1.48	0.79	0.63	1.13	1.01	0.00	0.90	0.27	0.01	0.50	0.93	0.50
92	8	3	1.56	0.78	0.63	1.13	1.00	0.00	0.90	0.29	0.01	0.50	0.93	0.50
93	8	4	1.63	0.78	0.63	1.13	0.99	0.00	0.90	0.30	0.01	0.50	0.92	0.49
94	8	5	1.70	0.77	0.63	1.13	0.98	-0.01	0.90	0.32	0.01	0.50	0.92	0.49
95	8	6	1.77	0.76	0.63	1.13	0.97	-0.01	0.90	0.34	0.01	0.50	0.92	0.48
96	8	7	1.83	0.75	0.63	1.13	0.96	-0.01	0.90	0.35	0.01	0.50	0.92	0.48
97	8	8	1.89	0.75	0.63	1.13	0.95	-0.01	0.90	0.36	0.01	0.50	0.92	0.47
98	9	1	1.97	0.77	0.63	1.13	0.98	-0.01	0.90	0.38	0.01	0.50	0.92	0.49
99	9	2	2.04	0.79	0.63	1.13	1.00	0.00	0.90	0.40	0.01	0.50	0.92	0.50
100	9	3	2.11	0.80	0.63	1.13	1.02	0.01	0.90	0.42	0.01	0.50	0.92	0.51
101	9	4	2.17	0.82	0.63	1.13	1.04	0.01	0.90	0.43	0.01	0.50	0.91	0.52
102	9	5	2.24	0.83	0.63	1.13	1.06	0.02	0.90	0.44	0.01	0.50	0.91	0.53
103	9	6	2.29	0.85	0.63	1.13	1.08	0.02	0.90	0.46	0.01	0.50	0.91	0.54

104	10	1	2.29	0.85	0.63	1.13	1.08	0.02	0.90	0.46	0.01	0.50	0.91	0.54
105	10	2	2.29	0.85	0.63	1.13	1.08	0.02	0.90	0.46	0.01	0.50	0.91	0.54
106	10	3	2.28	0.85	0.63	1.13	1.09	0.02	0.90	0.46	0.01	0.50	0.91	0.54
107	10	4	2.28	0.86	0.63	1.13	1.09	0.03	0.90	0.46	0.01	0.50	0.91	0.54
108	10	5	2.27	0.86	0.63	1.13	1.09	0.03	0.90	0.46	0.01	0.50	0.91	0.54
109	10	6	2.27	0.86	0.63	1.13	1.09	0.03	0.90	0.47	0.01	0.50	0.91	0.55
110	10	7	2.27	0.86	0.63	1.13	1.10	0.03	0.90	0.47	0.01	0.50	0.91	0.55
111	10	8	2.26	0.87	0.63	1.13	1.10	0.03	0.90	0.47	0.01	0.50	0.91	0.55
112	10	9	2.26	0.87	0.63	1.13	1.10	0.03	0.90	0.47	0.01	0.50	0.91	0.55
113	10	10	2.26	0.87	0.63	1.13	1.11	0.03	0.90	0.47	0.01	0.50	0.91	0.55
114	10	11	2.26	0.87	0.63	1.13	1.11	0.03	0.90	0.47	0.01	0.50	0.91	0.55
115	10	12	2.25	0.87	0.63	1.13	1.11	0.03	0.90	0.47	0.01	0.50	0.91	0.55
116	10	13	2.25	0.88	0.63	1.13	1.11	0.03	0.90	0.47	0.01	0.50	0.91	0.56
117	10	14	2.25	0.88	0.63	1.13	1.12	0.03	0.90	0.47	0.01	0.50	0.91	0.56
118	10	15	2.24	0.88	0.63	1.13	1.12	0.03	0.90	0.48	0.01	0.50	0.91	0.56
119	10	16	2.24	0.88	0.63	1.13	1.12	0.03	0.90	0.48	0.01	0.50	0.91	0.56

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 13
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-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	73.00	8.64	1.74	6.91	0.00	1.00	257.79	73.78	-1.76	-70.02	0.16	-2.12	-0.05
2	1	2	73.00	8.64	1.56	7.08	0.00	1.00	29.60	75.64	-1.74	-65.99	0.15	-2.10	-0.10
3	1	3	73.00	8.64	1.45	7.20	0.00	1.00	27.42	76.85	-1.73	-62.60	0.15	-2.08	-0.13
4	1	4	73.00	8.64	1.38	7.27	0.00	1.00	25.59	77.61	-1.72	-59.70	0.14	-2.06	-0.16
5	1	5	73.00	8.64	1.34	7.31	0.00	1.00	24.02	78.05	-1.71	-57.19	0.14	-2.05	-0.19
6	1	6	73.00	8.64	1.32	7.33	0.00	1.00	22.66	78.25	-1.70	-54.99	0.14	-2.04	-0.21
7	1	7	73.00	8.64	1.32	7.33	0.00	1.00	21.47	78.27	-1.69	-53.03	0.13	-2.02	-0.22
8	2	1	73.00	8.64	1.29	7.35	0.00	1.00	18.56	78.51	-1.69	-59.01	0.13	-2.01	-0.24
9	2	2	73.00	8.64	1.29	7.35	0.00	1.00	17.77	78.51	-1.68	-57.19	0.13	-2.00	-0.26
10	2	3	73.00	8.64	1.30	7.34	0.00	1.00	17.06	78.40	-1.67	-55.52	0.13	-1.99	-0.27
11	2	4	73.00	8.64	1.32	7.32	0.00	1.00	16.41	78.21	-1.66	-53.99	0.12	-1.98	-0.28
12	2	5	73.00	8.64	1.35	7.30	0.00	1.00	15.82	77.94	-1.66	-52.59	0.12	-1.97	-0.30
13	2	6	73.00	8.64	1.38	7.27	0.00	1.00	15.28	77.61	-1.65	-51.29	0.12	-1.96	-0.31
14	2	7	73.00	8.64	1.41	7.23	0.00	1.00	14.77	77.25	-1.64	-50.09	0.12	-1.95	-0.31
15	2	8	73.00	8.64	1.45	7.19	0.00	1.00	14.31	76.84	-1.64	-48.96	0.12	-1.94	-0.32
16	2	9	73.00	8.64	1.49	7.15	0.00	1.00	13.88	76.42	-1.63	-47.92	0.11	-1.93	-0.33
17	2	10	73.00	8.64	1.53	7.11	0.00	1.00	13.46	75.97	-1.62	-46.94	0.11	-1.92	-0.34
18	2	11	73.00	8.64	1.58	7.07	0.00	1.00	13.09	75.51	-1.62	-46.02	0.11	-1.91	-0.34
19	2	12	73.00	8.64	1.62	7.02	0.00	1.00	12.74	75.03	-1.61	-45.15	0.11	-1.91	-0.35
20	2	13	73.00	8.64	1.66	6.98	0.00	1.00	12.41	74.55	-1.61	-44.33	0.11	-1.90	-0.35
21	2	14	73.00	8.64	1.71	6.93	0.00	1.00	12.10	74.06	-1.60	-43.56	0.11	-1.89	-0.36
22	2	15	73.00	8.64	1.76	6.89	0.00	1.00	11.81	73.57	-1.60	-42.82	0.11	-1.88	-0.36
23	2	16	73.00	8.64	1.80	6.84	0.00	1.00	11.53	73.08	-1.59	-42.13	0.11	-1.88	-0.37
24	2	17	73.00	8.64	1.85	6.80	0.00	1.00	11.27	72.60	-1.59	-41.47	0.11	-1.87	-0.37
25	2	18	73.00	8.64	1.89	6.75	0.00	1.00	11.02	72.11	-1.58	-40.84	0.11	-1.86	-0.38
26	2	19	73.00	8.64	1.94	6.71	0.00	1.00	10.78	71.63	-1.58	-40.23	0.11	-1.85	-0.38

27	2	20	73.00	8.64	1.98	6.66	0.00	1.00	10.56	71.15	-1.57	-39.66	0.11	-1.85	-0.38
28	3	1	73.00	8.64	2.01	6.63	0.00	1.00	7.63	70.81	-1.56	-43.42	0.10	-1.84	-0.39
29	3	2	73.00	8.64	2.05	6.59	0.00	1.00	7.51	70.43	-1.55	-42.96	0.10	-1.83	-0.39
30	3	3	73.00	8.64	2.09	6.56	0.00	1.00	7.41	70.05	-1.54	-42.51	0.10	-1.82	-0.40
31	3	4	73.00	8.64	2.12	6.52	0.00	1.00	7.30	69.67	-1.53	-42.07	0.10	-1.81	-0.40
32	3	5	73.00	8.64	2.16	6.49	0.00	1.00	7.20	69.29	-1.52	-41.65	0.10	-1.81	-0.41
33	3	6	73.00	8.64	2.19	6.45	0.00	1.00	7.10	68.91	-1.50	-41.24	0.10	-1.80	-0.41
34	3	7	73.00	8.64	2.23	6.42	0.00	1.00	7.01	68.54	-1.49	-40.84	0.10	-1.79	-0.41
35	3	8	73.00	8.64	2.26	6.38	0.00	1.00	6.91	68.17	-1.48	-40.45	0.10	-1.78	-0.42
36	3	9	73.00	8.64	2.30	6.35	0.00	1.00	6.83	67.80	-1.48	-40.08	0.10	-1.77	-0.42
37	3	10	73.00	8.64	2.33	6.31	0.00	1.00	6.74	67.44	-1.47	-39.71	0.09	-1.77	-0.42
38	3	11	73.00	8.64	2.36	6.28	0.00	1.00	6.65	67.08	-1.46	-39.36	0.09	-1.76	-0.42
39	3	12	73.00	8.64	2.40	6.25	0.00	1.00	6.57	66.72	-1.45	-39.01	0.09	-1.75	-0.43
40	3	13	73.00	8.64	2.43	6.21	0.00	1.00	6.49	66.36	-1.44	-38.68	0.09	-1.75	-0.43
41	3	14	73.00	8.64	2.46	6.18	0.00	1.00	6.42	66.01	-1.43	-38.35	0.09	-1.74	-0.43
42	3	15	73.00	8.64	2.50	6.15	0.00	1.00	6.34	65.67	-1.42	-38.03	0.09	-1.73	-0.43

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 14

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

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-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
43	3	16	73.00	8.64	2.53	6.12	0.00	1.00	6.27	65.32	-1.42	-37.72	0.09	-1.73	-0.43
44	3	17	73.00	8.64	2.56	6.08	0.00	1.00	6.20	64.98	-1.41	-37.42	0.09	-1.72	-0.43
45	3	18	73.00	8.64	2.59	6.05	0.00	1.00	6.13	64.65	-1.40	-37.12	0.09	-1.71	-0.43
46	3	19	73.00	8.64	2.62	6.02	0.00	1.00	6.06	64.32	-1.39	-36.83	0.09	-1.71	-0.43
47	3	20	73.00	8.64	2.65	5.99	0.00	1.00	6.00	63.99	-1.39	-36.55	0.09	-1.70	-0.44
48	4	1	73.00	8.64	2.66	5.98	0.00	1.00	6.24	63.91	-1.36	-42.62	0.09	-1.66	-0.44
49	4	2	73.00	8.64	2.68	5.97	0.00	1.00	6.17	63.74	-1.33	-42.25	0.08	-1.62	-0.43
50	4	3	73.00	8.64	2.69	5.95	0.00	1.00	6.10	63.55	-1.30	-41.89	0.08	-1.58	-0.43
51	4	4	73.00	8.64	2.71	5.93	0.00	1.00	6.04	63.36	-1.27	-41.54	0.08	-1.55	-0.43
52	4	5	73.00	8.64	2.73	5.91	0.00	1.00	5.97	63.15	-1.24	-41.19	0.08	-1.51	-0.43
53	4	6	73.00	8.64	2.75	5.89	0.00	1.00	5.91	62.94	-1.22	-40.86	0.07	-1.48	-0.43
54	4	7	73.00	8.64	2.77	5.87	0.00	1.00	5.85	62.71	-1.19	-40.53	0.07	-1.45	-0.42
55	4	8	73.00	8.64	2.79	5.85	0.00	1.00	5.79	62.48	-1.17	-40.21	0.07	-1.41	-0.42
56	4	9	73.00	8.64	2.82	5.83	0.00	1.00	5.73	62.25	-1.14	-39.90	0.07	-1.38	-0.42
57	4	10	73.00	8.64	2.84	5.81	0.00	1.00	5.67	62.01	-1.12	-39.60	0.07	-1.35	-0.41
58	4	11	73.00	8.64	2.86	5.78	0.00	1.00	5.62	61.76	-1.10	-39.30	0.06	-1.33	-0.41
59	4	12	73.00	8.64	2.88	5.76	0.00	1.00	5.56	61.51	-1.08	-39.01	0.06	-1.30	-0.40
60	4	13	73.00	8.64	2.91	5.74	0.00	1.00	5.51	61.26	-1.05	-38.72	0.06	-1.27	-0.40
61	4	14	73.00	8.64	2.93	5.71	0.00	1.00	5.46	61.01	-1.03	-38.44	0.06	-1.24	-0.40
62	4	15	73.00	8.64	2.96	5.69	0.00	1.00	5.41	60.75	-1.01	-38.17	0.06	-1.22	-0.39
63	4	16	73.00	8.64	2.98	5.66	0.00	1.00	5.36	60.50	-1.00	-37.90	0.06	-1.19	-0.39
64	4	17	73.00	8.64	3.00	5.64	0.00	1.00	5.31	60.24	-0.98	-37.64	0.05	-1.17	-0.38
65	4	18	73.00	8.64	3.03	5.62	0.00	1.00	5.26	59.98	-0.96	-37.38	0.05	-1.15	-0.38
66	4	19	73.00	8.64	3.05	5.59	0.00	1.00	5.22	59.72	-0.94	-37.13	0.05	-1.13	-0.37
67	4	20	73.00	8.64	3.08	5.57	0.00	1.00	5.17	59.46	-0.92	-36.89	0.05	-1.10	-0.37

68	5	1	77.00	8.29	3.09	5.20	0.00	1.00	16.96	52.67	-0.98	-27.39	0.05	-1.25	-0.39
69	5	2	77.00	8.29	3.09	5.20	0.00	1.00	16.49	46.87	-0.93	-26.82	0.05	-1.20	-0.38
70	5	3	77.00	8.29	3.09	5.20	0.00	1.00	16.06	46.88	-0.89	-26.29	0.05	-1.14	-0.37
71	5	4	77.00	8.29	3.09	5.20	0.00	1.00	15.65	46.85	-0.86	-25.78	0.05	-1.09	-0.35
72	5	5	77.00	8.29	3.10	5.19	0.00	1.00	15.26	46.79	-0.82	-25.31	0.05	-1.05	-0.34
73	5	6	77.00	8.29	3.11	5.18	0.00	1.00	14.90	46.70	-0.79	-24.86	0.04	-1.00	-0.33
74	5	7	77.00	8.29	3.12	5.17	0.00	1.00	14.55	46.59	-0.76	-24.43	0.04	-0.96	-0.32
75	5	8	77.00	8.29	3.13	5.16	0.00	1.00	14.23	46.46	-0.73	-24.03	0.04	-0.93	-0.31
76	5	9	77.00	8.29	3.15	5.14	0.00	1.00	13.92	46.31	-0.71	-23.64	0.04	-0.89	-0.30
77	5	10	77.00	8.29	3.17	5.12	0.00	1.00	13.63	46.15	-0.68	-23.27	0.04	-0.86	-0.29
78	5	11	77.00	8.29	3.19	5.10	0.00	1.00	13.35	45.98	-0.66	-22.92	0.03	-0.83	-0.28
79	5	12	77.00	8.29	3.21	5.08	0.00	1.00	13.08	45.80	-0.64	-22.59	0.03	-0.80	-0.27
80	5	13	77.00	8.29	3.23	5.06	0.00	1.00	12.83	45.61	-0.62	-22.27	0.03	-0.77	-0.27
81	5	14	77.00	8.29	3.25	5.04	0.00	1.00	12.57	45.41	-0.60	-21.96	0.03	-0.74	-0.26
82	6	1	77.00	8.29	3.26	5.04	0.00	1.00	28.47	45.37	-0.56	-19.32	0.02	-0.70	-0.24

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 15

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

***** 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
83	6	2	77.00	8.29	3.26	5.03	0.00	1.00	27.44	45.35	-0.53	-18.76	0.02	-0.66	-0.23
84	7	1	77.00	8.29	3.27	5.02	0.00	1.00	16.33	45.26	-0.51	-20.41	0.02	-0.63	-0.22
85	7	2	77.00	8.29	3.29	5.00	0.00	1.00	15.95	45.08	-0.49	-20.08	0.01	-0.61	-0.21
86	7	3	77.00	8.29	3.31	4.98	0.00	1.00	15.60	44.90	-0.47	-19.76	0.01	-0.59	-0.21
87	7	4	77.00	8.29	3.33	4.96	0.00	1.00	15.26	44.70	-0.46	-19.45	0.01	-0.56	-0.20
88	7	5	77.00	8.29	3.35	4.94	0.00	1.00	14.94	44.50	-0.44	-19.16	0.01	-0.54	-0.19
89	7	6	77.00	8.29	3.37	4.92	0.00	1.00	14.64	44.30	-0.43	-18.88	0.00	-0.53	-0.19
90	8	1	77.00	8.29	3.42	4.87	0.00	1.00	11.86	43.88	-0.46	-16.74	0.00	-0.58	-0.18
91	8	2	77.00	8.29	3.46	4.83	0.00	1.00	11.69	43.55	-0.49	-16.55	0.00	-0.63	-0.18
92	8	3	77.00	8.29	3.49	4.80	0.00	1.00	11.53	43.23	-0.51	-16.37	0.00	-0.67	-0.18
93	8	4	77.00	8.29	3.53	4.76	0.00	1.00	11.37	42.91	-0.54	-16.19	0.00	-0.72	-0.18
94	8	5	77.00	8.29	3.56	4.73	0.00	1.00	11.21	42.61	-0.56	-16.02	-0.01	-0.76	-0.18
95	8	6	77.00	8.29	3.59	4.70	0.00	1.00	11.06	42.32	-0.59	-15.85	-0.01	-0.80	-0.18
96	8	7	77.00	8.29	3.63	4.67	0.00	1.00	10.92	42.03	-0.61	-15.69	-0.01	-0.84	-0.18
97	8	8	77.00	8.29	3.66	4.64	0.00	1.00	10.78	41.75	-0.63	-15.54	-0.01	-0.88	-0.18
98	9	1	77.00	8.29	3.66	4.63	0.00	1.00	12.85	41.68	-0.66	-17.23	-0.01	-0.93	-0.18
99	9	2	77.00	8.29	3.68	4.61	0.00	1.00	12.64	41.54	-0.69	-17.03	0.00	-0.97	-0.18
100	9	3	77.00	8.29	3.70	4.60	0.00	1.00	12.43	41.40	-0.71	-16.83	0.01	-1.02	-0.19
101	9	4	77.00	8.29	3.71	4.58	0.00	1.00	12.23	41.26	-0.74	-16.65	0.01	-1.06	-0.19
102	9	5	77.00	8.29	3.73	4.56	0.00	1.00	12.04	41.12	-0.76	-16.47	0.02	-1.10	-0.19
103	9	6	77.00	8.29	3.74	4.55	0.00	1.00	11.85	40.97	-0.78	-16.29	0.02	-1.13	-0.20

104	10	1	77.00	8.29	3.78	4.51	0.00	1.00	2.51	45.71	-0.78	-26.77	0.02	-1.13	-0.20
105	10	2	77.00	8.29	3.82	4.47	0.00	1.00	2.51	50.31	-0.78	-26.71	0.02	-1.14	-0.21
106	10	3	77.00	8.29	3.87	4.43	0.00	1.00	2.50	49.85	-0.79	-26.65	0.02	-1.14	-0.22
107	10	4	77.00	8.29	3.90	4.39	0.00	1.00	2.49	49.40	-0.79	-26.59	0.03	-1.14	-0.22
108	10	5	77.00	8.29	3.94	4.35	0.00	1.00	2.49	48.97	-0.79	-26.53	0.03	-1.14	-0.23
109	10	6	77.00	8.29	3.98	4.31	0.00	1.00	2.48	48.55	-0.79	-26.47	0.03	-1.14	-0.23
110	10	7	77.00	8.29	4.02	4.28	0.00	1.00	2.47	48.15	-0.79	-26.41	0.03	-1.14	-0.24
111	10	8	77.00	8.29	4.05	4.24	0.00	1.00	2.47	47.76	-0.79	-26.35	0.03	-1.14	-0.24
112	10	9	77.00	8.29	4.08	4.21	0.00	1.00	2.46	47.38	-0.79	-26.29	0.03	-1.15	-0.24
113	10	10	77.00	8.29	4.12	4.18	0.00	1.00	2.45	47.02	-0.80	-26.24	0.03	-1.15	-0.25
114	10	11	77.00	8.29	4.15	4.14	0.00	1.00	2.45	46.67	-0.80	-26.18	0.03	-1.15	-0.25
115	10	12	77.00	8.29	4.18	4.11	0.00	1.00	2.44	46.33	-0.80	-26.12	0.03	-1.15	-0.26
116	10	13	77.00	8.29	4.21	4.08	0.00	1.00	2.43	46.00	-0.80	-26.07	0.03	-1.15	-0.26
117	10	14	77.00	8.29	4.24	4.06	0.00	1.00	2.43	45.68	-0.80	-26.01	0.03	-1.15	-0.26
118	10	15	77.00	8.29	4.26	4.03	0.00	1.00	2.42	45.37	-0.80	-25.95	0.03	-1.15	-0.27
119	10	16	77.00	8.29	4.29	4.00	0.00	1.00	2.42	45.08	-0.80	-25.90	0.03	-1.15	-0.27

AUGUST 26, 1986 EVENT- FIRST FLUSH * * * QUAL-2E STREAM QUALITY ROUTING MODEL * * *
Version 3.21 - Feb. 1995

$$$ (PROBLEM TITLES) $$$

CARD TYPE		QUAL-2E PROGRAM TITLES
TITLE01		Cedar Creek- 8/26 Storm (Calibration)
TITLE02		
TITLE03	NO	CONSERVATIVE MINERAL I
TITLE04	NO	CONSERVATIVE MINERAL II
TITLE05	NO	CONSERVATIVE MINERAL III
TITLE06	NO	TEMPERATURE
TITLE07	YES	BIOCHEMICAL OXYGEN DEMAND
TITLE08	YES	ALGAE AS CHL-A IN UG/L
TITLE09	YES	PHOSPHORUS CYCLE AS P IN MG/L
TITLE10		(ORGANIC-P; DISSOLVED-P)
TITLE11	YES	NITROGEN CYCLE AS N IN MG/L
TITLE12		(ORGANIC-N; AMMONIA-N; NITRITE-N;' NITRATE-N)
TITLE13	YES	DISSOLVED OXYGEN IN MG/L
TITLE14	NO	FECAL COLIFORM IN NO./100 ML
TITLE15	NO	ARBITRARY NON-CONSERVATIVE
ENDTITLE		

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE		CARD TYPE	
LIST DATA INPUT	0.00000		0.00000
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 =	10.00000	NUMBER OF JUNCTIONS =	0.00000
NUM OF HEADWATERS =	1.00000	NUMBER OF POINT LOADS =	0.00000
TIME STEP (HOURS) =	1.00000	LNTH. COMP. ELEMENT (DX)=	0.05000
MAXIMUM ROUTE TIME (HRS)=	30.00000	TIME INC. FOR RPT2 (HRS)=	1.00000
LATITUDE OF BASIN (DEG) =	40.00000	LONGITUDE OF BASIN (DEG)=	90.00000
STANDARD MARIDIAN (DEG) =	90.00000	DAY OF YEAR START TIME =	228.00000
EVAP. COEF.,(AE) =	0.00103	EVAP. COEF.,(BE) =	0.00016
ELEV. OF BASIN (ELEV) =	771.00000	DUST ATTENUATION COEF. =	0.06000
ENDATA1	0.00000		0.00000

$$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE CARD TYPE

```
O UPTAKE BY NH3 OXID(MG O/MG N)=    3.4300         O UPTAKE BY NO2 OXID(MG O/MG N)=    1.1400
O PROD  BY ALGAE (MG O/MG A)   =    1.6000         O UPTAKE BY ALGAE (MG O/MG A)  =    2.0000
N CONTENT OF ALGAE (MG N/MG A) =    0.0850         P CONTENT OF ALGAE (MG O/MG A) =    0.0140
ALG MAX SPEC GROWTH RATE(1/DAY)=    2.5000         ALGAE RESPIRATION RATE (1/DAY) =    0.0500
N HALF SATURATION CONST (MG/L) =    0.2000         P HALF SATURATION CONST (MG/L) =    0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0008         NLIN SHADE(1/FT-(UGCHA/L)**2/3)=    0.0000
LIGHT FUNCTION OPTION (LFNOPT) =    1.0000         LIGHT SAT'N COEF (BTU/FT2-MIN) =    0.1100
DAILY AVERAGING OPTION (LAVOPT)=    2.0000         LIGHT AVERAGING FACTOR (AFACT) =    0.9200
NUMBER OF DAYLIGHT HOURS (DLH) =   14.0000         TOTAL DAILY SOLR RAD (BTU/FT-2)= 1300.0000
ALGY GROWTH CALC OPTION(LGROPT)=    2.0000         ALGAL PREF FOR NH3-N (PREFN)   =    0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4400         NITRIFICATION INHIBITION COEF  =   10.0000
ENDATA1A                            0.0000                                             0.0000

 $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE     RATE CODE     THETA VALUE

THETA( 1)      BOD DECA        1.047     USER
THETA( 2)      BOD SETT        1.024     USER
THETA( 3)      OXY TRAN        1.024     USER
THETA( 4)      SOD RATE        1.060     USER
THETA( 5)      ORGN DEC        1.047     USER
THETA( 6)      ORGN SET        1.024     USER
THETA( 7)      NH3 DECA        1.083     USER
THETA( 8)      NH3 SRCE        1.074     USER
THETA( 9)      NO2 DECA        1.047     USER
THETA(10)      PORG DEC        1.047     USER
THETA(11)      PORG SET        1.024     USER
THETA(12)      DISP SRC        1.074     USER
THETA(13)      ALG GROW        1.047     USER
THETA(14)      ALG RESP        1.047     USER
THETA(15)      ALG SETT        1.024     USER
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         47.3    TO           47.0
STREAM REACH     2.0  RCH=              2   FROM         47.0    TO           46.0
STREAM REACH     3.0  RCH=              3   FROM         46.0    TO           45.0
STREAM REACH     4.0  RCH=              4   FROM         45.0    TO           44.0
STREAM REACH     5.0  RCH=              5   FROM         44.0    TO           43.3
STREAM REACH     6.0  RCH=              6   FROM         43.3    TO           43.2
STREAM REACH     7.0  RCH=              7   FROM         43.2    TO           42.9
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STREAM REACH	8.0	RCH=	8	FROM	42.9	TO 42.5
STREAM REACH	9.0	RCH=	9	FROM	42.5	TO 42.2
STREAM REACH	10.0	RCH=	10	FROM	42.2	TO 41.4
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.	7.	1.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	2.	20.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD	3.	20.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD	4.	20.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD	5.	14.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
FLAG FIELD	6.	2.	2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	7.	6.	2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	8.	8.	2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	9.	6.	2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	10.	16.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.0.0.0.0.
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.	26.00	6.000	6.000	1.000	0.002	0.033
HYDRAULICS	2.	26.00	6.000	6.000	1.500	0.002	0.033
HYDRAULICS	3.	26.00	6.000	6.000	2.000	0.002	0.033
HYDRAULICS	4.	26.00	6.000	6.000	3.000	0.002	0.033
HYDRAULICS	5.	18.00	0.660	0.660	15.000	0.002	0.015
HYDRAULICS	6.	18.00	0.000	0.000	30.000	0.002	0.015
HYDRAULICS	7.	18.00	0.660	0.660	15.000	0.002	0.015
HYDRAULICS	8.	18.00	0.000	0.000	30.000	0.002	0.015
HYDRAULICS	9.	18.00	0.660	0.660	15.000	0.002	0.015
HYDRAULICS	10.	66.00	1.000	1.000	10.000	0.002	0.025
ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE			DUST	CLOUD	DRY BULB	WET BULB	ATM		SOLAR RAD
	REACH	ELEVATION	COEF	COVER	TEMP	TEMP	PRESSURE	WIND	ATTENUATION
TEMP/LCD	1.	771.00	0.06	1.00	70.00	70.00	30.00	0.00	1.00
TEMP/LCD	2.	771.00	0.06	1.00	70.00	70.00	30.00	0.00	1.00
TEMP/LCD	3.	771.00	0.06	1.00	70.00	70.00	30.00	0.00	1.00
TEMP/LCD	4.	771.00	0.06	1.00	70.00	70.00	30.00	0.00	1.00

TEMP/LCD	5.	771.00	0.06	1.00	70.00	70.00	30.00	0.00	1.00
TEMP/LCD	6.	771.00	0.06	1.00	70.00	70.00	30.00	0.00	1.00
TEMP/LCD	7.	771.00	0.06	1.00	70.00	70.00	30.00	0.00	1.00
TEMP/LCD	8.	771.00	0.06	1.00	70.00	70.00	30.00	0.00	1.00
TEMP/LCD	9.	771.00	0.06	1.00	70.00	70.00	30.00	0.00	1.00
TEMP/LCD	10.	771.00	0.06	1.00	70.00	70.00	30.00	0.00	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 OR SLOPE FOR OPT 8
REACT COEF	1.	0.13	1.00	0.210	1.	10.00	0.000		0.00000
REACT COEF	2.	0.13	1.00	0.210	1.	10.00	0.000		0.00000
REACT COEF	3.	0.13	1.00	0.210	1.	10.00	0.000		0.00000
REACT COEF	4.	0.13	1.00	0.210	1.	10.00	0.000		0.00000
REACT COEF	5.	0.13	1.00	0.140	1.	8.00	0.000		0.00000
REACT COEF	6.	0.13	1.00	0.140	1.	8.00	0.000		0.00000
REACT COEF	7.	0.13	1.00	0.140	1.	8.00	0.000		0.00000
REACT COEF	8.	0.13	1.00	0.140	1.	8.00	0.000		0.00000
REACT COEF	9.	0.13	1.00	0.140	1.	8.00	0.000		0.00000
REACT COEF	10.	0.13	1.00	0.230	1.	10.00	0.000		0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000		0.00000

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

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	2.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	3.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	4.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	5.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	6.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	7.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	8.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	9.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
N AND P COEF	10.	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	2.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	3.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	4.	10.00	1.00	0.01	0.00	0.00	0.00	0.00

ALG/OTHER COEF	5.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	6.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	7.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	8.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	9.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	10.	10.00	1.00	0.01	0.00	0.00	0.00	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	68.00	7.00	11.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	2.	68.00	7.00	11.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	3.	68.00	7.00	11.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	4.	68.00	7.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	5.	73.00	7.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	6.	73.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	7.	73.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	8.	73.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	9.	73.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	10.	73.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.00	1.00	0.20	0.00	7.00	0.00	0.12
INITIAL COND-2	2.	2.00	1.00	0.20	0.00	7.00	0.00	0.12
INITIAL COND-2	3.	2.00	1.00	0.20	0.00	7.00	0.00	0.12
INITIAL COND-2	4.	2.00	1.00	0.10	0.00	7.00	0.00	0.12
INITIAL COND-2	5.	4.00	0.70	0.10	0.00	4.00	0.00	0.07
INITIAL COND-2	6.	4.00	0.70	0.10	0.00	4.00	0.00	0.07
INITIAL COND-2	7.	4.00	0.70	0.10	0.00	4.00	0.00	0.07
INITIAL COND-2	8.	4.00	0.70	0.20	0.00	4.00	0.00	0.07
INITIAL COND-2	9.	4.00	0.70	0.20	0.00	0.50	0.00	0.07
INITIAL COND-2	10.	4.00	0.70	0.20	0.00	0.50	0.00	0.07
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.	0.100	68.00	2.40	13.50	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.300	68.00	2.40	13.50	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.200	68.00	2.40	13.50	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	4.	0.700	68.00	1.90	22.10	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	5.	1.500	73.00	1.90	22.10	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	6.	0.500	73.00	1.90	22.10	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.900	73.00	1.90	22.10	0.00	0.00	0.00	0.00	0.00

INCR INFLOW-1	8.	0.900	73.00	1.90	22.10	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	9.	0.900	73.00	1.90	22.10	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	10.	0.500	73.00	1.90	22.10	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INCR INFLOW-2	1.	1.00	2.00	0.94	0.00	2.00	0.00	1.00
INCR INFLOW-2	2.	1.00	2.00	0.94	0.00	2.00	0.00	1.00
INCR INFLOW-2	3.	1.00	2.00	0.94	0.00	2.00	0.00	1.00
INCR INFLOW-2	4.	1.00	0.00	0.64	0.00	0.00	0.00	0.00
INCR INFLOW-2	5.	3.00	0.00	0.64	0.00	0.00	0.00	0.00
INCR INFLOW-2	6.	3.00	0.00	0.64	0.00	0.00	0.00	0.00
INCR INFLOW-2	7.	3.00	0.00	0.64	0.00	0.00	0.00	0.00
INCR INFLOW-2	8.	3.00	0.00	0.64	0.00	0.00	0.00	0.00
INCR INFLOW-2	9.	3.00	2.00	0.64	0.00	2.00	0.00	0.00
INCR INFLOW-2	10.	3.00	2.00	0.64	0.00	2.00	0.00	1.00
ENDATA8A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT	UPSTRM	JUNCTION	TRIB
ENDATA9	0.	0.	0.	0.

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

CARD TYPE	HDWTR ORDER	NAME	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
HEADWTR-1	1.	1	0.10	68.00	2.40	13.50	0.00	0.00	0.00
ENDATA10	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	0.00	0.00	1.00	2.00	0.94	0.00	2.00	0.00	1.00
ENDATA10A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

CARD TYPE	POINT LOAD ORDER	NAME	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
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 ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	119
ALGAE GROWTH RATE	2	119
ALGAE GROWTH RATE	3	119
ALGAE GROWTH RATE	4	119
ALGAE GROWTH RATE	5	119
ALGAE GROWTH RATE	6	0
ALGAE GROWTH RATE	7	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:
----

1. LIGHT AVERAGING OPTION.   LAVOPT= 2

   METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

   SOURCE OF SOLAR VALUES: DATA TYPE 1A
   DAILY NET SOLAR RADIATION: 1300.000 BTU/FT-2 (352.782 LANGLEYS)
   NUMBER OF DAYLIGHT HOURS: 0.0
   PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): N/A
   MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.920

2. LIGHT FUNCTION OPTION: LFNOPT= 1

   HALF SATURATION METHOD, WITH HALF SATURATION COEF = 0.030 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS.   LGROPT= 2

   MINIMUM OF NITROGEN, PHOSPHORUS: FL*MIN(FN,FP)

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

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC 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	47.35	47.30	0.11	0.00	0.01	0.426	0.007	0.144	1.863	0.07	0.73	0.27	0.28
2	1	2	47.30	47.25	0.13	0.00	0.01	0.440	0.007	0.152	1.915	0.08	0.75	0.29	0.30
3	1	3	47.25	47.20	0.14	0.00	0.01	0.453	0.007	0.161	1.963	0.08	0.78	0.32	0.32
4	1	4	47.20	47.15	0.16	0.00	0.01	0.465	0.007	0.168	2.009	0.09	0.80	0.34	0.35
5	1	5	47.15	47.10	0.17	0.00	0.01	0.476	0.006	0.175	2.053	0.10	0.83	0.36	0.37
6	1	6	47.10	47.05	0.19	0.00	0.01	0.486	0.006	0.182	2.094	0.10	0.85	0.38	0.39
7	1	7	47.05	47.00	0.20	0.00	0.01	0.496	0.006	0.189	2.134	0.11	0.87	0.40	0.41
8	2	1	47.00	46.95	0.22	0.00	0.02	0.493	0.006	0.172	2.532	0.12	0.95	0.44	0.37
9	2	2	46.95	46.90	0.23	0.00	0.02	0.503	0.006	0.178	2.569	0.12	0.97	0.46	0.39
10	2	3	46.90	46.85	0.25	0.00	0.02	0.512	0.006	0.184	2.603	0.13	0.99	0.48	0.41
11	2	4	46.85	46.80	0.26	0.00	0.02	0.520	0.006	0.190	2.639	0.13	1.00	0.50	0.43
12	2	5	46.80	46.75	0.27	0.00	0.02	0.528	0.006	0.195	2.671	0.14	1.02	0.52	0.44
13	2	6	46.75	46.70	0.29	0.00	0.02	0.536	0.006	0.200	2.702	0.14	1.04	0.54	0.46
14	2	7	46.70	46.65	0.30	0.00	0.02	0.544	0.006	0.205	2.733	0.15	1.06	0.56	0.48
15	2	8	46.65	46.60	0.32	0.00	0.02	0.551	0.006	0.210	2.762	0.15	1.07	0.58	0.49
16	2	9	46.60	46.55	0.33	0.00	0.02	0.558	0.005	0.215	2.791	0.16	1.09	0.60	0.51
17	2	10	46.55	46.50	0.35	0.00	0.02	0.565	0.005	0.220	2.820	0.16	1.10	0.62	0.52
18	2	11	46.50	46.45	0.36	0.00	0.02	0.571	0.005	0.224	2.847	0.17	1.12	0.64	0.54
19	2	12	46.45	46.40	0.38	0.00	0.02	0.577	0.005	0.229	2.874	0.17	1.13	0.66	0.55
20	2	13	46.40	46.35	0.39	0.00	0.02	0.584	0.005	0.233	2.901	0.18	1.15	0.68	0.57
21	2	14	46.35	46.30	0.41	0.00	0.02	0.589	0.005	0.238	2.926	0.18	1.16	0.70	0.58
22	2	15	46.30	46.25	0.42	0.00	0.02	0.595	0.005	0.242	2.952	0.19	1.17	0.71	0.60
23	2	16	46.25	46.20	0.44	0.00	0.02	0.601	0.005	0.246	2.976	0.19	1.19	0.73	0.61
24	2	17	46.20	46.15	0.45	0.00	0.02	0.606	0.005	0.250	3.001	0.20	1.20	0.75	0.63
25	2	18	46.15	46.10	0.47	0.00	0.02	0.612	0.005	0.254	3.025	0.20	1.21	0.77	0.64
26	2	19	46.10	46.05	0.48	0.00	0.02	0.617	0.005	0.258	3.048	0.21	1.22	0.79	0.65
27	2	20	46.05	46.00	0.50	0.00	0.02	0.622	0.005	0.262	3.071	0.21	1.24	0.80	0.67
28	3	1	46.00	45.95	0.51	0.00	0.01	0.614	0.005	0.241	3.446	0.22	1.30	0.83	0.62
29	3	2	45.95	45.90	0.52	0.00	0.01	0.617	0.005	0.243	3.460	0.22	1.31	0.84	0.62
30	3	3	45.90	45.85	0.53	0.00	0.01	0.621	0.005	0.246	3.475	0.23	1.32	0.85	0.63
31	3	4	45.85	45.80	0.54	0.00	0.01	0.624	0.005	0.248	3.489	0.23	1.32	0.87	0.64
32	3	5	45.80	45.75	0.55	0.00	0.01	0.627	0.005	0.250	3.502	0.23	1.33	0.88	0.65
33	3	6	45.75	45.70	0.56	0.00	0.01	0.630	0.005	0.253	3.516	0.23	1.34	0.89	0.66

34	3	7	45.70	45.65	0.57	0.00	0.01	0.633	0.005	0.255	3.530	0.24	1.35	0.90	0.66
35	3	8	45.65	45.60	0.58	0.00	0.01	0.636	0.005	0.257	3.543	0.24	1.35	0.91	0.67
36	3	9	45.60	45.55	0.59	0.00	0.01	0.639	0.005	0.259	3.557	0.24	1.36	0.92	0.68
37	3	10	45.55	45.50	0.60	0.00	0.01	0.642	0.005	0.262	3.570	0.25	1.37	0.93	0.69
38	3	11	45.50	45.45	0.61	0.00	0.01	0.645	0.005	0.264	3.583	0.25	1.38	0.95	0.70
39	3	12	45.45	45.40	0.62	0.00	0.01	0.648	0.005	0.266	3.596	0.25	1.38	0.96	0.71
40	3	13	45.40	45.35	0.63	0.00	0.01	0.651	0.005	0.268	3.609	0.26	1.39	0.97	0.71
41	3	14	45.35	45.30	0.64	0.00	0.01	0.654	0.005	0.270	3.621	0.26	1.40	0.98	0.72
42	3	15	45.30	45.25	0.65	0.00	0.01	0.657	0.005	0.272	3.634	0.26	1.40	0.99	0.73

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

***** 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
43	3	16	45.25	45.20	0.66	0.00	0.01	0.660	0.005	0.274	3.646	0.26	1.41	1.00	0.74
44	3	17	45.20	45.15	0.67	0.00	0.01	0.662	0.005	0.276	3.659	0.27	1.42	1.01	0.74
45	3	18	45.15	45.10	0.68	0.00	0.01	0.665	0.005	0.279	3.671	0.27	1.42	1.02	0.75
46	3	19	45.10	45.05	0.69	0.00	0.01	0.668	0.005	0.281	3.683	0.27	1.43	1.03	0.76
47	3	20	45.05	45.00	0.70	0.00	0.01	0.670	0.005	0.283	3.695	0.28	1.44	1.04	0.77
48	4	1	45.00	44.95	0.73	0.00	0.04	0.656	0.005	0.249	4.496	0.30	1.59	1.12	0.68
49	4	2	44.95	44.90	0.77	0.00	0.04	0.665	0.005	0.256	4.533	0.31	1.61	1.16	0.70
50	4	3	44.90	44.85	0.80	0.00	0.04	0.673	0.005	0.262	4.570	0.32	1.63	1.20	0.72
51	4	4	44.85	44.80	0.84	0.00	0.04	0.682	0.004	0.268	4.605	0.33	1.65	1.23	0.75
52	4	5	44.80	44.75	0.87	0.00	0.04	0.690	0.004	0.273	4.640	0.33	1.67	1.27	0.77
53	4	6	44.75	44.70	0.91	0.00	0.04	0.698	0.004	0.279	4.674	0.34	1.69	1.30	0.79
54	4	7	44.70	44.65	0.94	0.00	0.04	0.705	0.004	0.285	4.707	0.35	1.71	1.34	0.81
55	4	8	44.65	44.60	0.98	0.00	0.04	0.713	0.004	0.290	4.740	0.36	1.72	1.37	0.83
56	4	9	44.60	44.55	1.01	0.00	0.04	0.720	0.004	0.295	4.772	0.37	1.74	1.41	0.85
57	4	10	44.55	44.50	1.05	0.00	0.04	0.727	0.004	0.301	4.807	0.38	1.76	1.45	0.88
58	4	11	44.50	44.45	1.08	0.00	0.04	0.733	0.004	0.306	4.838	0.39	1.77	1.48	0.90
59	4	12	44.45	44.40	1.12	0.00	0.04	0.740	0.004	0.311	4.868	0.40	1.79	1.51	0.92
60	4	13	44.40	44.35	1.15	0.00	0.04	0.747	0.004	0.316	4.897	0.41	1.81	1.55	0.94
61	4	14	44.35	44.30	1.19	0.00	0.04	0.753	0.004	0.321	4.926	0.42	1.82	1.58	0.96
62	4	15	44.30	44.25	1.22	0.00	0.04	0.759	0.004	0.326	4.955	0.43	1.84	1.61	0.98
63	4	16	44.25	44.20	1.26	0.00	0.04	0.765	0.004	0.330	4.983	0.43	1.85	1.65	1.00
64	4	17	44.20	44.15	1.29	0.00	0.04	0.771	0.004	0.335	5.011	0.44	1.87	1.68	1.02
65	4	18	44.15	44.10	1.33	0.00	0.04	0.777	0.004	0.340	5.039	0.45	1.88	1.71	1.04
66	4	19	44.10	44.05	1.36	0.00	0.04	0.783	0.004	0.344	5.066	0.46	1.90	1.74	1.06
67	4	20	44.05	44.00	1.40	0.00	0.04	0.789	0.004	0.349	5.092	0.47	1.91	1.78	1.07
68	5	1	44.00	43.95	1.51	0.00	0.11	0.968	0.003	0.103	15.068	0.41	4.03	1.56	0.15
69	5	2	43.95	43.90	1.61	0.00	0.11	0.995	0.003	0.108	15.071	0.43	4.03	1.62	0.16
70	5	3	43.90	43.85	1.72	0.00	0.11	1.020	0.003	0.112	15.074	0.45	4.03	1.69	0.17
71	5	4	43.85	43.80	1.83	0.00	0.11	1.045	0.003	0.116	15.077	0.46	4.03	1.75	0.18
72	5	5	43.80	43.75	1.94	0.00	0.11	1.069	0.003	0.120	15.079	0.48	4.04	1.81	0.19
73	5	6	43.75	43.70	2.04	0.00	0.11	1.092	0.003	0.124	15.082	0.49	4.04	1.87	0.20
74	5	7	43.70	43.65	2.15	0.00	0.11	1.114	0.003	0.128	15.084	0.51	4.04	1.93	0.21
75	5	8	43.65	43.60	2.26	0.00	0.11	1.136	0.003	0.132	15.087	0.52	4.04	1.99	0.22

76	5	9	43.60	43.55	2.36	0.00	0.11	1.157	0.003	0.135	15.089	0.54	4.05	2.04	0.23
77	5	10	43.55	43.50	2.47	0.00	0.11	1.177	0.003	0.139	15.092	0.55	4.05	2.10	0.23
78	5	11	43.50	43.45	2.58	0.00	0.11	1.197	0.003	0.143	15.094	0.57	4.05	2.15	0.24
79	5	12	43.45	43.40	2.69	0.00	0.11	1.216	0.003	0.146	15.097	0.58	4.05	2.21	0.25
80	5	13	43.40	43.35	2.79	0.00	0.11	1.235	0.002	0.150	15.107	0.60	4.05	2.26	0.26
81	5	14	43.35	43.30	2.90	0.00	0.11	1.253	0.002	0.153	15.108	0.61	4.06	2.31	0.27
82	6	1	43.30	43.25	3.15	0.00	0.25	0.989	0.003	0.106	30.000	0.84	7.98	3.19	0.16

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 3
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995

***** 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
83	6	2	43.25	43.20	3.40	0.00	0.25	1.019	0.003	0.111	30.000	0.88	7.98	3.34	0.17
84	7	1	43.20	43.15	3.55	0.00	0.15	1.357	0.002	0.173	15.117	0.69	4.07	2.62	0.32
85	7	2	43.15	43.10	3.70	0.00	0.15	1.380	0.002	0.177	15.120	0.71	4.07	2.68	0.34
86	7	3	43.10	43.05	3.85	0.00	0.15	1.401	0.002	0.182	15.122	0.73	4.07	2.75	0.35
87	7	4	43.05	43.00	4.00	0.00	0.15	1.423	0.002	0.186	15.124	0.74	4.08	2.81	0.36
88	7	5	43.00	42.95	4.15	0.00	0.15	1.443	0.002	0.190	15.127	0.76	4.08	2.88	0.37
89	7	6	42.95	42.90	4.30	0.00	0.15	1.464	0.002	0.194	15.129	0.78	4.08	2.94	0.39
90	8	1	42.90	42.85	4.41	0.00	0.11	1.131	0.003	0.130	30.000	1.03	7.99	3.90	0.21
91	8	2	42.85	42.80	4.53	0.00	0.11	1.142	0.003	0.132	30.000	1.05	7.99	3.96	0.22
92	8	3	42.80	42.75	4.64	0.00	0.11	1.153	0.003	0.134	30.000	1.06	7.99	4.02	0.22
93	8	4	42.75	42.70	4.75	0.00	0.11	1.164	0.003	0.136	30.000	1.08	7.99	4.08	0.23
94	8	5	42.70	42.65	4.86	0.00	0.11	1.175	0.003	0.138	30.000	1.09	7.99	4.14	0.23
95	8	6	42.65	42.60	4.98	0.00	0.11	1.186	0.003	0.140	30.000	1.11	7.99	4.19	0.24
96	8	7	42.60	42.55	5.09	0.00	0.11	1.197	0.003	0.142	30.000	1.12	7.99	4.25	0.24
97	8	8	42.55	42.50	5.20	0.00	0.11	1.207	0.003	0.144	30.000	1.14	8.00	4.31	0.25
98	9	1	42.50	42.45	5.35	0.00	0.15	1.595	0.002	0.221	15.147	0.89	4.10	3.35	0.47
99	9	2	42.45	42.40	5.50	0.00	0.15	1.612	0.002	0.225	15.149	0.90	4.10	3.41	0.48
100	9	3	42.40	42.35	5.65	0.00	0.15	1.629	0.002	0.229	15.151	0.92	4.10	3.47	0.49
101	9	4	42.35	42.30	5.80	0.00	0.15	1.646	0.002	0.233	15.154	0.93	4.11	3.52	0.50
102	9	5	42.30	42.25	5.95	0.00	0.15	1.663	0.002	0.236	15.156	0.94	4.11	3.58	0.52
103	9	6	42.25	42.20	6.10	0.00	0.15	1.679	0.002	0.240	15.158	0.96	4.11	3.63	0.53
104	10	1	42.20	42.15	6.13	0.00	0.03	1.414	0.002	0.416	10.418	1.14	2.95	4.34	4.29
105	10	2	42.15	42.10	6.16	0.00	0.03	1.416	0.002	0.418	10.419	1.15	2.95	4.35	4.31
106	10	3	42.10	42.05	6.19	0.00	0.03	1.419	0.002	0.419	10.421	1.15	2.95	4.36	4.33
107	10	4	42.05	42.00	6.23	0.00	0.03	1.422	0.002	0.420	10.422	1.16	2.95	4.38	4.35
108	10	5	42.00	41.95	6.26	0.00	0.03	1.424	0.002	0.421	10.423	1.16	2.95	4.39	4.37
109	10	6	41.95	41.90	6.29	0.00	0.03	1.427	0.002	0.423	10.424	1.16	2.96	4.41	4.39
110	10	7	41.90	41.85	6.32	0.00	0.03	1.430	0.002	0.424	10.426	1.17	2.96	4.42	4.41
111	10	8	41.85	41.80	6.35	0.00	0.03	1.432	0.002	0.425	10.427	1.17	2.96	4.43	4.43

112	10	9	41.80	41.75	6.38	0.00	0.03	1.435	0.002	0.426	10.428	1.17	2.96	4.45	4.45
113	10	10	41.75	41.70	6.41	0.00	0.03	1.438	0.002	0.428	10.429	1.18	2.96	4.46	4.47
114	10	11	41.70	41.65	6.44	0.00	0.03	1.440	0.002	0.429	10.430	1.18	2.96	4.47	4.49
115	10	12	41.65	41.60	6.48	0.00	0.03	1.443	0.002	0.430	10.432	1.18	2.96	4.49	4.50
116	10	13	41.60	41.55	6.51	0.00	0.03	1.446	0.002	0.431	10.433	1.19	2.96	4.50	4.52
117	10	14	41.55	41.50	6.54	0.00	0.03	1.448	0.002	0.433	10.434	1.19	2.96	4.51	4.54
118	10	15	41.50	41.45	6.57	0.00	0.03	1.451	0.002	0.434	10.435	1.20	2.96	4.53	4.56
119	10	16	41.45	41.40	6.60	0.00	0.03	1.453	0.002	0.435	10.436	1.20	2.96	4.54	4.58

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 4

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

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

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/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	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	3	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	4	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	5	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	6	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	7	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	3	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	4	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	6	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	7	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	8	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	9	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	10	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	11	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	12	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	13	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	14	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	15	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	16	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	17	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	18	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	19	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

2	20	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	1	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	4	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	5	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	6	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	7	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	8	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	9	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	10	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	11	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	12	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	13	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	14	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	15	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 5
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995

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

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/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
3	16	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	17	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	18	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	19	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	20	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	2	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	3	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	5	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	6	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	7	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	8	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	9	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	10	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	11	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	12	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	13	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	14	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	15	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	16	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	17	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	18	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	19	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	20	9.12	1	10.00	0.13	1.00	0.21	0.02	1.00	1.25	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1	8.64	1	9.61	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	2	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	3	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	4	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	5	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	7	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	8	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5	9	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	10	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	11	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	12	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	13	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	14	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	1	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 6
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995

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

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/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
6	2	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	1	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	2	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	3	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	4	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	5	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	6	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	2	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	3	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	4	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	5	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	6	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	7	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	8	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	1	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	2	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	3	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	4	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	5	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	6	8.64	1	8.55	0.15	1.07	0.16	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	1	8.64	1	9.61	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	2	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	3	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	4	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	5	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	6	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	7	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	8	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00

10	9	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	10	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	11	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	12	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	13	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	14	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	15	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	16	8.64	1	10.68	0.15	1.07	0.27	0.02	1.07	1.56	0.00	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STREAM QUALITY SIMULATION　　OUTPUT PAGE NUMBER 7

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

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
1	1	68.00	0.00	0.00	0.00	2.28	13.40	1.99	0.93	0.01	2.00	4.93	0.00	1.00	1.00	0.00	0.00	0.96
1	2	68.00	0.00	0.00	0.00	2.21	13.31	1.97	0.93	0.01	2.00	4.91	0.00	1.00	1.00	0.00	0.00	0.93
1	3	68.00	0.00	0.00	0.00	2.18	13.23	1.96	0.92	0.02	2.00	4.90	0.00	1.00	1.00	0.00	0.00	0.91
1	4	68.00	0.00	0.00	0.00	2.16	13.16	1.95	0.91	0.02	2.00	4.90	0.00	1.00	1.00	0.00	0.00	0.89
1	5	68.00	0.00	0.00	0.00	2.17	13.10	1.95	0.91	0.03	2.00	4.89	0.00	1.00	1.00	0.00	0.00	0.87
1	6	68.00	0.00	0.00	0.00	2.18	13.04	1.94	0.91	0.03	2.01	4.88	0.00	1.00	1.00	0.00	0.00	0.86
1	7	68.00	0.00	0.00	0.00	2.20	12.98	1.93	0.90	0.03	2.01	4.87	0.00	1.00	1.00	0.00	0.00	0.85
2	1	68.00	0.00	0.00	0.00	2.21	12.93	1.92	0.90	0.03	2.01	4.86	0.00	1.00	1.00	0.00	0.00	0.84
2	2	68.00	0.00	0.00	0.00	2.24	12.88	1.92	0.89	0.04	2.01	4.86	0.00	1.00	1.00	0.00	0.00	0.83
2	3	68.00	0.00	0.00	0.00	2.27	12.84	1.91	0.89	0.04	2.01	4.85	0.00	1.00	1.00	0.00	0.00	0.82
2	4	68.00	0.00	0.00	0.00	2.30	12.79	1.90	0.89	0.04	2.01	4.85	0.00	1.00	1.00	0.00	0.00	0.81
2	5	68.00	0.00	0.00	0.00	2.34	12.75	1.90	0.88	0.04	2.02	4.84	0.00	1.00	1.00	0.00	0.00	0.80
2	6	68.00	0.00	0.00	0.00	2.38	12.71	1.89	0.88	0.04	2.02	4.84	0.00	1.00	1.00	0.00	0.00	0.79
2	7	68.00	0.00	0.00	0.00	2.42	12.67	1.89	0.88	0.05	2.02	4.83	0.00	1.00	1.00	0.00	0.00	0.79
2	8	68.00	0.00	0.00	0.00	2.47	12.63	1.88	0.87	0.05	2.02	4.82	0.00	1.00	1.00	0.00	0.00	0.78
2	9	68.00	0.00	0.00	0.00	2.51	12.59	1.88	0.87	0.05	2.02	4.82	0.00	1.00	1.00	0.00	0.00	0.78
2	10	68.00	0.00	0.00	0.00	2.55	12.55	1.87	0.87	0.05	2.02	4.81	0.00	1.00	1.00	0.00	0.00	0.77
2	11	68.00	0.00	0.00	0.00	2.60	12.52	1.87	0.87	0.05	2.03	4.81	0.00	1.00	1.00	0.00	0.00	0.77
2	12	68.00	0.00	0.00	0.00	2.64	12.48	1.86	0.86	0.05	2.03	4.81	0.00	1.00	1.00	0.00	0.00	0.76
2	13	68.00	0.00	0.00	0.00	2.69	12.45	1.86	0.86	0.05	2.03	4.80	0.00	1.00	1.00	0.00	0.00	0.76
2	14	68.00	0.00	0.00	0.00	2.73	12.42	1.85	0.86	0.05	2.03	4.80	0.00	1.00	1.00	0.00	0.00	0.76
2	15	68.00	0.00	0.00	0.00	2.77	12.38	1.85	0.86	0.05	2.03	4.79	0.00	1.00	1.00	0.00	0.00	0.75
2	16	68.00	0.00	0.00	0.00	2.82	12.35	1.85	0.85	0.05	2.03	4.79	0.00	1.00	1.00	0.00	0.00	0.75
2	17	68.00	0.00	0.00	0.00	2.86	12.32	1.84	0.85	0.06	2.04	4.78	0.00	1.00	1.00	0.00	0.00	0.75
2	18	68.00	0.00	0.00	0.00	2.90	12.29	1.84	0.85	0.06	2.04	4.78	0.00	1.00	1.00	0.00	0.00	0.75

2	19	68.00	0.00	0.00	0.00	2.95	12.26	1.83	0.85	0.06	2.04	4.78	0.00	1.00	1.00	0.00	0.00	0.74
2	20	68.00	0.00	0.00	0.00	2.99	12.23	1.83	0.85	0.06	2.04	4.77	0.00	1.00	1.00	0.00	0.00	0.74
3	1	68.00	0.00	0.00	0.00	3.03	12.19	1.82	0.84	0.06	2.04	4.77	0.00	1.00	1.00	0.00	0.00	0.74
3	2	68.00	0.00	0.00	0.00	3.07	12.14	1.82	0.84	0.06	2.04	4.76	0.00	1.00	1.00	0.00	0.00	0.73
3	3	68.00	0.00	0.00	0.00	3.11	12.10	1.81	0.84	0.06	2.05	4.75	0.00	1.00	1.00	0.00	0.00	0.73
3	4	68.00	0.00	0.00	0.00	3.15	12.06	1.81	0.83	0.06	2.05	4.75	0.00	1.00	1.00	0.00	0.00	0.72
3	5	68.00	0.00	0.00	0.00	3.19	12.02	1.80	0.83	0.06	2.05	4.74	0.00	1.00	1.00	0.00	0.00	0.72
3	6	68.00	0.00	0.00	0.00	3.22	11.98	1.80	0.83	0.06	2.05	4.74	0.00	1.00	1.00	0.00	0.00	0.71
3	7	68.00	0.00	0.00	0.00	3.26	11.95	1.79	0.82	0.06	2.05	4.73	0.00	1.00	1.00	0.00	0.00	0.71
3	8	68.00	0.00	0.00	0.00	3.29	11.91	1.79	0.82	0.06	2.06	4.73	0.00	1.00	1.00	0.00	0.00	0.70
3	9	68.00	0.00	0.00	0.00	3.33	11.87	1.78	0.82	0.07	2.06	4.72	0.00	1.00	1.00	0.00	0.00	0.70
3	10	68.00	0.00	0.00	0.00	3.36	11.84	1.78	0.82	0.07	2.06	4.72	0.00	1.00	1.00	0.00	0.00	0.69
3	11	68.00	0.00	0.00	0.00	3.40	11.80	1.77	0.81	0.07	2.06	4.71	0.00	1.00	1.00	0.00	0.00	0.69
3	12	68.00	0.00	0.00	0.00	3.43	11.76	1.77	0.81	0.07	2.07	4.71	0.00	1.00	1.00	0.00	0.00	0.69
3	13	68.00	0.00	0.00	0.00	3.46	11.73	1.76	0.81	0.07	2.07	4.71	0.00	1.00	1.00	0.00	0.00	0.68
3	14	68.00	0.00	0.00	0.00	3.49	11.70	1.76	0.81	0.07	2.07	4.70	0.00	1.00	1.00	0.00	0.00	0.68
3	15	68.00	0.00	0.00	0.00	3.52	11.66	1.75	0.80	0.07	2.07	4.70	0.00	1.00	1.00	0.00	0.00	0.68

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

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
3	16	68.00	0.00	0.00	0.00	3.55	11.63	1.75	0.80	0.07	2.07	4.69	0.00	1.00	1.00	0.00	0.00	0.67
3	17	68.00	0.00	0.00	0.00	3.58	11.60	1.74	0.80	0.07	2.08	4.69	0.00	1.00	1.00	0.00	0.00	0.67
3	18	68.00	0.00	0.00	0.00	3.61	11.57	1.74	0.80	0.07	2.08	4.68	0.00	1.00	1.00	0.00	0.00	0.67
3	19	68.00	0.00	0.00	0.00	3.64	11.54	1.73	0.79	0.07	2.08	4.68	0.00	1.00	1.00	0.00	0.00	0.67
3	20	68.00	0.00	0.00	0.00	3.67	11.51	1.73	0.79	0.07	2.08	4.67	0.00	1.00	1.00	0.00	0.00	0.66
4	1	68.00	0.00	0.00	0.00	3.62	11.95	1.64	0.78	0.07	1.99	4.47	0.00	0.95	0.95	0.00	0.00	0.67
4	2	68.00	0.00	0.00	0.00	3.59	12.35	1.56	0.77	0.07	1.90	4.29	0.00	0.91	0.91	0.00	0.00	0.68
4	3	68.00	0.00	0.00	0.00	3.57	12.71	1.48	0.76	0.06	1.82	4.13	0.00	0.87	0.87	0.00	0.00	0.68
4	4	68.00	0.00	0.00	0.00	3.55	13.03	1.42	0.75	0.06	1.75	3.98	0.00	0.83	0.83	0.00	0.00	0.69
4	5	68.00	0.00	0.00	0.00	3.54	13.33	1.35	0.74	0.06	1.68	3.84	0.00	0.80	0.80	0.00	0.00	0.69
4	6	68.00	0.00	0.00	0.00	3.53	13.60	1.30	0.73	0.06	1.62	3.71	0.00	0.77	0.77	0.00	0.00	0.70
4	7	68.00	0.00	0.00	0.00	3.53	13.85	1.24	0.73	0.06	1.56	3.59	0.00	0.74	0.74	0.00	0.00	0.70
4	8	68.00	0.00	0.00	0.00	3.54	14.08	1.19	0.72	0.06	1.51	3.48	0.00	0.71	0.71	0.00	0.00	0.71
4	9	68.00	0.00	0.00	0.00	3.54	14.29	1.15	0.71	0.06	1.46	3.38	0.00	0.69	0.69	0.00	0.00	0.71
4	10	68.00	0.00	0.00	0.00	3.56	14.48	1.10	0.71	0.06	1.41	3.28	0.00	0.67	0.67	0.00	0.00	0.71
4	11	68.00	0.00	0.00	0.00	3.57	14.66	1.06	0.70	0.06	1.37	3.19	0.00	0.64	0.64	0.00	0.00	0.71
4	12	68.00	0.00	0.00	0.00	3.58	14.82	1.03	0.70	0.06	1.33	3.11	0.00	0.62	0.62	0.00	0.00	0.72
4	13	68.00	0.00	0.00	0.00	3.60	14.97	0.99	0.69	0.06	1.29	3.03	0.00	0.61	0.61	0.00	0.00	0.72
4	14	68.00	0.00	0.00	0.00	3.62	15.11	0.96	0.69	0.06	1.25	2.95	0.00	0.59	0.59	0.00	0.00	0.72
4	15	68.00	0.00	0.00	0.00	3.64	15.24	0.93	0.68	0.06	1.22	2.88	0.00	0.57	0.57	0.00	0.00	0.72
4	16	68.00	0.00	0.00	0.00	3.66	15.37	0.90	0.68	0.06	1.19	2.82	0.00	0.56	0.56	0.00	0.00	0.73
4	17	68.00	0.00	0.00	0.00	3.68	15.48	0.87	0.67	0.05	1.16	2.76	0.00	0.54	0.54	0.00	0.00	0.73
4	18	68.00	0.00	0.00	0.00	3.70	15.59	0.84	0.67	0.05	1.13	2.70	0.00	0.53	0.53	0.00	0.00	0.73
4	19	68.00	0.00	0.00	0.00	3.72	15.68	0.82	0.67	0.05	1.10	2.64	0.00	0.51	0.51	0.00	0.00	0.73
4	20	68.00	0.00	0.00	0.00	3.74	15.78	0.79	0.66	0.05	1.08	2.59	0.00	0.50	0.50	0.00	0.00	0.73
5	1	73.00	0.00	0.00	0.00	3.58	16.16	0.74	0.66	0.05	1.00	2.45	0.00	0.46	0.46	0.00	0.00	0.87
5	2	73.00	0.00	0.00	0.00	3.41	16.49	0.68	0.65	0.05	0.94	2.32	0.00	0.43	0.43	0.00	0.00	0.98
5	3	73.00	0.00	0.00	0.00	3.28	16.78	0.64	0.65	0.05	0.88	2.22	0.00	0.41	0.41	0.00	0.00	1.08
5	4	73.00	0.00	0.00	0.00	3.16	17.03	0.60	0.65	0.05	0.83	2.12	0.00	0.38	0.38	0.00	0.00	1.17
5	5	73.00	0.00	0.00	0.00	3.07	17.26	0.57	0.64	0.05	0.79	2.04	0.00	0.36	0.36	0.00	0.00	1.24
5	6	73.00	0.00	0.00	0.00	2.99	17.45	0.53	0.64	0.04	0.75	1.96	0.00	0.34	0.34	0.00	0.00	1.31
5	7	73.00	0.00	0.00	0.00	2.92	17.62	0.51	0.64	0.04	0.71	1.90	0.00	0.33	0.33	0.00	0.00	1.37
5	8	73.00	0.00	0.00	0.00	2.87	17.78	0.48	0.63	0.04	0.68	1.84	0.00	0.31	0.31	0.00	0.00	1.42

5	9	73.00	0.00	0.00	0.00	2.82	17.92	0.46	0.63	0.04	0.65	1.78	0.00	0.30	0.30	0.00	0.00	1.46
5	10	73.00	0.00	0.00	0.00	2.79	18.04	0.44	0.63	0.04	0.62	1.73	0.00	0.28	0.28	0.00	0.00	1.51
5	11	73.00	0.00	0.00	0.00	2.75	18.16	0.42	0.63	0.04	0.60	1.68	0.00	0.27	0.27	0.00	0.00	1.54
5	12	73.00	0.00	0.00	0.00	2.73	18.26	0.40	0.63	0.04	0.57	1.64	0.00	0.26	0.26	0.00	0.00	1.58
5	13	73.00	0.00	0.00	0.00	2.71	18.35	0.38	0.62	0.04	0.55	1.60	0.00	0.25	0.25	0.00	0.00	1.61
5	14	73.00	0.00	0.00	0.00	2.69	18.44	0.37	0.62	0.04	0.53	1.56	0.00	0.24	0.24	0.00	0.00	1.64
6	1	73.00	0.00	0.00	0.00	2.58	18.67	0.34	0.62	0.04	0.49	1.49	0.00	0.22	0.22	0.00	0.00	1.70

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

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

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
6	2	73.00	0.00	0.00	0.00	2.51	18.85	0.31	0.62	0.04	0.46	1.43	0.00	0.21	0.21	0.00	0.00	1.76
7	1	73.00	0.00	0.00	0.00	2.52	18.93	0.30	0.62	0.04	0.44	1.39	0.00	0.20	0.20	0.00	0.00	1.79
7	2	73.00	0.00	0.00	0.00	2.52	19.01	0.29	0.62	0.04	0.42	1.36	0.00	0.19	0.19	0.00	0.00	1.82
7	3	73.00	0.00	0.00	0.00	2.53	19.08	0.27	0.62	0.04	0.41	1.33	0.00	0.18	0.18	0.00	0.00	1.84
7	4	73.00	0.00	0.00	0.00	2.53	19.14	0.26	0.61	0.04	0.39	1.31	0.00	0.17	0.17	0.00	0.00	1.87
7	5	73.00	0.00	0.00	0.00	2.54	19.20	0.25	0.61	0.04	0.38	1.28	0.00	0.17	0.17	0.00	0.00	1.89
7	6	73.00	0.00	0.00	0.00	2.55	19.25	0.24	0.61	0.04	0.37	1.26	0.00	0.16	0.16	0.00	0.00	1.91
8	1	73.00	0.00	0.00	0.00	2.52	19.27	0.24	0.61	0.04	0.36	1.24	0.00	0.16	0.16	0.00	0.00	1.91
8	2	73.00	0.00	0.00	0.00	2.51	19.28	0.23	0.61	0.04	0.35	1.23	0.00	0.15	0.15	0.00	0.00	1.90
8	3	73.00	0.00	0.00	0.00	2.50	19.29	0.22	0.61	0.04	0.34	1.21	0.00	0.15	0.15	0.00	0.00	1.89
8	4	73.00	0.00	0.00	0.00	2.49	19.29	0.22	0.61	0.04	0.34	1.20	0.00	0.15	0.15	0.00	0.00	1.88
8	5	73.00	0.00	0.00	0.00	2.49	19.30	0.21	0.60	0.04	0.33	1.18	0.00	0.14	0.14	0.00	0.00	1.88
8	6	73.00	0.00	0.00	0.00	2.48	19.30	0.21	0.60	0.04	0.32	1.17	0.00	0.14	0.14	0.00	0.00	1.87
8	7	73.00	0.00	0.00	0.00	2.48	19.30	0.20	0.60	0.04	0.32	1.16	0.00	0.14	0.14	0.00	0.00	1.87
8	8	73.00	0.00	0.00	0.00	2.48	19.30	0.20	0.60	0.04	0.31	1.15	0.00	0.13	0.13	0.00	0.00	1.86
9	1	73.00	0.00	0.00	0.00	2.52	19.33	0.25	0.60	0.04	0.36	1.24	0.00	0.13	0.13	0.00	0.00	1.88
9	2	73.00	0.00	0.00	0.00	2.54	19.36	0.29	0.60	0.04	0.41	1.34	0.00	0.13	0.13	0.00	0.00	1.89
9	3	73.00	0.00	0.00	0.00	2.55	19.39	0.34	0.60	0.04	0.45	1.42	0.00	0.12	0.12	0.00	0.00	1.91
9	4	73.00	0.00	0.00	0.00	2.57	19.42	0.38	0.60	0.04	0.49	1.51	0.00	0.12	0.12	0.00	0.00	1.93
9	5	73.00	0.00	0.00	0.00	2.59	19.44	0.42	0.60	0.04	0.53	1.58	0.00	0.12	0.12	0.00	0.00	1.94
9	6	73.00	0.00	0.00	0.00	2.61	19.46	0.46	0.59	0.04	0.57	1.66	0.00	0.11	0.11	0.00	0.00	1.95
10	1	73.00	0.00	0.00	0.00	2.66	19.43	0.47	0.59	0.04	0.57	1.67	0.00	0.12	0.12	0.00	0.00	1.95
10	2	73.00	0.00	0.00	0.00	2.72	19.39	0.47	0.59	0.04	0.58	1.69	0.00	0.12	0.12	0.00	0.00	1.95
10	3	73.00	0.00	0.00	0.00	2.79	19.36	0.48	0.59	0.04	0.59	1.70	0.00	0.13	0.13	0.00	0.00	1.95
10	4	73.00	0.00	0.00	0.00	2.85	19.32	0.49	0.59	0.04	0.60	1.71	0.00	0.13	0.13	0.00	0.00	1.95
10	5	73.00	0.00	0.00	0.00	2.91	19.28	0.49	0.59	0.04	0.61	1.73	0.00	0.14	0.14	0.00	0.00	1.95
10	6	73.00	0.00	0.00	0.00	2.97	19.25	0.50	0.58	0.04	0.61	1.74	0.00	0.14	0.14	0.00	0.00	1.95
10	7	73.00	0.00	0.00	0.00	3.03	19.21	0.50	0.58	0.04	0.62	1.75	0.00	0.15	0.15	0.00	0.00	1.95
10	8	73.00	0.00	0.00	0.00	3.08	19.18	0.51	0.58	0.04	0.63	1.77	0.00	0.15	0.15	0.00	0.00	1.95

10	9	73.00	0.00	0.00	0.00	3.14	19.14	0.52	0.58	0.05	0.64	1.78	0.00	0.15	0.15	0.00	0.00	1.95
10	10	73.00	0.00	0.00	0.00	3.19	19.11	0.52	0.58	0.05	0.65	1.79	0.00	0.16	0.16	0.00	0.00	1.95
10	11	73.00	0.00	0.00	0.00	3.24	19.07	0.53	0.58	0.05	0.65	1.80	0.00	0.16	0.16	0.00	0.00	1.94
10	12	73.00	0.00	0.00	0.00	3.30	19.04	0.53	0.57	0.05	0.66	1.82	0.00	0.17	0.17	0.00	0.00	1.94
10	13	73.00	0.00	0.00	0.00	3.34	19.00	0.54	0.57	0.05	0.67	1.83	0.00	0.17	0.17	0.00	0.00	1.94
10	14	73.00	0.00	0.00	0.00	3.39	18.97	0.55	0.57	0.05	0.68	1.84	0.00	0.17	0.17	0.00	0.00	1.94
10	15	73.00	0.00	0.00	0.00	3.44	18.94	0.55	0.57	0.05	0.68	1.85	0.00	0.18	0.18	0.00	0.00	1.94
10	16	73.00	0.00	0.00	0.00	3.48	18.90	0.56	0.57	0.05	0.69	1.87	0.00	0.18	0.18	0.00	0.00	1.94

STREAM QUALITY SIMULATION — OUTPUT PAGE NUMBER 10

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

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

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS: LIGHT *	NITRGN *	PHSPRS *
1	1	1	0.96	1.17	0.05	1.00	18.76	0.17	0.90	0.81	0.01	0.50	0.94	0.96
2	1	2	0.93	1.17	0.05	1.00	18.76	0.17	0.90	0.81	0.01	0.50	0.94	0.96
3	1	3	0.91	1.17	0.05	1.00	18.76	0.16	0.90	0.81	0.01	0.50	0.94	0.96
4	1	4	0.89	1.17	0.05	1.00	18.75	0.16	0.90	0.80	0.01	0.50	0.94	0.96
5	1	5	0.87	1.17	0.05	1.00	18.75	0.16	0.90	0.80	0.01	0.50	0.94	0.96
6	1	6	0.86	1.17	0.05	1.00	18.75	0.15	0.90	0.80	0.01	0.50	0.94	0.96
7	1	7	0.85	1.17	0.05	1.00	18.75	0.15	0.90	0.80	0.01	0.50	0.94	0.96
8	2	1	0.84	1.17	0.05	1.00	18.75	0.15	0.90	0.80	0.01	0.50	0.94	0.96
9	2	2	0.83	1.17	0.05	1.00	18.75	0.15	0.90	0.80	0.01	0.50	0.94	0.96
10	2	3	0.82	1.17	0.05	1.00	18.75	0.14	0.90	0.80	0.01	0.50	0.94	0.96
11	2	4	0.81	1.17	0.05	1.00	18.75	0.14	0.90	0.80	0.01	0.50	0.94	0.96
12	2	5	0.80	1.17	0.05	1.00	18.75	0.14	0.90	0.80	0.01	0.50	0.94	0.96
13	2	6	0.79	1.17	0.05	1.00	18.75	0.14	0.90	0.80	0.01	0.50	0.94	0.96
14	2	7	0.79	1.17	0.05	1.00	18.75	0.14	0.90	0.80	0.01	0.50	0.94	0.96
15	2	8	0.78	1.17	0.05	1.00	18.75	0.14	0.90	0.80	0.01	0.50	0.94	0.96
16	2	9	0.78	1.17	0.05	1.00	18.74	0.14	0.90	0.80	0.01	0.50	0.94	0.96
17	2	10	0.77	1.17	0.05	1.00	18.74	0.14	0.90	0.79	0.01	0.50	0.94	0.96
18	2	11	0.77	1.17	0.05	1.00	18.74	0.14	0.90	0.79	0.01	0.50	0.94	0.96
19	2	12	0.76	1.17	0.05	1.00	18.74	0.14	0.90	0.79	0.01	0.50	0.94	0.96
20	2	13	0.76	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96
21	2	14	0.76	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96
22	2	15	0.75	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96
23	2	16	0.75	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96
24	2	17	0.75	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96

25	2	18	0.75	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96
26	2	19	0.74	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96
27	2	20	0.74	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96
28	3	1	0.74	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96
29	3	2	0.73	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96
30	3	3	0.73	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96
31	3	4	0.72	1.17	0.05	1.00	18.74	0.13	0.90	0.79	0.01	0.50	0.94	0.96
32	3	5	0.72	1.17	0.05	1.00	18.74	0.13	0.90	0.78	0.01	0.50	0.94	0.96
33	3	6	0.71	1.17	0.05	1.00	18.74	0.13	0.90	0.78	0.01	0.50	0.94	0.96
34	3	7	0.71	1.17	0.05	1.00	18.74	0.13	0.90	0.78	0.01	0.50	0.94	0.96
35	3	8	0.70	1.17	0.05	1.00	18.74	0.12	0.90	0.78	0.01	0.50	0.94	0.96
36	3	9	0.70	1.17	0.05	1.00	18.74	0.12	0.90	0.78	0.01	0.50	0.94	0.96
37	3	10	0.69	1.17	0.05	1.00	18.74	0.12	0.90	0.78	0.01	0.50	0.94	0.96
38	3	11	0.69	1.17	0.05	1.00	18.74	0.12	0.90	0.78	0.01	0.50	0.94	0.96
39	3	12	0.69	1.17	0.05	1.00	18.74	0.12	0.90	0.78	0.01	0.50	0.93	0.96
40	3	13	0.68	1.17	0.05	1.00	18.74	0.12	0.90	0.78	0.01	0.50	0.93	0.96
41	3	14	0.68	1.17	0.05	1.00	18.74	0.12	0.90	0.78	0.01	0.50	0.93	0.96
42	3	15	0.68	1.17	0.05	1.00	18.74	0.12	0.90	0.78	0.01	0.50	0.93	0.96

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 11
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995

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

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
43	3	16	0.67	1.17	0.05	1.00	18.74	0.12	0.90	0.78	0.01	0.50	0.93	0.96
44	3	17	0.67	1.17	0.05	1.00	18.74	0.12	0.90	0.78	0.01	0.50	0.93	0.96
45	3	18	0.67	1.17	0.05	1.00	18.74	0.12	0.90	0.78	0.01	0.50	0.93	0.96
46	3	19	0.67	1.17	0.05	1.00	18.74	0.12	0.90	0.77	0.01	0.50	0.93	0.96
47	3	20	0.66	1.17	0.05	1.00	18.74	0.12	0.90	0.77	0.01	0.50	0.93	0.96
48	4	1	0.67	1.17	0.05	1.00	18.69	0.12	0.90	0.78	0.01	0.50	0.93	0.96
49	4	2	0.68	1.17	0.05	1.00	18.64	0.12	0.90	0.78	0.01	0.50	0.93	0.96
50	4	3	0.68	1.16	0.05	1.00	18.60	0.12	0.90	0.79	0.01	0.50	0.93	0.96
51	4	4	0.69	1.16	0.05	1.00	18.55	0.12	0.90	0.79	0.01	0.50	0.93	0.95
52	4	5	0.69	1.16	0.05	1.00	18.51	0.12	0.90	0.80	0.01	0.50	0.92	0.95
53	4	6	0.70	1.15	0.05	1.00	18.47	0.12	0.90	0.80	0.01	0.50	0.92	0.95
54	4	7	0.70	1.15	0.05	1.00	18.43	0.12	0.90	0.81	0.01	0.50	0.92	0.95
55	4	8	0.71	1.15	0.05	1.00	18.39	0.12	0.90	0.81	0.01	0.50	0.92	0.95
56	4	9	0.71	1.15	0.05	1.00	18.35	0.12	0.90	0.82	0.01	0.50	0.92	0.95
57	4	10	0.71	1.14	0.05	1.00	18.31	0.12	0.90	0.82	0.01	0.50	0.91	0.94
58	4	11	0.71	1.14	0.05	1.00	18.27	0.12	0.90	0.82	0.01	0.50	0.91	0.94
59	4	12	0.72	1.14	0.05	1.00	18.24	0.12	0.90	0.83	0.01	0.50	0.91	0.94
60	4	13	0.72	1.14	0.05	1.00	18.20	0.12	0.90	0.83	0.01	0.50	0.91	0.94
61	4	14	0.72	1.14	0.05	1.00	18.17	0.12	0.90	0.83	0.01	0.50	0.91	0.94
62	4	15	0.72	1.13	0.05	1.00	18.13	0.12	0.90	0.83	0.01	0.50	0.90	0.93
63	4	16	0.73	1.13	0.05	1.00	18.10	0.12	0.90	0.84	0.01	0.50	0.90	0.93
64	4	17	0.73	1.13	0.05	1.00	18.07	0.12	0.90	0.84	0.01	0.50	0.90	0.93
65	4	18	0.73	1.13	0.05	1.00	18.03	0.12	0.90	0.84	0.01	0.50	0.90	0.93
66	4	19	0.73	1.13	0.05	1.00	18.00	0.12	0.90	0.84	0.01	0.50	0.90	0.93
67	4	20	0.73	1.12	0.05	1.00	17.97	0.12	0.90	0.85	0.01	0.50	0.90	0.93
68	5	1	0.87	1.27	0.06	1.07	17.88	0.17	0.90	0.85	0.01	0.50	0.89	0.92
69	5	2	0.98	1.26	0.06	1.07	17.80	0.19	0.90	0.86	0.01	0.50	0.89	0.92
70	5	3	1.08	1.26	0.06	1.07	17.72	0.21	0.90	0.87	0.01	0.50	0.88	0.91
71	5	4	1.17	1.25	0.06	1.07	17.65	0.22	0.90	0.87	0.01	0.50	0.88	0.91
72	5	5	1.24	1.25	0.06	1.07	17.58	0.23	0.90	0.88	0.01	0.50	0.88	0.90
73	5	6	1.31	1.24	0.06	1.07	17.51	0.25	0.90	0.89	0.01	0.50	0.87	0.90
74	5	7	1.37	1.24	0.06	1.07	17.45	0.26	0.90	0.89	0.01	0.50	0.87	0.89

75	5	8	1.42	1.23	0.06	1.07	17.39	0.26	0.90	0.89	0.01	0.50	0.87	0.89
76	5	9	1.46	1.23	0.06	1.07	17.33	0.27	0.90	0.90	0.01	0.50	0.86	0.88
77	5	10	1.51	1.23	0.06	1.07	17.28	0.28	0.90	0.90	0.01	0.50	0.86	0.88
78	5	11	1.54	1.22	0.06	1.07	17.23	0.28	0.90	0.90	0.01	0.50	0.86	0.87
79	5	12	1.58	1.22	0.06	1.07	17.18	0.29	0.90	0.91	0.01	0.50	0.86	0.87
80	5	13	1.61	1.22	0.06	1.07	17.13	0.29	0.90	0.91	0.01	0.50	0.85	0.86
81	5	14	1.64	1.21	0.06	1.07	17.09	0.30	0.90	0.91	0.01	0.50	0.85	0.86
82	6	1	1.70	1.21	0.06	1.07	16.98	0.31	0.90	0.92	0.01	0.50	0.85	0.85

STREAM QUALITY SIMULATION   OUTPUT PAGE NUMBER 12
QUAL-2E STREAM QUALITY ROUTING MODEL   Version 3.21 - Feb. 1995

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

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
83	6	2	1.76	1.19	0.06	1.07	16.78	0.31	0.90	0.92	0.01	0.50	0.84	0.84
84	7	1	1.79	1.18	0.06	1.07	16.66	0.32	0.90	0.93	0.01	0.50	0.84	0.83
85	7	2	1.82	1.17	0.06	1.07	16.54	0.32	0.90	0.93	0.01	0.50	0.84	0.83
86	7	3	1.84	1.17	0.06	1.07	16.42	0.32	0.90	0.93	0.01	0.50	0.84	0.82
87	7	4	1.87	1.16	0.06	1.07	16.31	0.32	0.90	0.93	0.01	0.50	0.83	0.81
88	7	5	1.89	1.15	0.06	1.07	16.20	0.33	0.90	0.94	0.01	0.50	0.83	0.81
89	7	6	1.91	1.14	0.06	1.07	16.08	0.33	0.90	0.94	0.01	0.50	0.83	0.80
90	8	1	1.91	1.14	0.06	1.07	16.00	0.33	0.90	0.94	0.01	0.50	0.83	0.80
91	8	2	1.90	1.13	0.06	1.07	15.92	0.32	0.90	0.94	0.01	0.50	0.83	0.79
92	8	3	1.89	1.12	0.06	1.07	15.84	0.32	0.90	0.94	0.01	0.50	0.83	0.79
93	8	4	1.88	1.12	0.06	1.07	15.76	0.32	0.90	0.94	0.01	0.50	0.82	0.79
94	8	5	1.88	1.11	0.06	1.07	15.68	0.31	0.90	0.94	0.01	0.50	0.82	0.78
95	8	6	1.87	1.11	0.06	1.07	15.60	0.31	0.90	0.94	0.01	0.50	0.82	0.78
96	8	7	1.87	1.10	0.06	1.07	15.52	0.31	0.90	0.94	0.01	0.50	0.82	0.77
97	8	8	1.86	1.10	0.06	1.07	15.45	0.31	0.90	0.95	0.01	0.50	0.82	0.77
98	9	1	1.88	1.09	0.06	1.07	15.34	0.31	0.90	0.94	0.01	0.50	0.83	0.77
99	9	2	1.89	1.08	0.06	1.07	15.24	0.31	0.90	0.93	0.01	0.50	0.83	0.76
100	9	3	1.91	1.08	0.06	1.07	15.14	0.31	0.90	0.92	0.01	0.50	0.84	0.76
101	9	4	1.93	1.07	0.06	1.07	15.05	0.31	0.90	0.92	0.01	0.50	0.84	0.75
102	9	5	1.94	1.06	0.06	1.07	14.95	0.31	0.90	0.91	0.01	0.50	0.85	0.75
103	9	6	1.95	1.05	0.06	1.07	14.85	0.31	0.90	0.90	0.01	0.50	0.85	0.74
104	10	1	1.95	1.07	0.06	1.07	15.00	0.31	0.90	0.90	0.01	0.50	0.85	0.75
105	10	2	1.95	1.08	0.06	1.07	15.14	0.31	0.90	0.90	0.01	0.50	0.85	0.76
106	10	3	1.95	1.08	0.06	1.07	15.27	0.32	0.90	0.90	0.01	0.50	0.86	0.76
107	10	4	1.95	1.09	0.06	1.07	15.39	0.32	0.90	0.90	0.01	0.50	0.86	0.77
108	10	5	1.95	1.10	0.06	1.07	15.50	0.32	0.90	0.90	0.01	0.50	0.86	0.77
109	10	6	1.95	1.11	0.06	1.07	15.61	0.32	0.90	0.90	0.01	0.50	0.86	0.78
110	10	7	1.95	1.12	0.06	1.07	15.71	0.33	0.90	0.89	0.01	0.50	0.86	0.78

111	10	8	1.95	1.12	0.06	1.07	15.81	0.33	0.90	0.89	0.01	0.50	0.86	0.79
112	10	9	1.95	1.13	0.06	1.07	15.90	0.33	0.90	0.89	0.01	0.50	0.86	0.79
113	10	10	1.95	1.14	0.06	1.07	15.98	0.33	0.90	0.89	0.01	0.50	0.86	0.80
114	10	11	1.94	1.14	0.06	1.07	16.07	0.33	0.90	0.89	0.01	0.50	0.86	0.80
115	10	12	1.94	1.15	0.06	1.07	16.14	0.33	0.90	0.89	0.01	0.50	0.86	0.81
116	10	13	1.94	1.15	0.06	1.07	16.22	0.34	0.90	0.89	0.01	0.50	0.86	0.81
117	10	14	1.94	1.16	0.06	1.07	16.29	0.34	0.90	0.88	0.01	0.50	0.86	0.81
118	10	15	1.94	1.16	0.06	1.07	16.36	0.34	0.90	0.88	0.01	0.50	0.86	0.82
119	10	16	1.94	1.17	0.06	1.07	16.42	0.34	0.90	0.88	0.01	0.50	0.86	0.82

STREAM QUALITY SIMULATION　　　　OUTPUT PAGE NUMBER 13

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

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-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	68.00	9.12	2.28	6.84	0.00	1.00	334.95	68.40	-1.74	-51.56	0.17	-4.00	-0.08
2	1	2	68.00	9.12	2.21	6.91	0.00	1.00	38.43	69.09	-1.73	-48.64	0.17	-3.97	-0.15
3	1	3	68.00	9.12	2.18	6.94	0.00	1.00	35.59	69.45	-1.72	-46.19	0.16	-3.94	-0.21
4	1	4	68.00	9.12	2.16	6.96	0.00	1.00	33.20	69.59	-1.71	-44.09	0.16	-3.92	-0.26
5	1	5	68.00	9.12	2.17	6.96	0.00	1.00	31.15	69.57	-1.70	-42.27	0.16	-3.90	-0.30
6	1	6	68.00	9.12	2.18	6.94	0.00	1.00	29.38	69.43	-1.69	-40.67	0.15	-3.88	-0.33
7	1	7	68.00	9.12	2.20	6.92	0.00	1.00	27.83	69.21	-1.69	-39.24	0.15	-3.86	-0.36
8	2	1	68.00	9.12	2.21	6.91	0.00	1.00	27.04	69.08	-1.68	-43.10	0.15	-3.85	-0.39
9	2	2	68.00	9.12	2.24	6.88	0.00	1.00	25.76	68.84	-1.67	-41.64	0.15	-3.83	-0.42
10	2	3	68.00	9.12	2.27	6.85	0.00	1.00	24.61	68.53	-1.67	-40.33	0.14	-3.82	-0.44
11	2	4	68.00	9.12	2.30	6.82	0.00	1.00	23.56	68.19	-1.66	-39.13	0.14	-3.80	-0.46
12	2	5	68.00	9.12	2.34	6.78	0.00	1.00	22.63	67.81	-1.66	-38.04	0.14	-3.79	-0.48
13	2	6	68.00	9.12	2.38	6.74	0.00	1.00	21.78	67.41	-1.65	-37.04	0.14	-3.78	-0.50
14	2	7	68.00	9.12	2.42	6.70	0.00	1.00	21.00	67.00	-1.65	-36.12	0.14	-3.76	-0.51
15	2	8	68.00	9.12	2.47	6.66	0.00	1.00	20.28	66.57	-1.64	-35.26	0.14	-3.75	-0.53
16	2	9	68.00	9.12	2.51	6.61	0.00	1.00	19.62	66.13	-1.64	-34.47	0.14	-3.74	-0.54
17	2	10	68.00	9.12	2.55	6.57	0.00	1.00	19.00	65.69	-1.63	-33.73	0.14	-3.73	-0.56
18	2	11	68.00	9.12	2.60	6.53	0.00	1.00	18.43	65.25	-1.63	-33.04	0.14	-3.72	-0.57
19	2	12	68.00	9.12	2.64	6.48	0.00	1.00	17.90	64.81	-1.62	-32.39	0.14	-3.71	-0.58
20	2	13	68.00	9.12	2.69	6.44	0.00	1.00	17.40	64.36	-1.62	-31.78	0.13	-3.69	-0.59
21	2	14	68.00	9.12	2.73	6.39	0.00	1.00	16.94	63.92	-1.61	-31.20	0.13	-3.68	-0.60
22	2	15	68.00	9.12	2.77	6.35	0.00	1.00	16.50	63.49	-1.61	-30.66	0.13	-3.67	-0.61
23	2	16	68.00	9.12	2.82	6.31	0.00	1.00	16.09	63.05	-1.61	-30.14	0.13	-3.66	-0.62

24	2	17	68.00	9.12	2.86	6.26	0.00	1.00	15.70	62.62	-1.60	-29.65	0.13	-3.65	-0.63
25	2	18	68.00	9.12	2.90	6.22	0.00	1.00	15.33	62.20	-1.60	-29.19	0.13	-3.64	-0.64
26	2	19	68.00	9.12	2.95	6.18	0.00	1.00	14.98	61.78	-1.59	-28.75	0.13	-3.63	-0.64
27	2	20	68.00	9.12	2.99	6.14	0.00	1.00	14.65	61.36	-1.59	-28.33	0.13	-3.62	-0.65
28	3	1	68.00	9.12	3.03	6.10	0.00	1.00	9.46	60.97	-1.58	-30.77	0.13	-3.61	-0.67
29	3	2	68.00	9.12	3.07	6.06	0.00	1.00	9.33	60.55	-1.58	-30.47	0.13	-3.60	-0.68
30	3	3	68.00	9.12	3.11	6.02	0.00	1.00	9.20	60.15	-1.57	-30.18	0.13	-3.58	-0.69
31	3	4	68.00	9.12	3.15	5.98	0.00	1.00	9.08	59.76	-1.57	-29.89	0.13	-3.57	-0.70
32	3	5	68.00	9.12	3.19	5.94	0.00	1.00	8.96	59.38	-1.56	-29.62	0.13	-3.56	-0.71
33	3	6	68.00	9.12	3.22	5.90	0.00	1.00	8.84	59.01	-1.56	-29.35	0.13	-3.55	-0.72
34	3	7	68.00	9.12	3.26	5.86	0.00	1.00	8.73	58.64	-1.55	-29.09	0.13	-3.53	-0.73
35	3	8	68.00	9.12	3.29	5.83	0.00	1.00	8.62	58.29	-1.55	-28.83	0.12	-3.52	-0.74
36	3	9	68.00	9.12	3.33	5.79	0.00	1.00	8.51	57.94	-1.54	-28.59	0.12	-3.51	-0.74
37	3	10	68.00	9.12	3.36	5.76	0.00	1.00	8.41	57.60	-1.54	-28.35	0.12	-3.50	-0.75
38	3	11	68.00	9.12	3.40	5.73	0.00	1.00	8.31	57.26	-1.53	-28.11	0.12	-3.49	-0.76
39	3	12	68.00	9.12	3.43	5.69	0.00	1.00	8.21	56.93	-1.53	-27.88	0.12	-3.48	-0.76
40	3	13	68.00	9.12	3.46	5.66	0.00	1.00	8.12	56.61	-1.52	-27.66	0.12	-3.47	-0.77
41	3	14	68.00	9.12	3.49	5.63	0.00	1.00	8.03	56.30	-1.52	-27.44	0.12	-3.46	-0.78
42	3	15	68.00	9.12	3.52	5.60	0.00	1.00	7.94	55.99	-1.52	-27.23	0.12	-3.45	-0.78

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 14
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-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)						
43	3	16	68.00	9.12	3.55	5.57	0.00	1.00	7.85	55.69	-1.51	-27.03	0.12	-3.44	-0.78
44	3	17	68.00	9.12	3.58	5.54	0.00	1.00	7.76	55.39	-1.51	-26.82	0.12	-3.42	-0.79
45	3	18	68.00	9.12	3.61	5.51	0.00	1.00	7.68	55.10	-1.50	-26.63	0.12	-3.41	-0.79
46	3	19	68.00	9.12	3.64	5.48	0.00	1.00	7.60	54.81	-1.50	-26.43	0.12	-3.41	-0.80
47	3	20	68.00	9.12	3.67	5.45	0.00	1.00	7.52	54.53	-1.50	-26.24	0.12	-3.40	-0.80
48	4	1	68.00	9.12	3.62	5.50	0.00	1.00	19.42	55.01	-1.55	-29.74	0.12	-3.35	-0.78
49	4	2	68.00	9.12	3.59	5.53	0.00	1.00	18.79	55.34	-1.61	-29.02	0.12	-3.30	-0.76
50	4	3	68.00	9.12	3.57	5.56	0.00	1.00	18.21	55.58	-1.65	-28.35	0.12	-3.26	-0.74
51	4	4	68.00	9.12	3.55	5.57	0.00	1.00	17.66	55.75	-1.69	-27.72	0.12	-3.22	-0.72
52	4	5	68.00	9.12	3.54	5.58	0.00	1.00	17.16	55.85	-1.73	-27.13	0.12	-3.18	-0.71
53	4	6	68.00	9.12	3.53	5.59	0.00	1.00	16.69	55.89	-1.77	-26.58	0.12	-3.15	-0.70
54	4	7	68.00	9.12	3.53	5.59	0.00	1.00	16.25	55.89	-1.80	-26.06	0.12	-3.12	-0.69
55	4	8	68.00	9.12	3.54	5.59	0.00	1.00	15.83	55.86	-1.83	-25.57	0.12	-3.09	-0.68
56	4	9	68.00	9.12	3.54	5.58	0.00	1.00	15.44	55.78	-1.86	-25.11	0.12	-3.06	-0.67
57	4	10	68.00	9.12	3.56	5.57	0.00	1.00	15.06	55.68	-1.88	-24.67	0.12	-3.04	-0.66
58	4	11	68.00	9.12	3.57	5.56	0.00	1.00	14.71	55.56	-1.91	-24.25	0.12	-3.01	-0.65
59	4	12	68.00	9.12	3.58	5.54	0.00	1.00	14.38	55.41	-1.93	-23.86	0.12	-2.99	-0.65
60	4	13	68.00	9.12	3.60	5.52	0.00	1.00	14.07	55.25	-1.95	-23.48	0.12	-2.97	-0.64
61	4	14	68.00	9.12	3.62	5.51	0.00	1.00	13.77	55.07	-1.96	-23.12	0.12	-2.94	-0.64
62	4	15	68.00	9.12	3.64	5.49	0.00	1.00	13.49	54.88	-1.98	-22.78	0.12	-2.92	-0.63
63	4	16	68.00	9.12	3.66	5.47	0.00	1.00	13.22	54.68	-2.00	-22.45	0.12	-2.91	-0.63
64	4	17	68.00	9.12	3.68	5.45	0.00	1.00	12.97	54.47	-2.01	-22.14	0.12	-2.89	-0.62
65	4	18	68.00	9.12	3.70	5.42	0.00	1.00	12.72	54.25	-2.03	-21.84	0.12	-2.87	-0.62
66	4	19	68.00	9.12	3.72	5.40	0.00	1.00	12.48	54.02	-2.04	-21.55	0.12	-2.85	-0.62
67	4	20	68.00	9.12	3.74	5.38	0.00	1.00	12.26	53.80	-2.05	-21.27	0.12	-2.84	-0.61
68	5	1	73.00	8.64	3.58	5.07	0.00	1.00	42.79	48.72	-2.39	-56.26	0.17	-3.51	-0.67
69	5	2	73.00	8.64	3.41	5.23	0.00	1.00	41.05	44.71	-2.44	-53.98	0.19	-3.49	-0.64
70	5	3	73.00	8.64	3.28	5.37	0.00	1.00	39.49	45.87	-2.48	-51.94	0.21	-3.47	-0.62
71	5	4	73.00	8.64	3.16	5.48	0.00	1.00	38.07	46.83	-2.52	-50.08	0.22	-3.45	-0.60
72	5	5	73.00	8.64	3.07	5.57	0.00	1.00	36.78	47.63	-2.55	-48.40	0.23	-3.44	-0.59
73	5	6	73.00	8.64	2.99	5.65	0.00	1.00	35.60	48.31	-2.58	-46.86	0.25	-3.42	-0.57
74	5	7	73.00	8.64	2.92	5.72	0.00	1.00	34.52	48.87	-2.60	-45.44	0.26	-3.41	-0.56

75	5	8	73.00	8.64	2.87	5.77	0.00	1.00	33.52	49.34	-2.63	-44.13	0.26	-3.39	-0.55
76	5	9	73.00	8.64	2.82	5.82	0.00	1.00	32.59	49.74	-2.65	-42.91	0.27	-3.38	-0.54
77	5	10	73.00	8.64	2.79	5.86	0.00	1.00	31.73	50.06	-2.67	-41.78	0.28	-3.37	-0.54
78	5	11	73.00	8.64	2.75	5.89	0.00	1.00	30.93	50.33	-2.68	-40.73	0.28	-3.36	-0.53
79	5	12	73.00	8.64	2.73	5.92	0.00	1.00	30.17	50.55	-2.70	-39.75	0.29	-3.35	-0.53
80	5	13	73.00	8.64	2.71	5.94	0.00	1.00	29.45	50.73	-2.71	-38.82	0.29	-3.34	-0.52
81	5	14	73.00	8.64	2.69	5.95	0.00	1.00	28.79	50.87	-2.72	-37.95	0.30	-3.33	-0.52
82	6	1	73.00	8.64	2.58	6.06	0.00	1.00	48.80	51.82	-2.76	-54.75	0.31	-3.32	-0.50

STREAM QUALITY SIMULATION OUTPUT PAGE NUMBER 15
QUAL-2E STREAM QUALITY ROUTING MODEL Version 3.21 - Feb. 1995

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

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-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
83	6	2	73.00	8.64	2.51	6.14	0.00	1.00	46.61	52.44	-2.78	-52.29	0.31	-3.32	-0.48
84	7	1	73.00	8.64	2.52	6.12	0.00	1.00	35.66	52.32	-2.80	-33.60	0.32	-3.31	-0.48
85	7	2	73.00	8.64	2.52	6.12	0.00	1.00	34.78	52.30	-2.81	-32.78	0.32	-3.30	-0.48
86	7	3	73.00	8.64	2.53	6.12	0.00	1.00	33.95	52.27	-2.82	-32.00	0.32	-3.29	-0.47
87	7	4	73.00	8.64	2.53	6.11	0.00	1.00	33.18	52.23	-2.83	-31.27	0.32	-3.29	-0.47
88	7	5	73.00	8.64	2.54	6.10	0.00	1.00	32.44	52.17	-2.84	-30.59	0.33	-3.28	-0.47
89	7	6	73.00	8.64	2.55	6.10	0.00	1.00	31.75	52.09	-2.84	-29.94	0.33	-3.28	-0.47
90	8	1	73.00	8.64	2.52	6.13	0.00	1.00	17.93	52.34	-2.85	-44.69	0.33	-3.27	-0.47
91	8	2	73.00	8.64	2.51	6.14	0.00	1.00	17.66	52.44	-2.85	-44.02	0.32	-3.26	-0.48
92	8	3	73.00	8.64	2.50	6.15	0.00	1.00	17.40	52.52	-2.85	-43.38	0.32	-3.25	-0.48
93	8	4	73.00	8.64	2.49	6.15	0.00	1.00	17.15	52.58	-2.85	-42.75	0.32	-3.24	-0.49
94	8	5	73.00	8.64	2.49	6.16	0.00	1.00	16.91	52.62	-2.85	-42.16	0.31	-3.23	-0.49
95	8	6	73.00	8.64	2.48	6.16	0.00	1.00	16.68	52.64	-2.85	-41.58	0.31	-3.22	-0.50
96	8	7	73.00	8.64	2.48	6.16	0.00	1.00	16.45	52.65	-2.85	-41.02	0.31	-3.21	-0.51
97	8	8	73.00	8.64	2.48	6.16	0.00	1.00	16.24	52.65	-2.85	-40.49	0.31	-3.21	-0.51
98	9	1	73.00	8.64	2.52	6.13	0.00	1.00	27.80	52.36	-2.86	-26.25	0.31	-3.20	-0.51
99	9	2	73.00	8.64	2.54	6.11	0.00	1.00	27.34	52.20	-2.86	-25.82	0.31	-3.20	-0.51
100	9	3	73.00	8.64	2.55	6.09	0.00	1.00	26.90	52.03	-2.86	-25.40	0.31	-3.19	-0.51
101	9	4	73.00	8.64	2.57	6.07	0.00	1.00	26.47	51.87	-2.87	-25.00	0.31	-3.19	-0.50
102	9	5	73.00	8.64	2.59	6.05	0.00	1.00	26.06	51.70	-2.87	-24.62	0.31	-3.19	-0.50
103	9	6	73.00	8.64	2.61	6.03	0.00	1.00	25.67	51.54	-2.87	-24.25	0.31	-3.18	-0.50
104	10	1	73.00	8.64	2.66	5.99	0.00	1.00	4.48	57.54	-2.87	-22.94	0.31	-3.18	-0.51
105	10	2	73.00	8.64	2.72	5.92	0.00	1.00	4.47	63.23	-2.86	-22.87	0.31	-3.17	-0.52
106	10	3	73.00	8.64	2.79	5.86	0.00	1.00	4.45	62.54	-2.86	-22.80	0.32	-3.16	-0.53
107	10	4	73.00	8.64	2.85	5.79	0.00	1.00	4.44	61.88	-2.85	-22.73	0.32	-3.15	-0.54
108	10	5	73.00	8.64	2.91	5.73	0.00	1.00	4.42	61.23	-2.85	-22.67	0.32	-3.14	-0.55
109	10	6	73.00	8.64	2.97	5.67	0.00	1.00	4.41	60.59	-2.84	-22.60	0.32	-3.13	-0.56
110	10	7	73.00	8.64	3.03	5.62	0.00	1.00	4.40	59.98	-2.84	-22.53	0.33	-3.12	-0.57

111	10	8	73.00	8.64	3.08	5.56	0.00	1.00	4.38	59.38	-2.83	-22.46	0.33	-3.11	-0.58
112	10	9	73.00	8.64	3.14	5.50	0.00	1.00	4.37	58.79	-2.83	-22.40	0.33	-3.10	-0.58
113	10	10	73.00	8.64	3.19	5.45	0.00	1.00	4.36	58.22	-2.82	-22.33	0.33	-3.09	-0.59
114	10	11	73.00	8.64	3.24	5.40	0.00	1.00	4.34	57.67	-2.82	-22.27	0.33	-3.08	-0.60
115	10	12	73.00	8.64	3.30	5.35	0.00	1.00	4.33	57.13	-2.81	-22.20	0.33	-3.08	-0.61
116	10	13	73.00	8.64	3.34	5.30	0.00	1.00	4.32	56.60	-2.81	-22.14	0.34	-3.07	-0.61
117	10	14	73.00	8.64	3.39	5.25	0.00	1.00	4.30	56.08	-2.80	-22.07	0.34	-3.06	-0.62
118	10	15	73.00	8.64	3.44	5.20	0.00	1.00	4.29	55.58	-2.80	-22.01	0.34	-3.05	-0.63
119	10	16	73.00	8.64	3.48	5.16	0.00	1.00	4.28	55.10	-2.79	-21.95	0.34	-3.04	-0.63

ATTACHMENT C

GSD MONITORING FROM MAY 3 TO JULY 26, 2001

Galesburg Sanitary District

Cedar Fork Creek

Temperature, °C

Date	Farnham WQ7-0	Pearl 003	West 022	Henderson 028	McClure 029
5/3/01	14.4	15.5	17.2	17.4	19.3
5/11/01	15.3	15.1	15.7	16.3	17.0
5/14/01	13.3	14.5	14.2	14.6	14.7
5/17/01	17.2	16.6	16.6	17.3	17.4
6/8/01	14.7	14.7	17.0	17.0	19.1
6/15/01	17.2	18.1	18.8	18.9	19.7
6/22/01	15.4	16.2	18.4	19.0	19.4
6/30/01	13.8	13.1	13.8	14.1	15.0
7/3/01	16.5	19.2	20.2	19.8	19.7
7/12/01	21.2	22.7	27.1	25.6	29.1
7/18/01	19.9	22.7	22.8	22.5	22.9
7/26/01	18.8	21.9	27.5	19.8	20.0
Mean	16.5	17.8	19.1	18.5	19.4
Maximum	21.2	22.7	27.5	25.6	29.1

Galesburg Sanitary District

Cedar Fork Creek

Total Suspended Solids, mg/L

Date	Rainfall, inches	Farnham WQ7-0	Pearl 003	West 002	Henderson 028	McClure 029
5/3/01	0.11 (5/3)	45	4	11	4	59
5/11/01	1.26 (5/10)	31	51	40	33	47
5/14/01	0.27 (5/13) 0.32 (5/14)	540	420	480	400	450
5/17/01	1.62 (5/16)	110	244	196	142	126
6/8/01	0	4	6	4	2	33
6/15/01	0.64 (6/14)	24	20	6	130	16
6/22/01	0.10 (6/21)	5	6	5	3	8
6/30/01	0	15	6	4	2	6
7/3/01		12	56	71	40	170
7/12/01		26	8	4	4	15
7/18/01		103	201	108	53	49
7/26/01		436	8	7	16	123
Mean		113	86	78	69	92
Maximum		540	42	480	400	450

Galesburg Sanitary District

Cedar Fork Creek

Dissolved Oxygen Results, mg/L

Date	Time	Farnham WQ7-0	Pearl 003	West 002	Henderson 028	McClure 029
5/3/01	9:30-10:30 AM	10.60	11.32	15.26	19.21	12.70
5/11/01	10:30-11:30 AM	6.95	8.37	9.19	9.73	8.88
5/14/01	9:30-10:30 AM	9.57	9.86	9.75	9.72	9.47
5/17/01	9:00-10:00 AM	5.83	8.03	7.83	7.86	7.61
6/8/01	10:00-11:00 AM	9.03	10.28	12.27	12.79	12.62
6/15/01	10:30-11:30 AM	7.01	8.62	11.21	9.09	8.88
6/22/01	9:15-10:15 AM	9.15	10.34	14.76	13.70	10.74
6/30/01		10.03	11.42	13.38	14.41	15.34
7/3/01	10:30-11:30 AM	6.90	7.69	6.33	6.03	5.24
7/12/01	1:30-2:30 PM	17.20	23.72	19.30	19.99	15.84
7/18/01	9:45-10:30 AM	4.64	6.75	6.62	6.59	5.64
7/26/01	9:00-9:40 AM	7.10	13.20	18.99	13.36	7.10
Minimum		4.64	6.75	6.33	6.03	5.24

Galesburg Sanitary District

Cedar Fork Creek

Ammonia Results, mg/L

Date	Farnham WQ7-0	Pearl 003	West 002	Henderson 028	McClure 029
5/3/01	1.9	1.2	<0.3	0.4	<0.3
5/11/01	0.4	<0.3	0.4	0.4	0.6
5/14/01	0.3	0.4	0.7	0.4	0.7
5/17/01	<0.3	<0.3	0.4	0.4	0.4
6/8/01	<0.2	<0.2	<0.2	<0.2	<0.2
6/15/01	<0.2	<0.2	<0.2	<0.2	<0.2
6/22/01	<0.2	<0.2	<0.2	<0.2	<0.2
6/30/01	<0.4	<0.4	<0.4	<0.4	<0.4
7/3/01	0.2	0.6	1.0	1.0	0.9
7/12/01	<0.2	<0.2	0.2	0.2	0.2
7/18/01	<0.2	0.6	0.4	0.6	0.6
7/26/01	<0.2	<.02	<0.2	<0.2	0.2
Mean	0.3	0.3	0.3	0.3	0.3
Maximum	1.9	1.2	1.0	1.0	0.7

APPENDIX B

FEDERAL FUNDING SOURCES

A variety of funding sources are available to support implementation of the best management practices (BMP) and other management measures addressed in the total maximum daily load (TMDL) document. The following table provides a brief overview of several of these sources available at the federal level. Additional information on these sources is available from the U.S. Environmental Protection Agency publication titled *Catalog of Federal Funding Sources for Watershed Protection* (EPA 841-B-99-003). The publication presents information on 69 federal funding sources (grants and loans) that may be used to fund a variety of watershed protection projects. The information on funding sources is organized into categories including coastal waters, conservation, economic development, education, environmental justice, fisheries, forestry, Indian tribes, mining, pollution prevention, and wetlands. More information is also available at http://www.epa.gov/owow/watershed/funding.html/.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
EPA - PROGRAM GRANTS TO STATES Watersheds and Nonpoint Source Programs Branch, U.S. EPA Region 5			
Nonpoint Source Implementation Grants (319)	The 319 program provides formula grants to the States to implement nonpoint source projects and programs in accordance with Section 319 of the Clean Water Act.	States and Indian Tribes	Grants are awarded to a lead state agency. States and local organizations receiving 319 grants are required to provide 40 percent of program cost.
Water Quality Cooperative Agreements (104 (b)(3))	Grants are provided to support new approaches to meeting storm water, combined sewer outflows, sludge, and pretreatment requirements as well as enhancing State capabilities. Eligible projects usually include research, investigations, experiments, training, environmental technology demonstrations, surveys, and studies related to the causes, effects, extent, and prevention of pollution.	State water pollution control agencies, interstate agencies, local public agencies, Indian Tribes, nonprofit institutions, organizations, and individuals	Grants are awarded; matching is encouraged .

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Water Quality Management Planning (205 (J))	Formula grants are awarded to State water quality management agencies to carry out water quality planning. States are required to allocate at least 40 percent of funds to eligible Regional Public Comprehensive Planning Agencies (RPCPO) and Interstate Organizations (IO).	States	States are required to allocate at least 40 percent of funds to eligible RPCPOs and IOs.
State Revolving Funds (SRF)	EPA awards grant money to States to establish SRFs. Under the SRF program, Illinois has created revolving loan funds to provide independent and permanent sources of low-cost financing for a range of water quality infrastructure projects. States set loan terms, repayment periods, and other loan features. SRFs are available to fund a wide variety of water quality projects including all types of nonpoint source and estuary management projects, as well as more traditional wastewater treatment projects.	States	Grants are awarded to a lead agency. Loans are provided to eligible participants.
Capitalization Grants for State Revolving Funds	EPA awards grants to States to capitalize their Clean Water State Resolving Funds (SRF). The States, through the SRF, make loans for high priority water quality activities. Loans are used for water quality management activities.	States, Tribes, Puerto Rico, Territories, and DC	Grants are awarded to a lead agency. Loans are provided by the state to eligible participants. States are required to provide a 20 percent match
Capitalization Grants for Drinking Water State Revolving Funds	EPA awards grant money to Illinois for Drinking Water State Revolving Funds (DWSRF) creation. Illinois, through its DWSRF, provides loans for drinking water supply-related projects. Although the majority of loan money is intended for upgrades of infrastructure (public or private drinking water supplies), Illinois also has the option to use some of the DWSRF funds for source water protection, capacity development, drinking water programs, and operator certification programs. DWSRF emphasizes preventing contamination and enhancing water systems management.	States, Territories, U.S. possessions, and Indian Tribes.	Grants and loans are awarded to drinking water suppliers. A 20 percent match from the State is required.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Water Pollution Control Program Grants (Section 106)	This program authorizes EPA to provide assistance to States and interstate agencies to establish and implement ongoing water pollution control programs. Prevention and control measures supported include permitting, pollution control activities, surveillance, monitoring, and enforcement; advice and assistance to local agencies; and the provision of training and public information. The Section 106 programs help foster a watershed approach at the State level by looking at water quality problems holistically.	States, interstate agencies, and Indian Tribes	Funds are allotted among the State and Interstate Water Pollution Control agencies on the basis of the extent of water pollution problems in the respective States.
EPA - PROJECT GRANTS Watersheds and Nonpoint Source Programs Branch, U.S. EPA Region 5			
Great Lakes Program	EPA's Great Lakes Program issues awards assistance to projects affecting the Great Lakes Basin or in support of the U.S.-Canada Great Lakes Water Quality Agreement. Such activities include surveillance and monitoring of Great Lakes water quality and land use activities.	State water pollution control agencies, interstate agencies, other public or nonprofit agencies, institutions, organizations, and individuals	Project grants, use of property and equipment, provision of specialized services, and dissemination of technical information are the forms of assistance provided.
Pollution Prevention Grants Program	This program provides project grants to States to implement pollution prevention projects. The grant program is focused on institutionalizing multimedia pollution prevention (air, water, land).	States and Indian Tribes	Individual grants are awarded based on requests. States are required to provide at least 50 percent of total project costs
Wetlands Protection Development Grants Program	This program provides financial assistance to States, Indian Tribes, and local governments to support wetlands development or augmentation and enhancement of existing programs. Projects must clearly demonstrate a direct link to an increase in the group's ability to protect its wetland resources.	States, Indian Tribes, Interstate/Intertribal agencies, local governments	Project grants are used to fund individual projects. States or Tribes must provide a 25 percent match of the total project cost

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
NATURAL RESOURCES CONSERVATION SERVICE (NRCS)			
Environmental Quality Incentives Program (EQIP)	EQIP provides technical, financial, and educational assistance, half of it targeted to livestock-related natural resource concerns and the other half to more general conservation priorities. EQIP is available primarily in priority areas where there are significant natural resource concerns and objectives.	Non-federal landowners engaged in livestock operations or agricultural productions. Eligible land includes cropland, rangeland, pasture, forest land, and other farm and ranch lands	EQIP can provide up to 75 percent of costs of certain conservation practices. Incentive payments can be up to 100 percent for 3 years, paid at a flat rate. The maximum is $10,000 per person per year and $50,000 over the length of the contract.
Forestry Incentives Program (FIP)	FIP supports good forest management practices on privately owned, nonindustrial forest lands nationwide. FIP is designed to benefit the environment while meeting future demands for wood products. Eligible practices are tree planting, timber stand improvement, site preparation for natural regeneration, and other related activities. FIP's forest maintenance and reforestation provides numerous natural resource benefits, including reduced soil erosion and enhanced water quality and wildlife habitat. Land must be suitable for conversion from nonforest to forest land, for reforestation, or for improved forest management and be capable of producing marketable timber crops.	Private landowner of at least 10 acres and no more than 1,000 acres of nonindustrial forest or other suitable land. Individuals, groups, Indian Tribes, and corporations whose stocks are not publicly traded might be eligible provided they are not primarily manufacturing forest products or providing public utility services.	FIP provides no more than 65 percent of the total costs, with a maximum of $10,000 per person per year.
Small Watershed Program	This program works through local government sponsors and helps participants solve natural resource and related economic problems on a watershed basis. Projects include watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in watersheds of 250,000 or fewer acres. Technical and financial assistance is available for installation of works of improvement to protect, develop, and utilize the land and water resources in small watersheds.	Local or State agency, county, municipality, town or township, soil and water conservation district, flood prevention or flood control district, Indian Tribe or Tribal organization, or nonprofit agency with authority to carry out, maintain, and operate watershed improvement works	Assistance can cover 100 percent of flood prevention construction costs; 50 percent of construction costs related to agricultural water management, recreation and fish and wildlife; and none of the costs for other municipal and industrial water management. Technical assistance and counseling may also be provided.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Wetlands Reserve Program (WRP)	The Wetlands Reserve Program (WRP) is a voluntary program to restore and protect wetlands on private property. WRP provides landowners with financial incentives to enhance wetlands in exchange for retiring marginal agricultural land. Landowners may sell a conservation easement or enter into a cost-share restoration agreement. Landowners voluntarily limit future use of the land, yet retain private ownership. Landowners and the NRCS develop a plan for the restoration and maintenance of the wetland.	The easement participant must have owned the land for at least 1 year. An owner can be an individual, partnership, association, corporation, estate, trust, business or other legal entities, a State (when applicable), political subdivision of a State, or any agency thereof owning private land. Land must be restorable and suitable for wildlife benefits.	WRP provides three options to the landowner: *Permanent Easement*: USDA purchases easement (price is lesser of land value or payment cap.) USDA pays 100 percent of restoration costs. *30-year Easement*: Payment will be 75 percent of what would be paid for a permanent easement. USDA pays 75 percent of restoration costs. *Restoration Cost Share Agreement*: Agreement (min. 10 yr.) to restore degraded wetland habitat. USDA pays 75 percent of restoration costs.
Wildlife Habitat Incentives Program (WHIP)	WHIP is a voluntary program for people who want to develop and improve wildlife habitat on private land. It provides both technical assistance and cost sharing to help establish and improve fish and wildlife habitat. A wildlife habitat plan is developed that describes the landowner's goals for improving wildlife habitat, includes a list of practices and schedule for installing them, and details the steps necessary for maintenance.	Individuals must own or have control of the land under consideration, and cannot have the land already enrolled in programs that have a wildlife focus, such as the WRP, or use the land for mitigation.	USDA will pay up to 75 percent of installation costs and will provide technical assistance for successfully establishing habitat development projects.
Resource Conservation and Development Program (RC&D)	RC & D provides a way for local residents to work together and plan how they can actively solve environmental, economic, and social problems facing their communities. Assistance is available for planning and installation of approved projects specified in RC&D area plans, for land conservation, water management, community development, and environmental enhancement.	Must be an RC&D area authorized by the Secretary of Agriculture for assistance	Technical assistance Grants (as funding allows) up to 25 percent of total cost not to exceed $50,000. Financial assistance has not been available in recent years due to budget constraints. Local or State government must provide 10 percent of total cost and are also responsible for operation and maintenance.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Watershed Surveys and Planning	This program provides planning assistance to Federal, State and local agencies for the development of coordinated water and related land resources programs in watershed and river basins. Special priority is given to projects helping to solve problems of upstream rural community flooding, water quality improvement coming from agricultural nonpoint sources, wetland preservation, and drought management for agricultural and rural communities.	State, Federal, Indian tribes, or local agencies	Technical assistance is provided. Each cooperating agency is expected to fund its own participation.
Emergency Watershed Protection (EWP) Program	The EWP Program was set up to respond to emergencies created by natural disasters. All EWP work must reduce threats to life and property. It must be economically and environmentally defensible. EWP work can include a wide variety of measures ranging from reshaping and protecting eroded banks to reseeding damaged areas.	Public and private landowners are eligible for assistance but must be represented by a project sponsor who must be a public agency.	NRCS can fund up to 75 percent of total cost.
U.S. FOREST SERVICE			
Cooperative Forestry Assistance	Cooperative Forestry Assistance helps State Foresters or equivalent agencies with forest stewardship programs on private, State, local, and other non-Federal forest and rural lands, plus rural communities and urban areas. This assistance is provided through the following programs: Forest Stewardship Program, Stewardship Incentive Program, Economic Action Programs, Urban and Community Forestry Program, Cooperative Lands Forest Health Protection Program, and Cooperative Lands Fire Protection Program. These programs help to achieve ecosystem health and sustainability by improving wildlife habitat, conserving forest land, reforestation, improving soil and water quality, preventing and suppressing damaging insects and diseases, wildfire protection, expanding economies of rural communities, and improving urban environments.	State Forester or equivalent State agency can receive moneys. State agencies can provide these moneys to owners of non-Federal lands, rural communities, urban/municipal governments, nonprofit organizations, and State, local, and private agencies acting through State Foresters or equivalent.	Formula grants, project grants, and cost share programs are available as well as use of property and facilities.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Stewardship Incentive Program	The Stewardship Incentive Program provides technical and financial assistance to encourage nonindustrial private forest landowners to keep their lands and natural resources productive and healthy. Qualifying land includes rural lands with existing tree cover or land suitable for growing trees and which is owned by a private individual, group, association, corporation, Indian tribe, or other legal private entity.	Eligible landowners must have an approved Forest Stewardship Plan and own 1,000 or fewer acres of qualifying land. Authorizations may be obtained for exceptions of up to 5,000 acres.	Technical or financial assistance can be provided.
U.S. FISH AND WILDLIFE SERVICE			
Coastal Wetlands Planning, Protection, and Restoration Act	This program provides funds to assist States in pursuing coastal wetland conservation projects. Funds can be used for acquisition of interests in coastal lands or waters, and for restoration, enhancement, or management of coastal wetland ecosystems on a competitive basis with all coastal states.	All States bordering the Atlantic, Gulf and Pacific coasts, Great Lakes and other U.S. coastal territories	Project grants. Federal share of costs not to exceed 50 percent; Federal share may be increased to 75 percent if a coastal State has established a fund (1) for the acquisition of coastal wetlands, other natural areas, or open spaces, or (2) derived from a dedicated recurring source of moneys.
Partners for Wildlife Habitat Restoration Program	The Partners for Wildlife Program provides technical and financial assistance to private landowners through voluntary cooperative agreements in order to restore formerly degraded wetlands, native grasslands, riparian areas, and other habitats to conditions as natural as feasible. Under cooperative agreements, private landowners agree to maintain restoration projects as specified in the agreement but otherwise retain full control of the land. To date, the Partners for Wildlife Program has restored over 360,000 acres of wetlands, 128,000 acres of prairie grassland, 930 miles of riparian habitat, and 90 miles of in-stream aquatic habitat.	Private landowners (must enter into a cooperative agreement for a fixed term of at least 10 years)	Project grants (cooperative agreements) are provided. Program's goal is that no more than 60 percent of project cost is paid by Federal moneys (the program seeks remainder of cost share from landowners and nationally-based and local entities).

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Wildlife Conservation and Appreciation Program	The Wildlife Conservation and Appreciation Program provides grants to fund projects that bring together USFWS, State agencies, and private organizations and individuals. Projects include identification of significant problems that can adversely affect fish and wildlife and their habitats; actions to conserve species and their habitats; actions that will provide opportunities for the public to use and enjoy fish and wildlife through nonconsumptive activities; monitoring of species; and identification of significant habitats.	State fish and wildlife agencies	Project grants are provided.
North American Wetlands Conservation Act (NAWCA) Grant Program	The NAWCA grant program promotes long-term conservation of North American wetland ecosystems. Principal conservation actions supported by NAWCA are acquisition, enhancement and restoration of wetlands and wetlands-associated habitat.	Public or private, profit or nonprofit entities or individuals establishing public-private sector partnerships	Project grants (cooperative agreements and contracts) are provided. Cost-share partners must at least match grant funds 1:1 with U.S. non-federal dollars.
U.S. ARMY CORPS OF ENGINEERS			
Planning Assistance to States Program	The USACE to assist States, Indian Tribes local governments, and other non-Federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources under this program. The program can encompass many types of studies dealing with water resources issues. Typical studies are only planning level of detail. Types of studies conducted in recent years include water quality studies, flood plain management, environmental conservation, and many others.	States, Indian Tribes local governments, and other non-Federal entities	Federal allotments for each State or Tribe from the nation-wide appropriation are limited to $500,000 annually.

Cedar Creek
Knox County

TABLE OF CONTENTS

This document is Appendix C of the TMDL for Cedar Creek, prepared for USEPA.

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
(Illinois EPA)

IN THE MATTER OF:
CEDAR CREEK IN KNOX COUNTY
TOTAL MAXIMUM DAILY LOAD DLC #330-01

RESPONSIVENESS SUMMARY

The public hearing record opened on July 6, 2001, and closed on September 6, 2001. Written comments postmarked by midnight September 6, 2001, were included in the hearing record. This responsiveness summary responds to questions and comments received from July 6, 2001, through September 6, 2001 (postmarked) and comments from the August 7 public hearing.

WHAT IS A TMDL?

The Total Maximum Daily Load (TMDL) plan will detail the actions necessary to reduce pollutant loads to a segment of Cedar Creek. The Illinois EPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act. A TMDL is the sum of the allowable amount of a single pollutant (nutrients, siltation, etc.) that a waterbody can receive from all contributing sources and still meet water quality standards or designated uses.

BACKGROUND

The 5.95 mile Knox County Cedar Creek waterbody segment from Galesburg to the headwaters of Cedar Creek was identified in the 1998 Illinois Water Quality Report as having impaired waters for ammonia, siltation, dissolved oxygen and habitat alterations. The Illinois EPA contracted Tetra Tech EM Inc., Chicago, Illinois, to prepare a TMDL report for this waterbody segment. Public meetings were held in the city of Galesburg on September 23, 2000, and January 18, 2001. The public hearing on the proposed plan was held on August 7, 2001.

PUBLIC HEARING

Beginning July 6, 2001, the public hearing notice was published thrice (July 6, 14, 21) in the *Galesburg Register-Mail*. The public hearing notice was mailed on July 6, 2001, to persons on the Illinois EPA hearing officer mailing list. The Bureau of Water sent a letter of invitation to all persons who had registered at the public meetings or who had indicated an interest in the proceedings. The public hearing notice and TMDL plan was posted on the Illinois EPA Internet web site http://www.epa.state.il.us. The TMDL plan was available for review at the Galesburg Public Library.

The public hearing was held on Tuesday, August 7, 2001, at 6 p.m. in the public library in the city of Galesburg. Twenty-seven persons (not including Illinois EPA personnel) representing interested citizens, environmental engineers, Knox County Farm Bureau, Galesburg Sanitary District, Knox County Health Department, city of Galesburg, Prairie Partners to Great Lakes, Prairie Rivers Network, Illinois Department of Agriculture, Galesburg Broadcasting (WGIL 14), Citizen Organization Project and the United States Environmental Protection Agency attended the hearing. A court reporter prepared a transcript of the public hearing.

Comments and Questions in regular type.
Responses in bold.

Justification of TMDL

1. The IDOA questions whether a TMDL should have been developed for this segment of Cedar Creek. The draft TMDL states that the stream segment cannot be used for swimming and fishing "because of the physical limitations of the stream." As the draft TMDL document itself points out, the Illinois State Water Survey concluded that this segment of Cedar Creek is an ephemeral stream that can have several dry periods in a year. The 7Q10 is zero in all but March, April and May; and the 7Q2 is zero in August, September, and October, Soil scientists with the USDA-Natural Resources Conservation Service mapped the segment north of the City of Galesburg as an intermittent drainage way; north of Highway 34, the segment is a grassed waterway.

   The development of a TMDL for this headwater segment is appropriate as it is not in compliance with applicable water quality standards. The term "water quality standards" include numeric and narrative standards, designated uses, and anti-degradation. The outcome of this TMDL development work will be used as an input to the development of the TMDL for the entire Cedar Creek

2. IDOA does not believe that the water quality endpoints and the load reductions called for in this TMDL are realistic or that the ammonia as a nutrient is contributing to low dissolved oxygen levels in the stream. Director Hampton has committed the Illinois Department of Agriculture to a leadership role in addressing agricultural impacts on the surface waters of the state and the Department does believe that significant reductions in sediment and nutrient loads to the lakes and streams of the State are necessary and achievable. However, the Department believes that the problem definition must be based on sound science and that the proposed solutions must be justified and feasible. We conclude that, as presented, the TMDL for Cedar Creek fails to meet these criteria and should be re-evaluated.

   The water quality end-points used are either the standards promulgated by federal and state regulations or the statistical guidelines documented in the 2000 305(b) Water Quality Report. The use of statistical guidelines are appropriate as they are based upon sound statistical principles and a considerably large amount of database. It is a well established knowledge that ammonia-nitrogen is one among several factors that act as a sink for DO in a water column. Illinois EPA is glad to know about Director Hampton's commitment of IDOA to work toward achievement of water quality standards by appropriate reductions of sediment and nutrient loads to the Illinois waters. Further, the development of TMDLs in this portion of Cedar Creek is based upon currently available sound science. After the TMDL is approved by USEPA, Illinois EPA looks forward to working with IDOA and other federal, state, and local agencies and citizens toward implementation of

economically feasible and environmentally sound BMPs to accomplish our common water quality goals.

3. The draft TMDL (page 8) states, "The Cedar Creek segment is impaired as a result of nutrients, siltation and other habitat alterations that exceed water quality guidelines for general use waters (1998 Illinois 303[d] list)." However, the Department does not believe that the draft TMDL has demonstrated that this segment of Cedar Creek is impaired or that the proposed water quality endpoints are either appropriate or will result in any improvement in water quality.

   Please refer to page 6, section 2.6 of the draft TMDL document. This portion of the document addresses the basis for the listed causes of impairment. The purpose of the Cedar Creek TMDL is to document the causes and potential sources of impairment, and then to describe the approach that may be used to achieve all appropriate water quality uses. The water quality end-points used in the development of the TMDL are documented in the 2000 305(b) Report. Consequently, at the time this TMDL was started, the Illinois EPA believed that the statistical basis used in the establishment of numeric guidelines for the pollutants of concern was valid and appropriate. More recently we have reviewed the technical and legal basis for this statistically based approach to TMDL target-setting. In the future we plan to distinguish between water quality standards and other criteria, including statistically based values, through the use of "Confidence Levels." Since this TMDL was sufficiently far along in development and the "Confidence Level" approach has not been reviewed by the public or reflected in an updated 303(d) List, we were compelled to proceed with the TMDL targets established in both the 2000 305(b) Report and the 1998 303(d) List. When all recommended control measures are fully implemented, Illinois EPA believes that this segment of Cedar Creek will exhibit improvement in water quality. However, only a follow-up monitoring plan will demonstrate if this segment of Cedar Creek will have then achieved applicable water quality standards.

4. In June 2001, the National Academy of Science's National Research Council recommended changes in how the TMDL program is conducted. The Cedar Creek study is an example of some of the problems identified by the national Research Council in that much of the data relied upon were 16 years old and in lieu of more recent data which were available.

   Data used to determine the degree of impairment and whether this segment of Cedar Creek should be on the 1998 303(d) List may have included data older than five years. The actual TMDL was conducted using water quality data from several sources (Illinois EPA, USGS and the Galesburg Sanitary District) collected in the mid and late 1990s. Given the listing criteria established by USEPA at the time Cedar Creek was first identified as impaired and the subsequent collection and use of data, we believe the appropriate data were used and are recent and representative in nature.

5. The "calibrated" model in 5.0 predicts that with SOD at zero, the stream cannot meet the 6.0 mg/L D.O. standard, either upstream of the concrete channel or in the concrete channel. Doesn't this suggest the need to address a "use attainability" analysis with respect to D.O. in zero flow streams, and Cedar Creek in particular? Shouldn't this be a major component of the TMDL Study?

   In the draft TMDL document, section 5.0, nowhere is it stated that the DO standard of 6.0mg/L will not be met in the concrete channel after recommended control measures are fully implemented. Also, please see response to question #8 under General Comments.

6. The Illinois EPA should withdraw the proposed TMDL report on this segment of Cedar Creek and should study the entire Cedar Creek watershed as a whole and then make recommendations that are based on scientifically proven data and economically justifiable benefits.

   There is no justifiable reason to withdraw the TMDL developed for the headwater segment of Cedar Creek. An independent TMDL can be developed for small as well as large watersheds. The development of a TMDL for the remaining portion of Cedar Creek will be conducted in the next batch of watersheds to be addressed by the Illinois EPA. Please be assured that the outcome of the TMDL for the headwater segment will be used as an input in the development of the TMDL for the remaining portion of Cedar Creek. Also, sound scientific available tools have been utilized in the development of the TMDL for this portion of Cedar Creek.

Nutrient Loads and Dissolved Oxygen

{Note to the reader: During the development of the Draft TMDL, the Illinois EPA addressed nutrients and certain other constituents as "impaired" when water chemistry or other data indicated that concentrations of these constituents were above guidelines that had been based on a statistical derivation of statewide data for each constituent. For nutrients, those concentrations were based on concentrations for phosphorus, inorganic nitrogen or nitrates—impairment for inorganic nitrogen, for example, was set statistically at 7.8 mg/L for one sample in the most recent three years of data, for water samples collected at the Agency's Ambient Water Quality Monitoring Network.

Following the public hearing on this TMDL, the Illinois EPA reconsidered its approach on nutrient impairment and impairment by other constituents for which these statistically based guidelines had been applied. In developing the responses to questions on nutrient impairment, we have attempted to address the change in our approach to the use of these guidelines, and the emphasis on constituents for which water quality standards have been established. In short, although nutrients were identified as a potential cause of impairment on Cedar Creek, that determination was based on data that does not necessarily show violations of water quality standards. Therefore, the TMDL implementation plan will not emphasize reduction of nutrients but will rather focus on other potential causes that are supported by water quality standards.}

1. Page 1 of the executive summary states "Nutrient loads are primarily a concern in the upstream agricultural area where fertilizers are applied… Excess nutrient loads have resulted in elevated in-stream concentrations of ammonia-N which is a surrogate measure for nutrients considered in this analysis." The implication that ammonia-N is caused by agricultural sources and that it is a surrogate measure for nutrients goes well beyond the database included in the report. Similarly, we are not aware of any literature to justify this implication.

   In this headwater segment of Cedar Creek, upstream of the concrete channel, there is no known source/activity other than agriculture. At this point, one potential link to ammonia-nitrogen in the stream is agriculture. Also see response to question #9 under this section.

2. The implication that ammonia-N was caused by agricultural sources appears to have been based on four samples. It is unlikely that ammonia collected in August samples would be results from fertilizer applications. Virtually all fertilizer applications are made in the time period from late October to early December or late March to late May. The ammonia that is applied during those time periods will be rapidly converted to ammonium and when soils are warm on to nitrate. Based on these chemical reactions that are well documented – ammonia ✍ ammonium ✍ nitrate, it is difficult to understand

how ammonia could be used as a surrogate for nutrient contamination. If agriculture were a major contributor, we would expect nitrate contamination (report indicates that nitrate was not found to be in the excess of accepted standards) to be of concern, especially in August – September samples. The Henderson St. sampling position is located at the downstream end of a concrete-lined channel, 3 miles from the Farnham Rd. site and almost on the opposite side of Galesburg. If the dissolved ammonia is derived largely from agricultural land, we wouldn't expect an increase in concentration during urban stream flow, but that seems to be what happened. Unfortunately, no information has been provided as to sampling times at the different locations, and this could have had a considerable effect on concentration data, judging from Table 2 – 3.

While the Illinois EPA does not have time-varying data for ammonia nitrogen to adequately address the concerns raised, it is evident from data presented in Table 2-3 in Appendix A that agriculture is a contributor of ammonia-nitrogen in the portion of Cedar Creek for which the TMDL has been developed. The data collected at Farnham Road are reflections of agriculture as the primary contributor of ammonia nitrogen. The data collected at the downstream site (Henderson Street) are reflections of combined contributions of ammonia nitrogen from agriculture as well as urban areas. At Farnham Road the ammonia nitrogen concentrations of 1 and 0.5 mg/L were observed on August 30, 1994 and August 18, 1999, respectively. Both values are above the guideline for ammonia nitrogen (0.41 mg/L) given in the 2000 305(b) Report, which was used as a basis to develop the TMDL for this portion of Cedar Creek.

The three components of nutrients identified in the Illinois 2000 305(b) Report are total phosphorus, total ammonia nitrogen and nitrate nitrogen. Of the three components of nutrients, total phosphorus and nitrate nitrogen did not exceed the guidelines set forth in the 2000 305(b) Report. The third component of nutrients, total ammonia nitrogen, did exceed the guideline (0.41mg/L) provided in the 2000 305(b) Report. As there is no water quality standard or guideline in place for nutrients in streams, the component that exceeded the guideline (in this case, ammonia nitrogen) was the remaining surrogate for nutrients. At the time this TMDL was started, the Illinois EPA believed that the statistical basis used in the establishment of numeric guidelines for the pollutants of concern was valid and appropriate. More recently we have reviewed the technical and legal basis for this statistically based approach to TMDL target-setting. In the future we plan to distinguish between water quality standards and other criteria, including statistically based values, through the use of "Confidence Levels." Since this TMDL was sufficiently far along in development and the "Confidence Level" approach has not been reviewed by the public or reflected in an updated 303(d) List, we were compelled to proceed with the TMDL targets established in both the 2000 305(b) Report and the 1998 303(d) List. The Illinois EPA's current approach to the use of these statistically based guidelines is to allot them a low "Confidence Level." Alternatively, TMDL targets based on established water quality standards would receive a high "Confidence Level" and a TMDL would, under this approach, be developed sooner and with a greater degree of confidence in the outcome of the predictive model and implementation plan.

3. The fact that peak ammonia-N concentration occurred in the first flush of water implies to us that that it is not likely fertilizer derived. While ammonia is very soluble in water, any ammonia that was fertilizer derived would have had to move from the point of application – 6 – 8 inches into soil – to a tile line – usually 3 feet into the soil – and then into the water channel. It is unlikely this would have occurred in the first flush. Anhydrous ammonia reacts instantly with soil water to form NH_4OH, and the NH_4^+ thereby generated will bind to soil exchange sites. Transport of NH_4^+ through the profile is highly unlikely, except with a sand soil. It might occur through counterion transport in response to anion leaching, but NO_3^- is the primary anion that leaches from N-fertilized soils, and we know where that comes from. Most plausible explanations for the first flush observation might be an accumulation of microbial biomass in the tile lines that are producing ammonia; surface runoff that contained organic residue that quickly mineralized; or animal waste from livestock or wildlife. Since there were no reports of livestock facilities in the area, we doubt the problem was livestock waste.

   The non-point source discharges from the tiles are considered agricultural runoff, regardless of how the ammonia was produced. The ammonia within the system may be negligible. Also refer to responses to questions #1 and 9.

4. The concentration of ammonia in the water will depend on pH and the analytical process used to determine ammonia concentration. The complete lack of detail concerning sampling collection, storage, and analysis raises major concerns about data integrity.

   The Illinois EPA adheres to strict quality assurance and quality control procedures while performing chemical or biological sampling, transporting, storing, and analyzing. The purpose of the TMDL was not to address the specific techniques used in the collection, storage and analysis of water quality data. However, the Agency's water quality data and quality control protocols are available for public review.

5. There are inconsistencies in the report. In some places, low DO is blamed on ammonia-N, but in other places, the report implies that low DO is due to a lack of reaeration of the water. Do the authors know what causes low DO in this water body?

   Cedar Creek was listed on Illinois 303(d) list for nutrients. Ammonia-N was the only nutrient that exceeded Illinois EPA's guidelines and therefore was a focus of the TMDL. DO concentrations in the creek were also evaluated and modeled because concentrations of DO below water quality standards were observed in the creek. Elevated concentrations of ammonia-N were linked to low concentrations of DO along Cedar Creek as a hypothesis, not a conclusion. In fact, modeling results concluded that DO concentration were more affected by reaeration rates than ammonia-N loads, as stated on page 12 of the draft TMDL document. Consequently, reducing ammonia-N loads, while addressing the problems of

elevated concentrations of ammonia-N concentration in the creek and partially contributing to improved DO levels, would not be sufficient to improve DO concentrations in the creek.

6. The authors suggest that buffer strips and/or wetlands will work to remove ammonia-N. These systems will only be of help if the ammonia-N is coming from surface runoff and if such runoff travels through the constructed structures.

   The draft report states that ammonia-N is coming from non-point source surface water runoff. Buffer strips and wetlands are designed and implemented in areas where the runoff will be intercepted.

7. The decision to not examine nutrient pollutants other than ammonia was not well documented or well substantiated. There is no mention of whether total or dissolved phosphorus was considered as a pollutant of concern. Neither was there any mention of examining total nitrogen. The only other nutrient-based pollutant that was mentioned in the study was nitrate, and this was dismissed as unimportant because nitrate, "was not detected in Cedar Creek above its Illinois EPA guideline of 7.8 milligram per liter (*mg/l*) and therefore it is not a focus of this study". It should be noted that this level of nitrate is taken from the Agency's methodology for conducting its 305(b) assessments and is based only on 7.8 mg/l nitrate being the 85^{th} percentile of data collected over the past few years. There is no scientifically based connection between this level of nitrates and impairment.

   Total phosphorus, inorganic nitrogen (nitrate nitrogen) and nitrates were used in the 305(b) Report that resulted in the listing for "nutrients" as a potential cause of impairment. Each of these constituents was sampled through various Illinois EPA monitoring programs (i.e., the Ambient Water Quality Monitoring Network), and applicable water quality standards or statistical guidelines were used to gauge the results. As further described in the 305(b) Report, the assessment protocol explains how those data were evaluated and how determinations were made regarding possible impairment of the stream. Each of these parameters then became possible targets for the TMDL. All except nitrate are based on statistical guidelines, the 85 percentile of statewide data collected by the Illinois EPA. Nitrate was not used for this segment since the standard is based on the designated use as a drinking water supply. Therefore, the TMDL was done only for the nutrients that exceeded the statistical guidelines. As previously discussed in response to a question on the use of these guidelines, the Illinois EPA's current approach to the use of these statistically based guidelines is to allot them a low "confidence level." Alternatively, TMDL targets based on established water quality standards would receive a high "confidence level" and a TMDL would, under this approach, be developed sooner and with a greater degree of confidence in the outcome of the predictive model and implementation plan.

8. Our ability to evaluate whether ammonia is contributing to low dissolved oxygen levels was severely limited because the draft TMDL presents only selected water quality data for Cedar Creek. Because those data were the basis for placing the stream on the 303(d) list and are necessary for a fair technical review of the TMDL analysis, the entire data set for Cedar Creek should be presented. The following excerpts from the draft TMDL demonstrate the report's inconsistent and contradictory discussion of the role of ammonia as a nutrient causing low dissolved oxygen levels.

   "Ammonia-N, a surrogate measure for nutrients, and TSS and silt/mud percentages, surrogate measures of siltation, are the primary concern along the listed segment of Cedar Creek." (page 6)

   "In addition, dissolved oxygen (DO) concentrations have been identified as a concern because elevated nutrient loads are often linked to drops in DO concentration." (page 6)

   " . . . and an ammonia-N concentration of 0.41 mg/L has been identified by Illinois EPA as the water quality guidelines for assessing . . . nutrients; therefore . . . use of ammonia-N as a surrogate measure for nutrients is appropriate . . . The use of DO as an indicator for nutrient loading is also appropriate because low DO concentrations are known to be linked to elevated nutrient loads." (page 7)

   "In addition, DO is being used as an indicator of stream conditions impacted by excess nutrient loading." (page 8)

   "Periodic water quality monitoring conducted along the listed segment of the creek from 1985 to 2000 and QUAL2E model simulations indicated that DO is the primary concern during base-flow conditions. TSS and ammonia-N are not of concern because groundwater, which is the source of water in the creek during base-flow conditions, contains low TSS and ammonia-N concentrations."

   As stated above in response #5, the draft TMDL developed for Cedar Creek did not conclude that ammonia-N loads were the primary cause for low DO concentrations along the creek segment (see page 12 of the draft TMDL document); therefore, a complete set of data of all nutrient concentrations measured along the creek was not included. The draft TMDL includes all data used to place the listed segment of the creek on the 303(d) list, including ammonia-N, DO, and TSS concentrations and percent silt or mud, which are presented in Tables 2-2 and 2-3 in Appendix A. All nutrient data can be viewed by obtaining the following documents which are available through Illinois EPA:

   1) Illinois EPA. September 1991. "Facility Related Stream Survey, Biological and Water Quality Survey of Cedar Creek, (USEPA Reach Index 07080104-019) in the Vicinity of the Galesbrug Sanitary District Discharge, Knox County, Illinois." Prepared by Matthew Short and Bill Ettinger, Division of Water Pollution Control, Planning Section. Page 11.

   2) Illinois EPA. August 1994. "Biological and Water Quality Survey of Cedar

Creek USEPA Reach Index 07080104-019/on) in the Vicinity of the Galesburg Sanitary District Discharge." Prepared by Mark W. Joseph, Division of Water Pollution Control, Planning Section. Page 12.

3) Illinois EPA June 2000. "Biological and Water Quality Survey of Cedar Creek (USEPA Reach Index 07080104-019/on) in the Vicinity of the Galesburg Sanitary District Discharge, Knox County, Illinois." Prepared by J.E. Hefley, Division of Water Pollution Control, Planning Section. Table 2.

4) USGS. 1987. "Data-Collection Methods and Data Summary for the Assessment of Water Quality in Cedar Creek, West-Central Illinois." Report 87-543. Pages 98 through 108, 128 through 131, and 148, 149, 158, and 159.

In addition, daily ammonia and dissolved oxygen monitoring results through 2001 can be obtained from the Galesburg Sanitary District.

9. Other potential sources include atmospheric deposition, in-stream decomposition of plant materials, wildlife and ammonification of soil organic nitrogen. (Note: it is our understanding that the total ammonia-N reported in water quality analyses measures both un-ionized ammonia and ammonium, with the relative proportion of each determined by the temperature and pH of the water.) Dr. William Roy of the Illinois State Geological Survey has suggested that the occurrence of ammonium in groundwater can be related to the distribution of buried Pleistocene-age soils or organic-rich zones. The USGS (Warner 2000) has reported that the statewide median value of 1,885 water well samples was 0.41 mg/L NH_4^{+}. The TMDL does not discuss these as potential sources, but we recommend that they be considered in the analysis.

Agricultural runoff, atmospheric deposition, in-stream decomposition of plant materials, wildlife, ammoniafication of soil organic nitrogen, and infiltration of groundwater with elevated concentrations of ammonia-N are all potential sources of ammonia in any watershed. The draft Cedar Creek TMDL focuses on agricultural runoff because the creek is lined by agricultural land along segments where ammonia-N concentrations exceeded IEPA's guidelines. Furthermore, ammonia-N concentrations only exceeded IEPA guidelines on days when there were small storm events, indicating that runoff is the source of ammonia-N loads. An isotope study would be the best way to conclusively identify the ammonia-N source, but such a study was not within the scope of the TMDL study. Sources other than agricultural runoff were also not a focus in the upstream portions of the creek because of the additional reasons listed below:

1) Some of the ammonia-N load entering Cedar Creek could come from atmospheric deposition that is common in the Central Plain States where ammonia-based fertilizers are used and can volatilize. Regardless of whether the ammonia-N load is coming from the atmosphere or runoff, the best management practices that have been proposed for the agricultural area will improve ammonia-N loads to the creek.

2) In-stream decomposition of plant materials: The correlation between small storm events and ammonia-N concentrations suggests that the ammonia-N source is not coming from an in-stream source.

3) Wildlife: Cedar Creek is channelized, concrete in some areas, largely surrounded by urban areas, and, therefore, does not provide a good habitat for wildlife. Although wildlife does exist in the area and could contribute to the ammonia-N loads in the creek, its impact is likely insignificant and cannot be controlled.

4) Ammoniafication of soil organic nitrogen: Ammoniafication of soil organic nitrogen is a possible source; however, excess organic nitrogen in the soils is the result of using the land for crops; therefore, implementing the agricultural BMPs described in the draft TMDL could control ammoniafication of soil organic nitrogen as well.

5) Infiltration of groundwater with elevated concentrations of ammonia: Ammonia-N loads from groundwater were considered. Ammonia-N concentrations in the groundwater were assumed to be between 0.4 and 0.5 mg/L, which is consistent with the USGS study. Inflow concentrations were back-calculated using the QUAL2E model and known instream ammonia-N concentrations during base flow. The volume of water in the creek from groundwater is small compared to the volume of water from runoff; therefore, concentrations from groundwater have little impact on the instream ammonia-N concentrations.

10. The draft TMDL lists ammonia-N as a nutrient contributing to excessive algal growth and subsequent low dissolved oxygen levels. It is our understanding that some aquatic species prefer ammonia as a source of nitrogen but that other species prefer nitrate. Because the draft TMDL does not present data for all the typical water quality parameters, it is not possible to evaluate the relative importance of ammonia and nitrate as sources of nitrogen. Considering that the watershed is intensively cropped and that part is tile drained, we would expect that nitrate concentrations are at least an order of magnitude greater than ammonia-N concentrations and that algal growth in the stream is not limited by the availability of nitrogen. Again, the absence of water quality data in the report limits our ability to provide additional comments or alternative hypotheses, but we would suggest that if, in fact, excessive algal growth is the cause of low dissolved oxygen levels that phosphorus be considered as the nutrient most likely to be limiting algal growth.

    The draft TMDL does not conclude ammonia-N loads are the primary cause of low DO concentrations in the creek (see page 12 of the draft TMDL document). The draft TMDL concludes that low DO is more directly the result of low reaeration that has resulted from the channelization of the creek. It is true that nitrate concentrations are an order of magnitude greater than ammonia-N

concentrations, but ammonia-N is the only nutrient that exceeds its guideline. Nitrate and phosphorous concentrations do not exceed IEPA guidelines and are therefore not a focus. Refer to Response #9 for complete list of all data sources.

11. Although not explicitly stated, it appears that the TMDL analysis attributes the ammonia in the stream to runoff from agricultural lands. However, the correlation between TSS (typically highly correlated with flow) and ammonia concentrations is not consistent in the data presented. For example, the water quality endpoint for ammonia of 0.41 mg/L is reported as being exceeded even at times when there is not surface water flow (0.5 mg/L on August 18, 1999). We also note that the model was calibrated with a data set from 1985 and then verified with a data set from 1986. While this calibration/verification procedure may be appropriate for sediment and TSS, we question whether it is appropriate for ammonia. As previously noted, the draft TMDL has not identified a current source of ammonia in the watershed. However, there may have been one in 1985 and 1986.

    The correlation between TSS, ammonia, and flow is consistent throughout the report. Ammonia-N concentrations only exceed IEPA guidelines when there is surface water flow. On August 18, 1999 (when an ammonia-N concentration of 0.5 mg/L was measured along a segment in the agricultural area) there was surface water flow due to a small storm with a precipitation level of 0.3 inch and an intensity of 0.1 inch per hour (refer to page 6 of the draft TMDL and Table 2-2 of Appendix A). Therefore, the correlation between runoff and elevated ammonia-N loads is consistent and current. However, as expressed in other responses (see responses to questions #1 and (in the preceding section), the ammonia within the system may be negligible.

12. We also do not believe that the draft TMDL adequately justifies developing a TMDL for ammonia-N as a surrogate for excessive nutrients. The draft TMDL says that excessive nutrients can lead to low dissolved oxygen levels, but later says that low dissolved oxygen is only a problem in Cedar Creek when flow is low. However, at low flows, ammonia is also low, and, therefore, ammonia does not contribute to the low dissolved oxygen values in the stream. The draft TMDL goes on to say that the low dissolved oxygen levels in the stream at low flow conditions are because the flow is primarily groundwater with low dissolved oxygen levels.

    As explained in response #5, a TMDL was developed for ammonia-N as a surrogate for excessive nutrients because ammonia-N concentrations have consistently exceeded IEPA guidelines, not because ammonia-N concentrations contribute to low DO concentrations. Regardless of the relationship between ammonia-N and DO concentrations, ammonia-N has consistently been detected in the creek at levels exceeding Illinois EPA guidelines; therefore, ammonia-N TMDL development for Cedar Creek was conducted. The Agency is continuing to review

the issue of nutrient impairment and the use of surrogates and other guidelines within the TMDL program. Our present approach is to defer TMDLs for causes of impairment that are not based on a water quality standard. In this instance, we would defer any implementation plan elements that refer to ammonia-N until the link between ammonia-N and stream impairment is more firmly established. Implementation plan elements for DO, however, would proceed.

13. The draft TDML does not identify the source of ammonia in the agricultural part of watershed or a specific transport mechanism. The most common agricultural source of ammonia in streams is livestock, but the TMDL does not describe livestock in the watershed nor were any observed during a recent visit to the watershed by a representative of the Department. Although urea fertilizer may be transported via overland flow if rainfall occurs immediately after application and the urea (H_2NCON_2H) may be degraded biotically to ammonium and then ammonia, the TMDL provides no evidence that urea is used in the watershed. Also, as noted below, there is no consistent relationship between ammonia concentrations and runoff. Anhydrous ammonia cannot be a source because it is applied as a gas and is rapidly converted to nitrate in the soil.

    Personnel from Inness Farm Supply Inc., a Galesburg fertilizer supplier, confirmed that ammonia-based fertilizers are the most predominant source of nutrients applied in the area. Anhydrous ammonia is the preferred choice of fertilizer, but urea is applied when anhydrous ammonia is too expensive. Urea can be transported by overland flow if rainfall occurs immediately after application as stated in comment #13. Although anhydrous ammonia is applied as gas and rapidly converts to nitrate in soil, small amounts can be carried to the listed segment of the creek through surface water runoff from the row crops, especially if fertilizers are not applied appropriately. Regardless of the transport mechanism, elevated concentrations of ammonia-N concentrations resulting from surface water runoff is evidenced by elevated ammonia-N concentrations measured in the creek following small storm events. (Response #11 explains that the correlation between surface water runoff and elevated concentrations of ammonia-N is consistent.) The magnitude of ammonia-N concentration that reaches surface water is an order of magnitude less than the concentration of nitrate that reaches the water, but so are the guidelines.

14. Tetra Tech notes "extreme diurnal variations of DO concentrations in Cedar Creek was observed during low-flow conditions in 1985." This fluctuation is from photosynthesis due to vegetation and algae. This condition is due to the shallow depth and the absence of canopy cover, which allows sunlight penetration. This condition continues to this day. In Appendix A, DO levels up to 3.7 mg/L were recorded in the early afternoon. It is this same vegetation and algae that consume dissolved oxygen at night (respiration) and cause low DO levels, not sediment oxygen demand (SOD) as referenced in this report. In fact, there is minimal sediment within the concrete channel and this is why no SOD measurements have been historically collected in the concrete channel. The use of a

steady state model while utilizing early morning DO readings yields a model with little in common with reality. If you want to increase the minimum DO levels on Cedar Creek, efforts need to be focused on reducing the concentration of the controlling nutrient, decreasing temperature, and/or decreasing sunlight penetration (e.g. canopy cover).

Diurnal variation is the result of photosynthesis in algae and vegetation and respiration, and the draft TMDL does not suggest otherwise. However, several other factors magnify the low DO concentrations measured in the listed segment of Cedar Creek including (1) SOD, which was evidenced by sediment with organic matter in the concrete sections during a site visit on August 7, 2001; (2) low reaeration due to hydraulic modifications; and (3) nutrient loads that have been evidenced by elevated ammonia-N concentrations in the creek. Based on modeling result, improving SOD, reaeration, and ammonia-N load conditions along the creek will most directly address problems with DO. Decreasing temperature and/or decreasing sunlight penetration would also increase DO concentrations but would be difficult to implement given that the creek is concrete-lined and runs through an urban area with little room for planting trees. The draft TMDL focuses on feasible options for improving the quality of Cedar Creek.

15. The statement is made "Low flows and shallow depths also cause extreme diurnal variation in the creek, which makes maintaining a DO above 6.0 mg/L difficult." This statement is <u>not</u> correct. The shallow depth favors reaeration (more surface area per gal of flow). It is the low hydraulic gradient, not low flow, that limits reaeration. The shallow depth allows full light penetration and thus high vegetative/algae population, resulting in the "extreme diurnal (DO) variation."

    The statement, "Low flows and shallow depths also cause extreme diurnal variation in the creek, which makes maintaining DO concentrations above 6.0 mg/L difficult" is correct because shallow depth allows full light penetration and high algae population that results in diurnal DO variation, as explained in the last sentence in comment #15. It is true that shallow depths favor reaeration, and the statement quoted from the draft TMDL does not state otherwise.

16. What effect does dissolved oxygen have on the ammonia nitrogen levels if there is an increase in dissolved oxygen?

    Ammonia-nitrogen acts as a sink for dissolved oxygen (DO). DO by itself does not have any effect on ammonia-nitrogen. However, presence of dissolved oxygen is a must for chemical transformation of nitrogen from one form to another. Also, presence of an adequate amount of DO in the stream is necessary for aquatic life use support.

17. Dissolved oxygen levels are deemed too low in the portion of the Cedar Creek watershed in question. Yet those levels are only fractionally lower than the allowable standards, and result in a rating of "fair" aquatic conditions. The origin of much of the agriculturally-derived surface water in the creek is field tile outlets. Water that originates from underground field tile would be expected to be naturally low in dissolved oxygen content. Dissolved oxygen levels are not shown to be problematic for the support of current levels of aquatic life in the watershed below the area that was studied.

    The term "too low" is a relative expression in comparison with DO standards. Note that DO as low as 1.1 mg/L was measured and it certainly fits in the category of being "too low" when compared to the DO standard of 6 mg/L. Also, note that the watershed downstream of the headwater segment is not a part of this TMDL development effort. The fact that the aquatic life use support (ALUS) is not impaired in a downstream segment can be attributed to a number of factors such as changes in stream width and depth, aeration coefficients related to flow, change in riparian vegetation, etc.

18. A major portion of the Cedar Creek streambed studied is a concrete channel running through the heart of the city of Galesburg. This concrete channel serves a vitally important function as a storm water drain. It is neither necessary nor desirable for this portion of the stream to support aquatic life. In fact, it would be a major detriment to the function of the channel to have aquatic plants and/or animals living in the channel. Only a very small portion of watershed below the concrete channel was examined for water quality impairment, insufficient to establish significance. Therefore, efforts to make the water flowing into or discharged from the channel capable of supporting aquatic life would be counterproductive.

    Illinois EPA is fully aware of the purposes for which the concrete channel was built. The intent of this TMDL is not to negate the original purposes but to enhance the capabilities of the concrete channel to carry waters,which comply with applicable water quality standards at all times.

19. Tetra-Tech states that "nutrient loads are a concern in the upstream agricultural area where fertilizers are applied." This is an unscientific statement of opinion. Proof of the origin of any and all nutrients in question must be given before making such a sweeping statement. Also, the effect of those nutrients must be analyzed and considered over the whole of the watershed, not limited to one small portion.

    The statement, "nutrient loads are a concern in the upstream agricultural area where fertilizers are applied," are based on the following two facts that are stated in the draft TMDL:
    (1) ammonia-N concentrations exceed Illinois EPA guidelines in the upstream portion of the listed segment and (2) the upstream portion of the listed segment is lined by agricultural land where ammonia-based fertilizers are applied. Nutrient loads were considered over the entire watershed adjacent to the listed segment,

but proved to be a primary concern in the upstream agricultural areas. In addition, response Nos. 9 and 13 further explain the focus on the agricultural area as a source of ammonia-N.

20. Tetra-Tech does not give any indication of the source(s) of ammonium nitrogen, though they have purportedly determined it to be highest in the "upstream agricultural area." There are many sources for ammonium nitrogen, both man-made and natural. Further study and proof of the sources of the ammonium nitrogen in question are required before making recommendations for agricultural-related solutions.

    Refer to response #9 for a detailed discussion on the sources of ammonia-N considered and focused on in the draft TMDL for Cedar Creek.

Sediment

1. The draft TMDL indicates that the current annual sediment yield from the agricultural land in the Cedar Creek watershed is 134,685 pounds per year or about 67 tons per year from the entire watershed, which is equivalent to about 117 pounds per acre per year or about 0.0585 tons/acre/year. This in an area of the state where the Illinois State Water Survey has reported sediment yields as high as 46 tons/acre/year and even the lowest reported sediment yield is more than 30 times greater than reported for Cedar Creek. We conclude that the landowners have done an excellent job in controlling soil erosion and sedimentation and should be congratulated. The draft TMDL proposes a load allocation of 27 pounds of sediment per day for all of the agricultural land within the watershed. This load allocation is equivalent to a sediment yield of 0.004 tons per acre per year or 8.55 pounds per acre per year.

   The draft TMDL used TSS as surrogates for siltation with an endpoint of 116 mg/L. The load allocations do not represent 'sediment yields'-they refer specifically to TSS. TSS and 'sediment yields' may be correlated but are not equivalent. Total sediment loads carried by a stream can be many times TSS loads, and may be composed of sediment loads from both land erosion and stream channel erosion, depending on hydraulic and geomorphic factors. The rationale for TSS as a surrogate for siltation is that low TSS indicates reduction of siltation. The TSS load allocation presented in the draft TMDL was based on a model calibrated to measure seasonal (not annual) TSS concentrations and runoff volumes for five storms in the watershed during the period May to October 1986 season. A larger set of measurements would be preferable but no other set of TSS or total sediment measurements specific to the watershed were available (draft TMDL page 15 and 17).

2. IDOA does not believe that excessive sediment is a problem in Cedar Creek. As noted by the Galesburg Sanitary District in their comments on the draft TMDL: "No SOD measurements have been taken in this concrete channel because of a lack of sediment." Our limited observations of the listed segment also failed to detect any sediment buildup in the channel. Also, since as noted by the draft TMDL, the listed segment is not fishable or swimmable, what impairment to aquatic life or other designated uses is caused by the suspended sediment during high flow conditions?

   The concrete channel is only 1.8 miles of the 5.95 miles headwater segment for which the TMDLs are being developed. There may not be excessive sediment in the concrete channel, but the residual sediment in the concrete channel after high flow exerts DO demand during low flow conditions. In addition, your comments are noted.

3. The IDOA's primary concern about the draft TMDL for Cedar Creek is the unrealistic and unachievable load allocation for sediment that is a mathematical consequence of the unrealistic water quality endpoints for siltation and total suspended solids. We do not

believe the guideline used in the 305(b) report for identifying streams impacted by sediment on the basis of more than 34 percent silt/mud in the streambed is appropriate. The draft TMDL states: "As specified under 35 IAC, Subtitle C, Part 302, the applicable siltation standard is as follows: Siltation: Water of the State shall be free from sludge or bottom deposits . . . of more than natural origin . . ." Cedar Creek is in a watershed where the upper 10 to 15 feet of earth materials are 100 percent silt. There are no earth materials coarser than silt within the surficial geologic materials in the watershed or immediately underlying the streambed. The IDOA would be concerned about erosion in the Cedar Creek watershed if the streambed did not contain more than 90 percent silt and mud. The presence of coarse-grained materials would indicate either that 10 to 15 feet of loess had eroded from the watershed or that the stream had downcut severely and exposed the underlying glacial till.

Within the range of data used, the analysis resulted in reductions of loads. Whether it is unrealistic or unachievable will be evident only by monitoring the water quality after all recommended control measures are fully implemented. Also, please see response to questions #2 and #3 of this responsiveness summary under Justification of a TMDL.

4. The siltation quotation attributed to 35 Ill. Adm. Code 302 is misleading and out-of-context. Section 302.203 prohibits offensive conditions, including "sludge or bottom deposits." Nowhere is "siltation" tied into either "sludge or bottom deposits" in the regulations.

   It is correct that 35 Il. Adm. Code 302.203 does neither use the term siltation nor ties siltation directly with sludge or bottom deposits. Siltation is a process by which suspended materials in a water column settle down at the bottom of the stream. In this context, siltation is certainly tied to bottom deposits.

5. Tetra Tech makes the statement "Once these endpoints are achieved, the biological status of the listed segment of Cedar Creek should improve" (emphasis added). Some basis for this statement is appropriate. To the extent Cedar Creek basin is in a silty clay type soils, it is not clear how the percent silt/mud will ever change. An explanation of where the sand and/or gravel is to come from would be helpful.

   The suggested BMPs are based upon model predictions. Therefore, the word "should" is used because other unforeseeable extreme events could occur which would not improve the biological status to the point of achieving the desired endpoints of the listed segments even after the BMPs are implemented. Once all recommended control measures are implemented, it is anticipated that the amount of soil coming into the stream as surface runoff will be at a level which will bring the silt/mud deposits within the Illinois EPA guidelines.

6. The statement is made in Section 4.0, "The reason observed D.O. concentrations in the listed creek segment are below water quality standards is the current level of reaeration rates are not sufficient to compensate for SOD." This statement is without foundation, and is not correct. The low DO concentrations are due to vegetation and algae in Cedar Creek.

   T**he statement in Section 4.0, "The reason observed D.O. concentrations in the listed creek .....compensate for SOD" is correct according to modeling results, which are explained in detail in Appendix A. The statement is made in Section 4.0, Pollutant Load Modeling, and should not be taken out of context. Throughout the draft TMDL, including Section 4.0, other causes of low DO such as diurnal variation resulting from vegetation and algae are explained. Increasing reaeration rates and decreasing SOD rates were focused on because those changes result in the biggest increase in DO concentration and can be implemented.**

Water Quality Data

1. With regard to the water quality data:

   a.) How often were samples collected (i.e. weekly, monthly, etc…).

   b.) Were all samples collected simultaneously for all parameters?

   c.) Were samples collected during the flow regimes modeled in the TMDL analysis?

   d.) Were the water quality data correlated in any way with flow?

   Please see Tables 2-2 and 2-3 in Appendix A of the draft TMDL document. The development of an explicit correlation for any parameter with flow was not considered necessary.

2. The GSD, for over sixteen years, has been required to collect water quality data on Cedar Creek, as a condition of its NPDES Permit. For much of this period, dissolved oxygen has been monitored at Farnham St. and immediately upstream of the treatment plant. The study does not indicate that this data were utilized in preference to the 1985 data. In addition, GSD has collected data temperature, TSS, DO and ammonia for the period of May 3 through July 18, 2001.

   Data collected by GSD through 2000 were utilized and referenced in Table 2-2 of Appendix A. 1985 data were preferred for modeling purposes because it was the only period when sufficient DO, ammonia, flow, and precipitation data were collected from multiple segments of the creek Tetra Tech received data collected by GSD along multiple segments of the creek, from May 3 through July 18, 2001, but the data was received after submittal of the report, and the data did not include flow measurements needed for modeling. However, these data were reviewed and determined to be consistent with all other monitoring conducted along the creek from 1985 through 1999.

Water Quality Monitoring Plan

1. The monitoring plan described in section 8 (p. 18) is insufficient to measure the progress towards attaining the suggested pollutant allocations. According to the proposed monitoring plan, Illinois EPA will “monitor ammonia-N, TSS, and DO levels” once every five years. One data point every five years is insufficient to monitor progress on TMDL implementation. Throughout this document are numerous statements which indicate more data is necessary and it is insinuated that data must be collected more than once every five years.

   Please note that recommended monitoring frequency is a minimum requirement. At this point it is difficult to lay out a comprehensive monitoring plan. In all likelihood a more comprehensive monitoring plan will be developed after all recommended control measures are fully implemented.

2. Illinois EPA should conduct more monitoring itself, assign additional monitoring to other entities, or secure agreements from other entities that have responsibility for TMDL implementation to conduct additional monitoring. For example, more instream monitoring could be added to the NPDES permit conditions for the Galesburg Sanitary District’s combined sewer outfalls (CSOs). In fact such monitoring should probably be part of their NPDES permit in order to comply with USEPA’s CSO Control Policy. In addition upstream agricultural drainage districts could be asked to conduct monitoring which could be paid for using those districts’ authority under the Drainage District Pollution Abatement Act.

   Thank you for your comment.

3. The Agency should consider adding an annual biological monitoring component to the final monitoring plan. This monitoring should be similar in scope to the Agency’s “Intensive Basin Surveys”, and include data of fish species, macroinvertebrate populations and mussel populations, if possible.

   Thank you for your comment.

Implementation Plan

1. The implementation plan described in Section 9 is fairly detailed, but does not lay out specific timelines for implementation nor does it specify what entities would ultimately be responsible for implementation in some cases. While the descriptions of possible actions such as channel modification, agricultural BMPs and urban BMPs are informative they, in many cases, do not provide assurance that actions will be taken.

   There are considerable time constraints involved in the TMDL process, which include development of a TMDL, approval of the TMDL from USEPA, and implementation of all recommended control measures. As a result, it is hoped that the specifics (e.g., timeframe, organization/person responsible, financial arrangements, and others) for implementation will be worked out after USEPA approves the TMDL. Also, see response to question #3 under Justification of a TMDL.

2. The final implementation plan should include the following:

   ??Timelines of implementation actions to meet water quality goals established by the TMDL;

   ??Specific actions to be taken by individual sources, classes of sources, or other sources to meet water quality defined by the TMDL;

   ??Specific pollutant reductions from individual permitted point sources and a schedule for when those reductions will be incorporated into NPDES permits not to exceed one year;

   ??Schedule for inspecting, monitoring, and maintaining onsite wastewater systems;

   ??A plan for how future requests for 401 certifications and NPDES permits will be handled;

   ??Descriptions of voluntary agreements, memos of understanding, contracts, and local government resolutions, ordinances, etc. … that are part of an overall strategy for attaining the water quality goals established by the TMDL as well as the status of ongoing discussions of where these agreements are at present, who will be approached by the Agency, etc. …

   Thank you for your comment.

3. What is the amount of 319 funds that the Agency estimates may be available for implementation of voluntary non-point source controls?

   If the annual federal appropriation for Illinois' Section 319 program is comparable to the FY 2001 appropriation, Illinois EPA estimates that $5 million will be

available for developing TMDLs and implementation of voluntary nonpoint source BMPs.

4. What additional USDA funds are going to be available for TMDL implementation?

   USDA offers a wide variety of programs that provide technical and financial assistance and encourage land stewardship: Environmental Quality Incentive Program (EQIP), Wildlife Habitat Incentive Program (WHIP), Wetlands Reserve Program (WRP), Forest Legacy Program (FLP), Conservation 2000, Conservation Reserve Program (CRP), and Small Watershed Program. These programs are summarized on the USDA website at www.usda.gov.

5. Which local government agencies or offices has the Agency approached to discuss the details of the implementation plan to date? Are there any pending voluntary agreements, memos of understanding, contracts, and/or local government resolutions, ordinances, etc. … that are consistent with the goals of the TMDL?

   Illinois EPA has an NRCS liaison staff located in its headquarter offices in Springfield, IL. Also, see response to question #1 under Implementation Plan.

6. The Galesburg Sanitary District submitted photograph, (Exhibit 3, August 30, 2001), of the concrete portion of Cedar Creek showing sufficient slope that during low flows the water is only one to two feet in width. The existing channel produces a stream which is narrower than the proposed in the report. GSD believes that modification of the concrete channel is unnecessary.

   The purpose of modifying the concrete channel is to promote an increase in aeration and thus an increase in dissolved oxygen concentrations during low flow conditions.

7. Cedar Creek was channelized and concreted after two very serious floods caused millions of dollars of damage to downtown Galesburg in the 1920s. While restoring the natural channel may somehow result in compliance with the ammonia-N guideline, it may lead to serious flooding damage. The cost of this flooding damage should be considered in the final report.

   Please see response to questions #18 under Nutrient Loads and Dissolved Oxygen.

8. Throughout this draft report, Tetra Tech makes repeated references toward increasing the creek reaeration through modification to the channel, and thereby eliminate low DO levels. Any type of structures in the creek, including gravel or stone will impede flow and

result in sediment accumulation in the resulting pool areas and between the stones. An increase in head loss would result in ponding upstream to compensate for greater head loss downstream.

Reaeration in the creek is low during low flows, during which there is no risk of flooding. Because the measures are being proposed for a small portion of the creek bed, the effect on the conveyance of the creek should be minimal. An evaluation of impacts of proposed modifications to the creek conveyance would be included in the final design of proposed alternative, since the creek is mapped as a regulatory floodway. In addition, sediment accumulation would not be a problem because the proposed measures would increase velocities, decreasing sediment deposition.

9. Figure 3 of the draft report depicts gravel or riprap on the bottom two sides of the concrete channel. Such an installation will fill in with silt, retard flow, and increase SOD in this stretch. In addition, they will allow rooted aquatic vegetation to become established in the concrete channel, which will be detrimental to minimum DO levels. Maintenance costs for replacing silted in stone with vegetation should be addressed in this recommendation.

   The proposed design is for low flow conditions. High flows tend to wash out any deposited silt, debris and even vegetation in the channel, which has been observed. By having a well-defined flow line in which higher velocities can be achieved, less deposition of silts would be expected resulting in low maintenance costs. Because of the absence of a well-defined low flow path/channel, flow tends to spread over the whole width of the channel bed. As discussed below, the resulting low velocities promote silt deposition and accumulation of debris. Another benefit of providing a low flow channel is elimination of the stagnant flow areas which can promote mosquito breeding in the channel.

10. On page 22 of the draft report, the statement is made "Modifying the flow line to create a narrow, well defined, low flow channel at the channel centerline would increase DO levels by creating higher velocity turbulent conditions." While higher velocities will indeed improve reaeration, without changing the slope of the channel, a "narrow well defined low flow channel" will not significantly change the velocity, only the depth. Much of this discussion presumes significant SOD, within the concrete channel, which is not the situation. the channel will reduce algae/vegetation growth at lower flows, which would be favorable; however, the water upstream would pool more which is detrimental to DO levels.

    In its present condition, during low flows, the flow is spread over an approximately 30 feet channel bottom resulting in low flow depths and velocities. Under such conditions laminar flow predominates. This situation was evident during a site visit on August 7, 2001. In addition to the very low flow velocities, significant amounts of sediment and debris could be observed in the creek and

stagnant flow regions were present during the site visit. Confining low flows to a narrower channel with a smaller wetted perimeter create higher velocities and turbulent conditions that will result in less deposition in the channel.

11. What Tetra Tech did not address, but is relevant is whether a more diversified aquatic habitat will exist in the concrete channel if the recommendations are successful. Factoring in stream temperature would also seem appropriate. Will fish reside in this narrow channel, without any canopy cover? Is the aquatic diversity above the concrete channel limited because of the concrete channel, or can a more diversified aquatic community be expected to reside upstream of this concrete channel?

    Small fish were observed in the channel during the August 7, 2001, site visit. If recommendations are successful, aquatic life, including aquatic diversity, is expected to improve in both the concrete and natural portions of the segment. Although establishing a canopy cover would be ideal, it is not a feasible option and is not the only solution for improving aquatic life.

12. Some landowners in the upstream agricultural portion are already installing buffer strips and have expressed interest in ripples, which are a series of aerations. This should be considered by Tetra Tech.

    Thank you for the information.

13. Would a concave channel bottom accomplish the goal of consolidating the flow into a smaller stream?

    Tetra-Tech responded at the hearing that their report considered minimal conceptual alternatives. You can try this modification in the channel, take some measurements and determine if this leads to improvements. If this is workable, you might then consider a full-scale implementation.

Reasonable Assurance

1. Section ten on reasonable assurance mentions that NRCS concurs with the findings and will work with local landowners to install these BMPs, but no specifics are included to describe how or when this will be accomplished. Prairie Rivers believes that more could be done to provide “reasonable assurance” through the creation of voluntary agreements, memos of understand, contracts, or the encouragement of local resolutions, ordinances, etc. … Has the Agency taken any actions to date to provide this type of “reasonable assurance” in cooperation with the appropriate local stakeholders?

   Upon receiving USEPA approval, Illinois EPA will proceed with implementation plans and working with the local stakeholders. Also, see response to question #1 and #5 under Implementation Plan.

2. The citizens of Galesburg will be asked to expend considerable efforts to implement this plan, and some assurance that the environment will be better off is appropriate. Simply attaining what appear to be arbitrary guidelines for ammonia, TSS and sediment composition does not translate into a "better" environment, given the other limitations on Cedar Creek. The acknowledgment that upstream DO levels cannot attain the 6.0 mg/L water quality standards, no matter what efforts are expended, is particularly revealing. If the regulated DO level cannot be achieved, what are the benefits of implementation of the recommendations?

   Illinois EPA’s guidelines for ammonia-N, TSS, and sediment composition are not arbitrary and are defined in Illinois EPA’s 2000 305 (b) Water Quality Report. This report is available to the public by contacting IEPA. In general, ammonia-N levels in excess of recommended guidelines harm aquatic life by causing alteration of metabolism or increase in body pH, reduction in hatching success and reduction in growth rate and morphological development, to name a few. Increased TSS and a change in sediment composition can degrade habitat for aquatic plants, fish and other aquatic organisms, impacting the entire food chain. DO levels cannot be attained at 6.0 mg/L in a one-mile length of the upstream segment of the creek. DO levels can be attained at 6.0 mg/L in the remainder of the listed segment if the recommended BMPs are implemented.

General Comments

1. For future TMDL documents that are circulated to the public, better use should be made of the maps of the local area, graphs of data, and other visualizations. This would make the documents easier to understand, and more accessible for lay members of the public. A land use map showing the watershed would be useful, given the mixed land-use in the area. A map showing the location of the CSO outfalls and other features that are discussed in the TMDL study also would have been useful.

   Thank you for your comment.

2. Given the highly technical nature of TMDL development and the science behind the analysis, the use of more visual representations of information will make the documents easier to understand, will enhance the public participation, and will improve the feedback which the Agency receives from interested member of the public.

   Thank you for your comment.

3. How many pending 401 certificates are located in the watershed?

   To the Agency's knowledge there are currently no pending 401 certificates in this watershed.

4. How many pending NPDES permits are located in the watershed?

   Due to the processing procedures for NPDES permits, the Agency's database is not set up to track the status of pending NPDES permits on a watershed basis. Point sources located along the listed segment of Cedar Creek include GSD combined sewer overflows (CSOs). At this point, all GSD CSOs are permitted and the GSD NPDES permit does not expire until late 2004.

5. The 1999 Illinois EPA biological survey reported an MBI of 6.0 at Farnham, which according to the summary list should be classified as "Good", yet the report states this is "Fair" water quality. Similarly at Henderson an MBI of 7.5 was reported, which is "Fair" water quality, not the "Poor" stated in the report. Some clarification and/or correction is appropriate.

   Thank you for bringing this to our attention. The appropriate changes have been made to the final report.

6. The Agency has conducted numerous MBI surveys over the years. The historical ratings should be included to give some perspective on water quality trends. In addition,

Illinois EPA sampling station A-1, which is within the TMDL study area, was not included in this section. Station A-1 in 1999 had an MBI value of 5.9.

Station A-1 is not in the TMDL area of study. Historical MBI data does exist from Facility Related Stream Surveys conducted throughout the years. The data from these surveys reveal trends of poor water quality for the listed segments.

7. The DO value of 1.1 mg/L is 16 years old and should be discarded. This result does not reflect current agricultural practices, as noted elsewhere in the report. More recent DO readings are presented in appendix A.

   The DO data collected during 1985 was used only to calibrate the water quality model, QUAL2E.

8. Section 5.0 also states, "The headwater portion of the creek therefore will remain in violation of the DO standard of 6 mg/L." How far will this "violation" extend, and does this suggest the Agency should petition the Pollution Control Board to change the DO standard for the headwaters of Cedar Creek?

   This situation appears due to boundary conditions input. DO below 6 mg/L is predicted for a distance of one mile downstream from the headwater boundary point. There appears no justifiable reason for Illinois EPA to petition the Illinois Pollution Control Board to change the DO standard for the headwaters of Cedar Creek. Also see response to question #2 under Reasonable Assurance section.

9. Precipitation data from 20 miles away was used by Tetra Tech in Section 5.0. The District doubts the Illinois EPA would accept such data from a regulated discharger and questions the use of such data in this study.

   As Tetra Tech stated in the draft report, the precipitation data from Galesburg only recorded daily precipitation results and had long periods of missing records. The gage in Alexis contained hourly precipitation and temperature data from May 1989 through June 1999. Although storm patterns in Galesburg and Alexis may differ, the two locations were assumed to be similar climatically for the purposes of estimating and planning level pollutant loads.

10. The statement is made several times that nutrient removals are variable "with high removal rates in fall and winter." A citation for high nutrient removals in the winter in a northern climate should be provided, as this is contrary to logic. During the winter, the plants are dormant and ice formation allows any water to pass rapidly through any wetlands.

The statement, "with high removal rates in fall and winter" should read "with high removal rates in the growing season." That statement is inconsistent with the sentence which follows it (see page 23 of the draft TMDL) that explains that nutrient removal rates are low in the fall and winter because of floating, dead plant material released from the basin and complex nutrient cycling patterns often associated with wetlands.

11. Swales are recommended as a low cost alternative to storm sewers. Some discussion of the safety considerations of swales, especially during heavy rain events when swales are flowing full in front of houses would be appropriate.

    The Agency assumes that the designer will address this issue if the swales are to be implemented.

12. A recommendation is included with regard to roof drain discharges. The district believes that clarification of what Tetra Tech envisions here is needed. Is the city/district to adopt an ordinance requiring roof discharges be located some minimum distance from the house?

    The report recommends an evaluation of the location of discharges from roof drains to ensure that storm flows do not reenter the sanitary system via the perimeter foundation drains. The benefit of disconnecting the roof drain is compromised in situations where the topography slopes towards the foundation because the rain water will have an easy path to the foundation drains, which are still connected to the sanitary system. Such infiltration to the foundation drains can be minimized if a positive grade away from the building is provided. Alternatively, such flows can be directed to the storm sewer system or sufficiently far from the structure if space allows. The city or district can give guidelines to assist residents to choose the most effective ways of placing disconnected roof drains.

13. The statement is made "Disconnection of roof drains into the sanitary system would benefit the listed segment by reducing wet weather sanitary flows." To the district's knowledge all roof drains to the sanitary sewer have been disconnected for over fifteen years. The district suggests the deletion of this recommendation.

    The report acknowledges on page 29 under "Roof Drain Disconnection" that all roof drains have been disconnected. The discussion revolves around the concern for the remaining subsurface drains which are still connected to the CSOs and provide a direct path for stormwater runoff.

14. The Illinois EPA Compliance Assurance Section expects verification and demonstration that the Galesburg combined sewer overflows are not degrading Cedar Creek. Will the

final report support the GSD's statement that the overflows are not degrading Cedar Creek?

The report addresses the segment of Cedar Creek approximately upstream of McClure Street. The segment of Cedar Creek downstream of McClure Street was not the subject of the report. The report acknowledges that the relative direct contribution of CSO to DO impairments and TSS loads appear to have been significantly reduced compared to other factors such as reaeration rates, and TSS loads from storm runoff. The report notes, however, that TSS loads can contribute to SOD loads in the channel, which were identified in DO simulations to be sensitive input. In addition, an evaluation of the impacts of remaining CSO loads to the downstream segment was not performed since it was not within the scope of the report. Based on these considerations, the final report cannot support GSD's statement that overflows are not degrading Cedar Creek.

Glossary & Acronyms

Agency		Illinois EPA
BMP	-	Best Management Practice
DO	-	Dissolved Oxygen
GSD	-	Galesburg Sanitary District
IAC	-	Illinois Administrative Code
IDOA	-	Illinois Department of Agriculture
Illinois EPA	-	Illinois Environmental Protection Agency
MBI	-	Macroinvertebrate Biotic Index
mg/L		milligrams per Liter (or parts per million)
NPDES	-	National Pollutant Discharge Elimination System
NRCS	-	Natural Resources Conservation Services (USDA)
SOD	-	Sediment Oxygen Demand
TMDL	-	Total Maximum Daily Load
TSS	-	Total Suspended Solids
USDA	-	United States Department of Agriculture
USGS		United States Geological Survey
7Q2	-	Seven Day 2 Year Low Flow
7Q10	-	Seven Day 10 Year Low Flow
305(b)	-	Section 305(b) Report of the Clean Water Act Water Quality
303(d)	-	Section 303(d) of the Clean Water Act

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DISTRIBUTION OF RESPONSIVENESS SUMMARY

Copies of this responsiveness summary were mailed in 2002, 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 217-785-3924 or e-mail Bill.Hammel@epa.state.il.us.

BUREAU OF WATER STAFF WHO CAN ANSWER YOUR QUESTIONS

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Questions regarding the public hearing record and access to the exhibits should be directed to Hearing Officer Bill Seltzer, 217-782-5544.

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