ASSESSMENT OF WATER QUALITY AND FACTORS AFFECTING DISSOLVED OXYGEN IN THE SANGAMON RIVER, DECATUR TO RIVERTON, ILLINOIS, SUMMER 1982

By Arthur R. Schmidt and John K. Stamer

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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM OF UNITS (SI)

For the convenience of readers who may want to use metric (International System) units, the inch-pound values in this report may be converted by using the following factors:

Multiply inch-pound unit	By	To obtain metric unit
foot (ft)	0.3048	meter (m)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
	3,785	cubic meter per day (m^3/d)
cubic feet per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot per second (ft/s)	0.3048	meter per second (m/s)
ton, short	0.9072	megagram (Mg)

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows:

$$°F = 9/5°C + 32$$

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ABSTRACT

Water quality and processes that affect dissolved oxygen in a 45.9-mile reach of the Sangamon River (from Decatur to Riverton, Illinois) were determined by analysis of field data collected during low-flow periods in the summer of 1982. Relations among dissolved oxygen concentrations, water discharge, biochemical oxygen demand, ammonia nitrogen, nitrite plus nitrate nitrogen, and phosphorus concentrations, and photosynthetic-oxygen production were simulated using a one-dimensional, steady-state computer model. Results from the model were used to quantify processes affecting dissolved oxygen.

Average measured concentrations of dissolved oxygen decreased from about 8.0 mg/L (milligrams per liter) at Decatur to less than 5.2 mg/L 12.2 miles downstream. Ammonia nitrogen concentration increased from 0.1 mg/L at Decatur to as much as 45 mg/L at the mouth of Stevens Creek (2.6 miles downstream), which carries the treated wastewater from the city of Decatur into the river. Ammonia nitrogen concentrations decreased steadily with distance downstream from Stevens Creek to 0.03 mg/L at Riverton. Un-ionized ammonia concentrations exceeded the maximum concentration specified in the State water-quality standard (0.04 mg/L) throughout most of the study reach.

Data were collected during two 24-hour periods to quantify the diel variation in dissolved oxygen concentrations and to provide input for a computer model of the water quality. Model simulations indicate that oxidation of ammonia nitrogen to nitrite and nitrate nitrogen is the primary process responsible for depletion of dissolved oxygen concentrations.

INTRODUCTION

The U.S. Geological Survey and the Illinois Environmental Protection Agency (IEPA) operate a network of 204 water-quality observation stations in Illinois to provide baseline water-quality information, to determine trends in the surface-water quality in Illinois, and to identify water-quality problem areas that need more intensive study. On the basis of water-quality data collected at stations in the network from July 1979 through June 1981 and Federal (U.S. Environmental Protection Agency, 1976) water-quality criteria, a water-quality index was assigned to each station. According to the indices for three stations along a reach of the Sangamon River between Decatur and Riverton (U.S. Geological Survey station numbers 05573540, 05573650, and

05573800), that reach of the river was considered to have "severe water-quality problems" (Illinois Environmental Protection Agency, 1982a). Additional water-quality measurements made at these three stations from October 1980 through September 1981 showed DO (dissolved oxygen) concentrations as low as 1.2 mg/L, ammonia nitrogen concentrations as high as 24 mg/L, and nitrite plus nitrate nitrogen concentrations as high as 15 mg/L (U.S. Geological Survey, 1982). In comparison, the Illinois general-use water-quality standards list minimum acceptable DO concentrations at 5 mg/L and maximum ammonia nitrogen concentrations such that un-ionized ammonia not exceed 0.04 mg/L, and that ammonia nitrogen not exceed 15 mg/L (Illinois Pollution Control Board, 1982). In 1982, the U.S. Geological Survey entered into a cooperative agreement with the IEPA to assess the water-quality conditions of the Sangamon River between Decatur and Riverton, and to describe those conditions that cause depletion of DO. This report presents the results of the assessment.

Purpose and Scope

The purpose of this report is to present a description of the water quality and the factors affecting dissolved oxygen for a 45.9-mile reach of the Sangamon River during low flow. The report presents an overview of methods of data collection and methods used to calculate DO model parameters from other measurements. Results from field measurements and water-sample analyses are presented to quantify the water quality of the river. Methods used to calibrate the computer model, values used as input to the computer model, and results from model simulations are presented. The relative importance of different processes to DO concentrations in the river are interpreted from these model results.

Dissolved oxygen concentrations are used as the principal indicator of the water quality in the river. Instream processes that affect deoxygenation and reoxygenation are evaluated by use of a computer model. These processes include the biochemical uptake of oxygen, as represented by CBOD (carbonaceous biochemical oxygen demand), nitrification, atmospheric exchange, and PNET (photosynthetic DO production).

This study was limited to water-quality conditions during low-flow periods, when runoff from agricultural and urban lands was minimal. Outflow from Lake Decatur was controlled to provide steady hydraulic conditions for the different phases of the field-sample collection.

Study Area

The Sangamon River, located in central Illinois (fig. 1), originates about 45 miles northeast of Decatur and flows southwesterly past the cities of Monticello and Decatur to Roby. From Roby, it flows northwesterly toward its mouth at the Illinois River. The Sangamon River is 240.9 miles in length and drains an areas of 5,419 mi^2 (square miles) (Healy, 1979). The study reach extends from just downstream from Lake Decatur at RM 129.0 (river miles upstream from confluence with Illinois River) to Riverton (RM 83.1). The study reach is 45.9 miles long and drains an intervening area of 1,680 mi^2 (fig. 2).

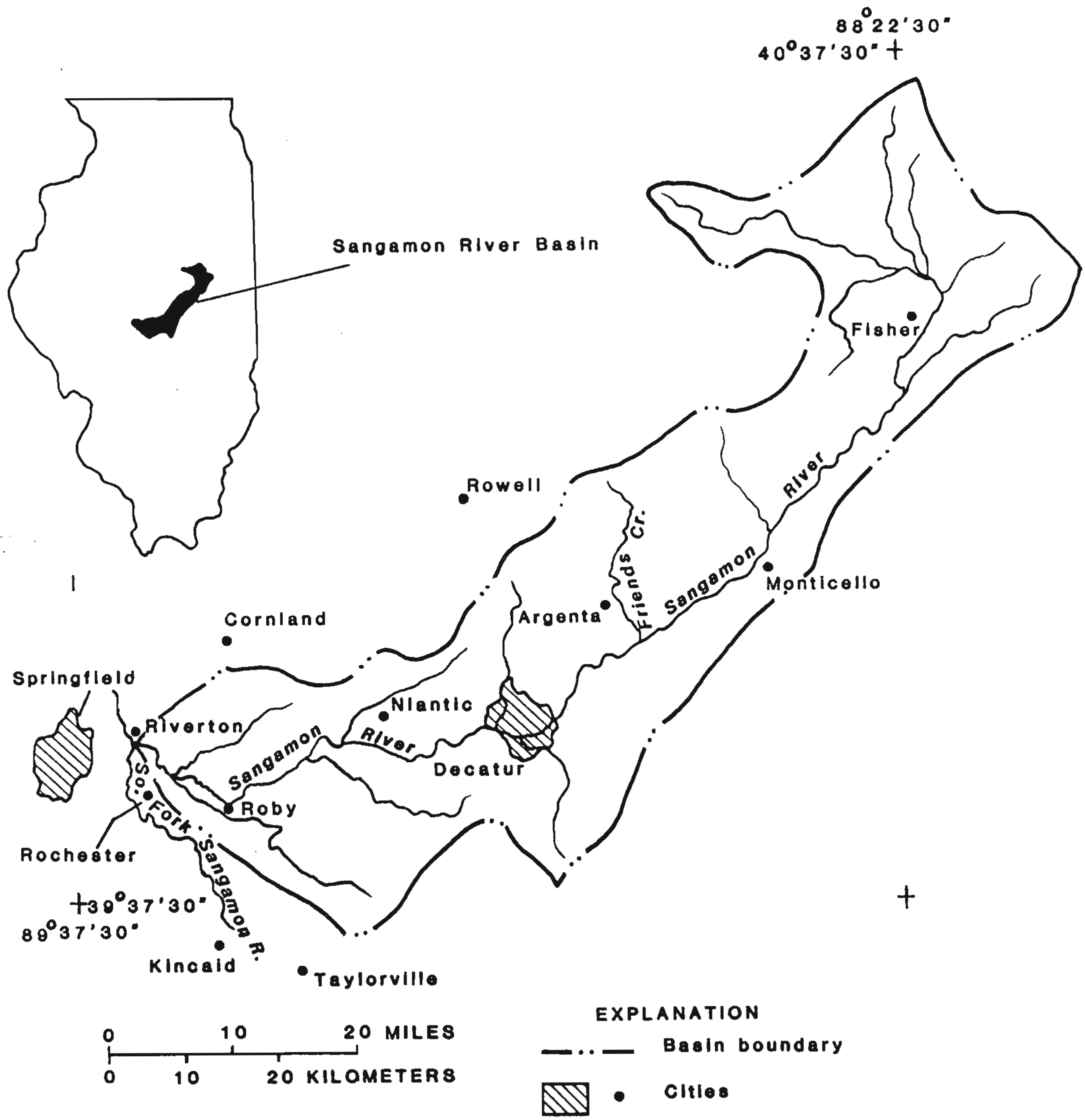

Figure 1.--Location of the Sangamon River basin upstream from Riverton.

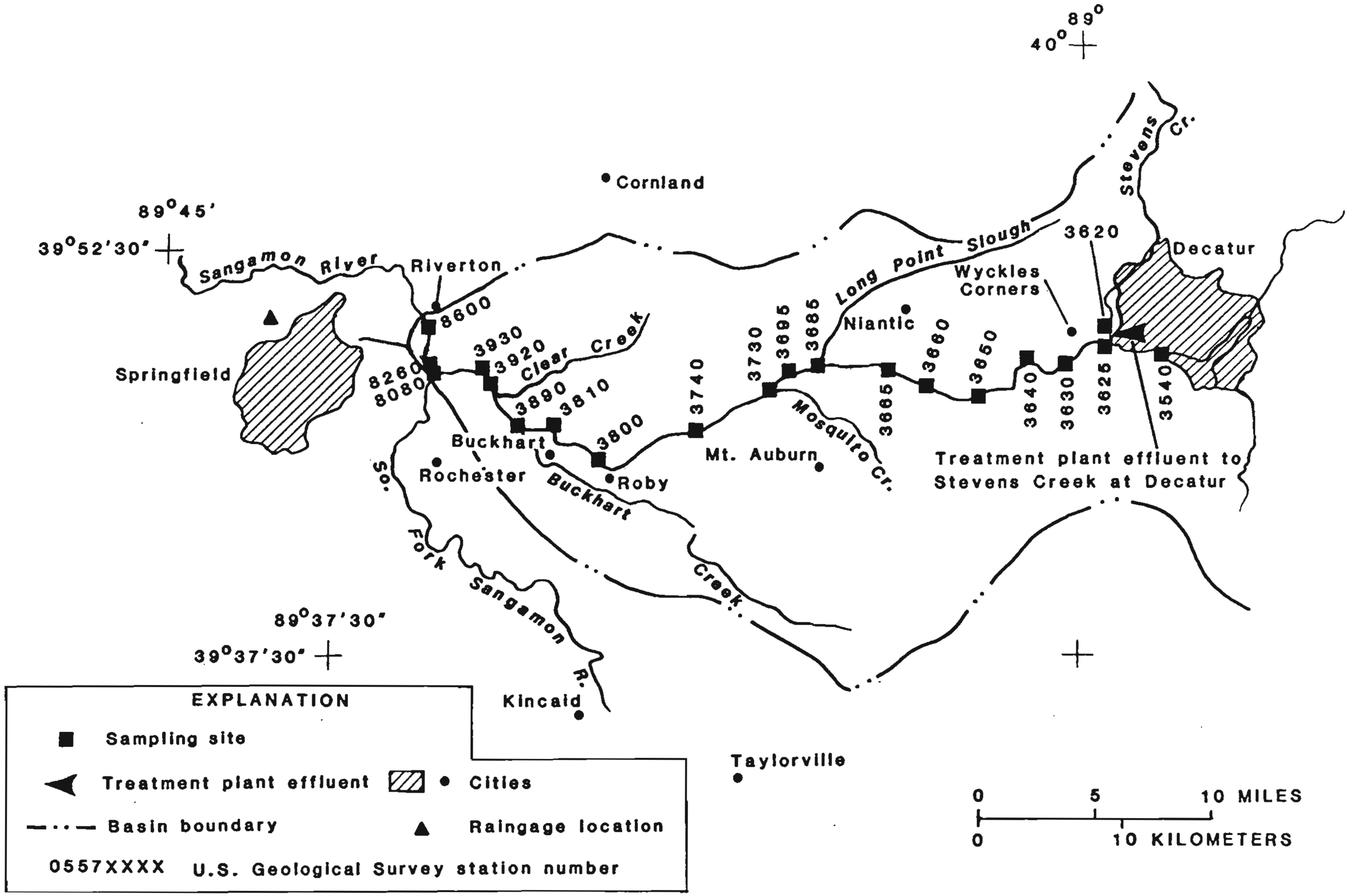

Figure 2.--Sampling sites in study area.

In the study reach, the river primarily follows a meandering channel, although some parts have been channelized. The entire length of the study reach flows through agricultural land. During the low-flow conditions of this study, the flow in the river was a sequence of 3- to 6-foot-deep pools interspersed with 1- to 2-foot-deep riffles. The water velocity varied widely, with velocities measured in pools as low as 0.38 ft/s (foot per second) and velocities measured over riffles as high as 2.07 ft/s. The channel width is about 60 to 80 feet throughout the study reach. The average channel slope is about 1.5 feet per mile. The channel bottom is primarily hard packed sand and gravel.

The study reach has a single regulated headwater (outlet of Lake Decatur). The stream receives discharges from eight known wastewater treatment facilities. All of these known wastewater sources discharge into tributaries rather than to the river itself, and all of these tributaries were sampled during the sample collection periods.

Acknowledgments

The authors wish to acknowledge the extensive technical support from personnel of the IEPA. In particular, the authors thank the personnel from the Planning Section of the Water Pollution Control Division, who worked with the authors to plan the data collection and to collect and analyze the stream data. Special thanks go to Kenneth Rogers of the IEPA, whose dedication and diligence were of paramount importance to the completion of the project. The authors also wish to thank the personnel of the Sanitary District of Decatur for providing data and allowing use of their facilities as a base of operations. Finally, the authors wish to thank the Illinois Department of Transportation for facilitating an aerial reconnaissance of the river.

APPROACH

A DO mass-balance approach was used to determine the amounts and rates of deoxygenation and reoxygenation along the study reach. Stream deoxygenation was computed from estimates of ammonia nitrogen loads, CBOD loads, DO consumption through algal respiration, and water temperatures. Stream reoxygenation was computed from relations involving water temperature, stream velocity and depth, and the difference between DO saturation and ambient DO concentrations. The effect of algae and aquatic plants on the DO balance was quantified as a net oxygen production from relations based on diel fluctuations in DO.

The approach to data collection consisted of several consecutive phases, herein referred to as synoptic data collection, diel data collection, stage-discharge relations, traveltime and reaeration-rate determinations, and photosynthetic DO production and respiration. Identification and evaluation of the effects of different instream processes on DO concentrations were done using a computer model in phases herein referred to as model calibration, model verifications, and process evaluation. Figure 3 shows the different phases of the approach to the study, how they interrelate, and how they relate to the purposes of this report. Table 1 lists the sampling sites and identifies the phases of the study for which each site was used.

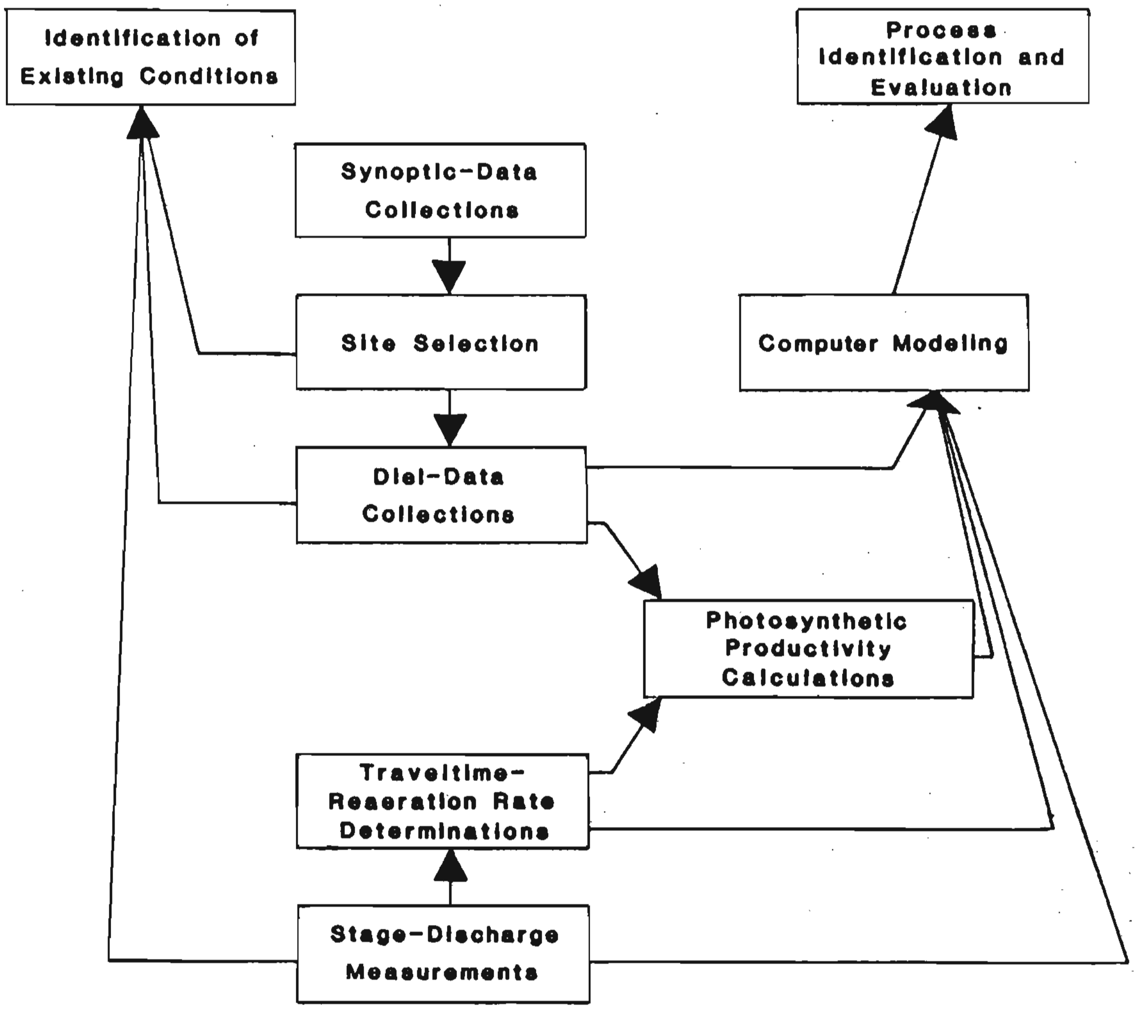

Figure 3.--Phases of data collection and analysis, interrelations between phases, and relations to project purposes.

Table 1.--Water-quality sampling sites

[mi^2, square miles; dashes indicate no data]

Station number	Station name	Drainage area (mi^2)	River mile	Type of sampling[1]
05573540	Sangamon River at Route 48 at Decatur	938	129.0	P,S,D,R,Q
05573620	Stevens Creek at Decatur	87.1	[2]126.4	P,D
[3]395009089001500	Treatment plant effluent to Stevens Creek at Decatur	--	--	P,D
05573625	Stevens Creek near mouth at Decatur	87.9	[2]126.4	P,D,R
05573630	Sangamon River at Wyckles Bridge near Wyckles Corners	1,034	124.4	P,S,D,R,Q
05573640	Sangamon River near Wyckles Corners	1,046	122.1	D
05573650	Sangamon River near Niantic	1,054	116.9	P,S,D,R,Q
05573660	Sangamon River at Niantic Bridge near Niantic	1,075	113.8	P,S,D,R,Q
05573665	Sangamon River near Long Point Church near Niantic	1,084	112.1	D
05573685	Long Point Slough near Illiopolis	61.1	[2]108.0	D
05573695	Sangamon River near Mount Auburn	1,154	107.2	P,S,D,R,Q
05573730	Mosquito Creek near Mount Auburn	79.8	[2]106.8	D
05573740	Sangamon River near Bolivia	1,256	102.1	S,D,R,Q
05573800	Sangamon River at Roby	1,264	98.5	S,D,R,Q
05573810	Sangamon River near Buckhart	1,268	94.9	S,D,R,Q
05573890	Buckhart Creek at Buckhart	99.6	[2]92.1	D
05573920	Clear Creek near Dawson	56.6	[2]89.6	D
05573930	Sangamon River near Dawson	1,435	88.2	S,D,R,Q
05576060	South Fork Sangamon River near Highway 29 near Rochester	882	[2]85.3	D
05576250	Sugar Creek near Springfield	270	[2]85.3	D
05576500	Sangamon River at Riverton	2,618	83.1	D,R,Q

[1] P = Sampled during preliminary reconnaissance;
S = Sampled during synoptic data collection;
D = Sampled during diel data collection;
R = Traveltime-reaeration sampling site;
Q = stage-discharge rating for this site.

[2] River miles indicate the location of the mouth of the tributary above the mouth of the Sangamon River.

[3] This site is a wastewater-treatment plant outfall and has no corresponding drainage area.

During the two synoptic data collections, concentrations of DO, ammonia nitrogen, nitrite plus nitrate nitrogen, and ultimate CBOD were measured for conditions similar to those at which the data used to calibrate the model would be collected. The synoptic data collections were planned assuming steady-state conditions and were intended to indicate the expected location of the lowest DO concentrations in the study reach and the processes that most influence the DO under modeling conditions. This information could then be used in selecting the final location of diel data-collection sites.

Two diel data collections were done to identify the variations in concentrations of selected constituents over a 24-hour period. The diel data collections were done to obtain the data needed to calculate PNET and to calibrate the model.

Reaeration-rate coefficients and traveltimes were calculated for the study reach to enable calculation of the reoxygenation rates.

METHODS

Measurement of Streamflow and Channel Characteristics

Stream discharges were needed to calculate reaeration rates and traveltimes as well as dilution of any water-quality constituents in inflows to the stream. Current-meter measurements were made during the synoptic and diel sampling using methods described by Rantz and others (1982). Relations between stage and discharge were determined at 10 bridges near where water-quality data were collected. Stage was measured, from a reference point or by using a wire-weight gage, every time water-quality data were collected or discharge measured. These stage measurements were used to determine the slope of the water surface and in developing stage-discharge relations used to estimate discharge.

Average values of water discharge, flow depth and velocity, channel width, cross-sectional area, and slope were determined for each of 16 subreaches based on values for sites within the subreach. The subreaches were delimited by the bridges from which samples were collected, by the mouth of Stevens Creek, and by the mouth of the South Fork Sangamon River (fig. 4). Channel width, slope, and cross-sectional area were determined for 63 locations in the study reach from cross-section data provided by the U.S. Army Corps of Engineers. Channel width at each water-quality sampling site was considered to be equal to the surface width, and the average channel slope for each subreach was assumed to be equal to the water-surface profile.

Measurement of Water Quality

Water-quality characteristics presented in this report include measured values of DO concentration, discharge, pH, specific conductance, water temperature, and the results of laboratory analyses of water samples. Instream measurements of water temperature, specific conductance, pH, and DO concentration were made during all phases of the data collection by using four-parameter instruments.

During each synoptic sampling, measurements were made and samples were collected once at nine sites between RM 129.0 and RM 88.2. Discharge, DO concentration, pH, water temperature, and specific conductance were measured in the river. Samples for analysis of ammonia nitrogen, nitrite plus nitrate nitrogen, and ultimate CBOD were collected at each site.

During both diel data collections, sampling was done at 21 sites throughout the study reach, including effluent from a wastewater treatment facility and eight tributary sites. Water samples were collected at approximately 3-hour intervals at every site on the river, Stevens Creek, and the wastewater treatment facility outfall. At the remaining tributary sites, water samples were collected once during each diel period. Concentrations of organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, phosphorus, chlorophyll-a,

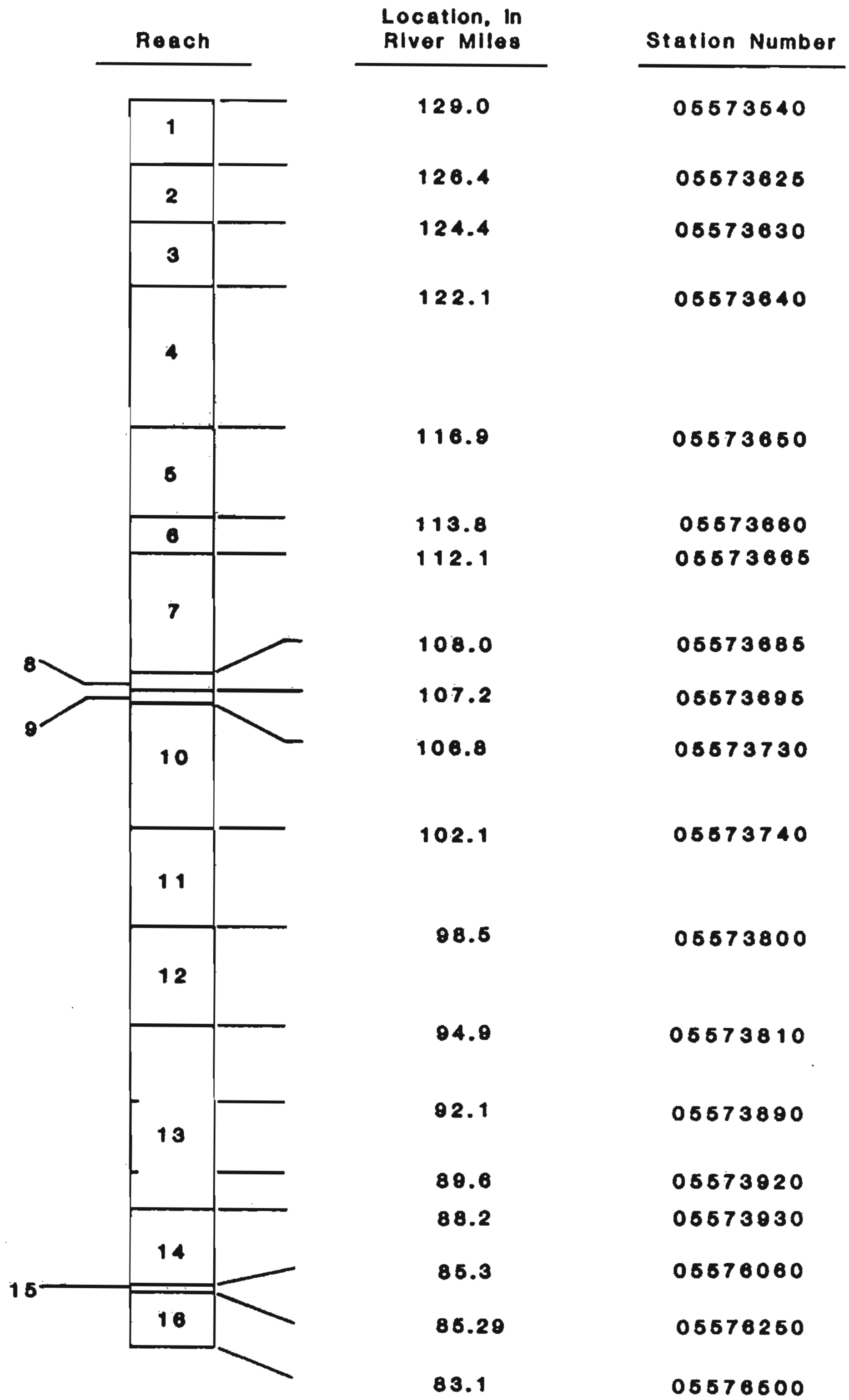

Figure 4.--River reaches simulated by the computer model.

and ultimate CBOD were determined from laboratory analysis of water samples. Dissolved oxygen concentration, pH, water temperature, and specific conductance were measured in the river each time water samples were collected and once at each site between sampling times, when time permitted. Discharge was measured once at each site during the 24-hour sampling period.

All water samples, except those for ethylene, were analyzed at the IEPA laboratory in Champaign, Illinois. All analyses, except for ultimate CBOD, were done according to methods described in the IEPA Manual of Laboratory Methods (Illinois Environmental Protection Agency, 1982b).

Determination of Carbonaceous Biochemical Oxygen Demand

Amounts and rates of oxygen depletion due to CBOD were determined by using the method described by Stamer and others (1983). In this method, samples were treated with nytrapyrin to inhibit nitrification, and then incubated in the dark at 20°C. Dissolved oxygen concentrations in the samples were measured periodically for a minimum of 10 days. The samples were aerated as necessary to maintain aerobic conditions. The ultimate CBOD and the specific decay rate were calculated from relations between cumulative DO consumption and elapsed time.

Calculation of Net Photosynthetic Dissolved Oxygen Production

The effect that algae and aquatic macrophytes had on the DO concentrations was represented as a net photosynthetic DO production over a 24-hour period. Net photosynthetic DO production is the gross photosynthetic DO production less the DO consumption by algal respiration over a 24-hour period.

Net daytime oxygen production and nighttime respiration were calculated from DO and water-temperature data measured over a 24-hour period using a computer program developed by Stephens and Jennings (1976). The program follows an approach developed by Odum (1956), in which these values are calculated based on the variation in DO over a 24-hour period. The net daytime oxygen production given by the program is the gross photosynthetic oxygen production less the daytime oxygen consumption by benthal demands, CBOD, and other demands. Similarly, the nighttime respiration value is the total nighttime DO consumption by algal respiration, CBOD, and benthal and other demands.

An approach outlined by Terry and others (1983) was used to calculate PNET from the net daytime oxygen production and the nighttime respiration. In this method, nighttime and daytime algal respiration values are assumed to be equal and proportional to the chlorophyll-a concentration (Shindala, 1972). The difference between nighttime algal respiration and the nighttime respiration value is assumed to be the nighttime DO consumption by CBOD and by benthal and other demands. The DO consumption by algal respiration, by CBOD, and by benthal and other demands is assumed to be constant throughout the 24-hour period. The DO consumption by daytime algal respiration, by CBOD and by benthal and other demands is added to the net daytime photosynthetic oxygen production to get the gross photosynthetic oxygen production. Net photosynthetic DO production is calculated by subtracting the DO consumption by algal respiration (daytime and nighttime) from the gross photosynthetic oxygen production.

The result of these calculations is a value that includes only the net effect of photosynethetic DO production and algal respiration, is site specific, and is correct only for the average water temperature during the 24-hour data-collection period. The following equation was used to correct the PNET values to 20°C:

$$PNET_{20} = PNET_t \ (1.08)^{(T-20)} \qquad (1)$$

where $PNET_t$ is the PNET at T degrees Celsius, in milligrams per liter per day;

$PNET_{20}$ is the PNET value at 20°C; and

T is the 24-hour average temperature, in degrees Celsius.

Measurement of Traveltime and Reaeration Rate Coefficients

For the study, the traveltime through any reach of a stream was calculated as the time required for the peak of the cloud of a conservative, dissolved tracer dye to travel the length of the reach. Traveltime defines the residence time of dissolved solutes and suspended materials in the reach, and therefore affects the deoxygenation and reoxygenation that occur in the reach.

Atmospheric reaeration is the physical transfer of oxygen between the atmosphere and the river water. The driving force for the process is the DO deficit, which is the difference between the concentration of DO at saturation and the actual DO concentration in the river. The reaeration coefficient, which quantifies the process, is believed to be dependent on stream characteristics such as depth, slope, and flow velocity, and other factors such as barometric pressure and temperature. The reaeration rate is the rate of change of DO concentration with time and is equal to the product of the reaeration coefficient and the DO deficit.

Traveltimes and reaeration rates were measured by using a modified tracer technique described by Rathbun (1979). In the technique, a fluorescent water-soluable dye solution (Rhodamine WT) and a low molecular-weight hydrocarbon gas (ethylene) were injected into the river at constant rates for a predetermined time. Samples were collected downstream from the injection site and analyzed to determine the concentration of the gas and dye with respect to time.

Two methods were used to calculate the ethylene desorption rates. One method is based on the upstream-to-downstream changes in the peak concentration of gas and dye, and the other method is based on the upstream-to-downstream changes in area under the gas concentration versus time curves. Both methods require correction for changes in flow in the subreach.

Measured reaeration rates for each reach were standardized to 20°C by using the following equation:

$$K_{20} = K_t \ (1.024)^{(T-20)} \qquad (2)$$

where K_t is the reaction coefficient (base e) at T degrees Celsius, in reciprocal days;

K_{20} is the reaction coefficient (base e) at 20°C, in reciprocal days; and

T is the average observed temperature, in degrees Celsius.

Data used to calculate the reaeration rate coefficients were collected at two different release rates from Lake Decatur. Reaeration rates were measured in six subreaches from RM 129.0 to RM 107.2 with a release from Lake Decatur of 105 ft^3/s (cubic feet per second). Reaeration rates were measured in subreaches from RM 116.9 to RM 84.6, and in a subreach from RM 126.4 to RM 124.4 with a release from Lake Decatur of 2.7 ft^3/s. Predictive equations (Rathbun, 1977) that best estimated the measured reaeration coefficients from the measured depth, discharge, and velocity were identified. These were later used to predict the reaeration coefficients corresponding to hydraulic conditions other than those for which traveltimes and reaeration rates were measured.

OBSERVED WATER QUALITY

Existing water quality was characterized from samples collected during the synoptic and diel data collections. Measured constituent concentrations were compared with State water-quality standards to identify constituents that did not meet State standards. Measured constituent concentrations and comparisons with State standards are presented in this section of the report.

The river characteristics presented in this report were determined for periods when the discharge in the river at RM 129.0 (05573540) ranged from 2.7 to 135 ft^3/s. The 7-day, 10-year low-flow discharge estimated for this location is 4.6 ft^3/s. The 7-day, 10-year low-flow is calculated based on streamflow records, and its value will change as the climate changes or as the hydrologic properties of the area drained by the stream change; it is presented here as an index low-flow discharge for comparison with the discharges at which the river was studied.

Ambient

Date collected during the synoptic data collections of August 2, 1982, and August 5, 1982, are presented in tables 2 and 3, respectively. The lowest DO concentration was measured at RM 124.4 (05573630) on both days, with a DO concentration of 5.2 mg/L on August 2 and 3.0 mg/L on August 5. Based on these data, additional sampling locations at RM 122.1 (05573640) and RM 112.1 (05573665) were added for the diel data collections.

The State standard for un-ionized ammonia (less than 0.04 mg/L) was exceeded at all sites downstream from RM 126.4 during the synoptic sampling of August 2, and at all sites between RM 126.4 and RM 94.9 during the synoptic sampling of August 5. Other water-quality standards exceeded during the synoptic samplings were the minimum DO standard, which was exceeded at RM 124.4 and RM 116.9, and the maximum ammonia nitrogen standard, which was exceeded at RM 124.4, RM 116.9, and RM 113.8. All of these were observed during the synoptic sampling of August 5.

Table 2.--Water-quality data measured during the synoptic data collection of August 2, 1982

[ft^3/s, cubic feet per second; mg/L, milligrams per liter; (µS/cm, microsiemens per centimeter at 25°C; °C, degrees Celsius; dashes indicate no data]

Station number	River mile	Time (hours)	Dis-charge (ft^3/s)	pH (stand-ard units)	Oxygen, dis-solved (mg/L)	Spe-cific con-duct-ance (µS/cm)	Temper-ature (°C)	Oxygen demand, biochem nitrog. ult. (mg/L)	Nitro-gen, ammonia dis-solved (mg/L as N)	Nitro-gen, NO2+NO3 total (mg/L as N)	Ammonia, un-ionized (mg/L as N)
05573540	129.0	1316	112	7.7	8.6	468	28.2	8.2	0.15	4.2	0.005
05573630	124.4	1257	--	7.2	5.2	929	27.2	--	11	4.2	.121
05573650	116.9	1235	161	7.2	7.2	945	27.0	--	9.5	4.7	.103
05573660	113.8	1212	--	7.7	7.8	927	26.4	--	8.5	4.9	.274
05573695	107.2	1149	--	7.4	10.6	927	26.3	23	6.1	5.6	.099
05573740	102.1	1028	--	7.4	8.7	918	25.3	--	6.1	5.5	.093
05573800	98.5	1001	180	7.4	8.4	943	24.9	29	5.0	6.2	.074
05573810	94.9	0940	--	7.6	8.4	932	24.9	--	3.7	6.7	.086
05573930	88.2	0852	--	7.6	7.6	850	24.7	15	2.1	6.9	.048

Table 3.--Water-quality data measured during the synoptic data collection of August 5, 1982

[ft^3/s, cubic feet per second; mg/L, milligrams per liter; (μS/cm, microsiemens per centimeter at 25°C; °C, degrees Celsius; dashes indicate no data]

Station number	River mile	Time (hours)	Discharge (ft^3/s)	pH (standard units)	Oxygen, dissolved (mg/L)	Specific conductance (μS/cm)	Temperature (°C)	Oxygen demand, biochem nitrog. ult. (mg/L)	Nitrogen, ammonia dissolved (mg/L as N)	Nitrogen, NO2+NO3 total (mg/L as N)	Ammonia, un-ionized (mg/L as N)
05573540	129.0	1200	7.0	7.8	9.9	505	29.5	8.7	0.06	3.2	0.003
05573630	124.4	1130	--	6.8	3.0	1,700	29.0	20	30	2.4	.150
05573650	116.9	1100	--	7.2	5.0	1,450	28.5	--	20	4.1	.240
05573660	113.8	1035	--	7.2	5.8	1,325	28.0	31	17	4.6	.198
05573695	107.2	1010	--	7.5	9.0	885	27.5	22	3.8	6.2	.084
05573740	102.1	0935	--	7.6	9.6	835	27.5	28	1.9	6.1	.053
05573800	98.5	0915	105	7.7	8.5	855	27.5	27	1.6	6.3	.055
05573810	94.9	0855	--	7.7	7.1	890	27.5	31	.87	6.8	.030
05573930	88.2	0825	--	7.8	7.6	820	28.0	25	.03	6.1	.001

Diel

The first diel data collection (August 17-18, 1982) was done with a steady release from Lake Decatur of 105 ft^3/s; a release rate that had been maintained since August 10, 1982. The results of the water-quality analyses of samples collected during this period are presented in table 10. Dissolved oxygen concentrations varied from 2.9 mg/L at RM 112.1 to 13.2 mg/L at RM 83.1. The largest diel variation in DO concentration occurred at RM 83.1, where DO concentrations varied from 13.2 mg/L at 1700 hours on August 17, to 5.0 mg/L at 0800 hours on August 18. During this period, ammonia nitrogen concentrations ranged from less than 0.1 mg/L at RM 129.0 to 13.0 mg/L at RM 124.4. The ultimate CBOD in the river ranged from 4.9 mg/L at RM 129.0 to 29.0 mg/L at RM 124.4.

Figure 5 shows the un-ionized ammonia concentrations in the river during the August diel sampling and, for comparison, the State standard of 0.04 mg/L. These concentrations were calculated based on river pH, temperature, and ammonia nitrogen concentration, using the following equations (Illinois Pollution Control Board, 1982):

$$U = \frac{N}{[0.94412\ (1 + 10^{x}) + 0.0559]} \qquad (3)$$

where $$x = 0.09018 + \frac{2729.92}{(T + 273.16)} - pH \qquad (4)$$

U is the concentration of un-ionized ammonia, in milligrams per liter;

N is the concentration of ammonia nitrogen, in milligrams per liter;

T is the water temperature, in degrees Celsius; and

pH is the pH of the water, in units.

The un-ionized ammonia standard was exceeded in a majority of the samples at all sampling locations downstream from RM 126.4.

During the second diel data collection (September 14-15, 1982), the release from Lake Decatur was 2.7 ft^3/s--a release rate that had been maintained since August 19, 1982. The results of the water-quality analyses of samples collected during this period are presented in table 10. Measured DO concentrations ranged from 0.1 mg/L at RM 124.4 to 15.9 mg/L at RM 102.1. The maximum diel variation of 10.5 mg/L occurred at RM 102.1. Ammonia nitrogen concentrations varied from 1.2 mg/L at RM 129.0 to 43.0 mg/L at RM 124.4. The ultimate BOD in the river varied from 7.6 mg/L at RM 129.0 to 31.5 mg/L at RM 94.9.

Figure 6 shows the un-ionized ammonia concentrations in the river during the September diel sampling and the State standard for un-ionized ammonia. The un-ionized ammonia standard was exceeded in a majority of the samples at all sampling locations downstream from RM 126.4.

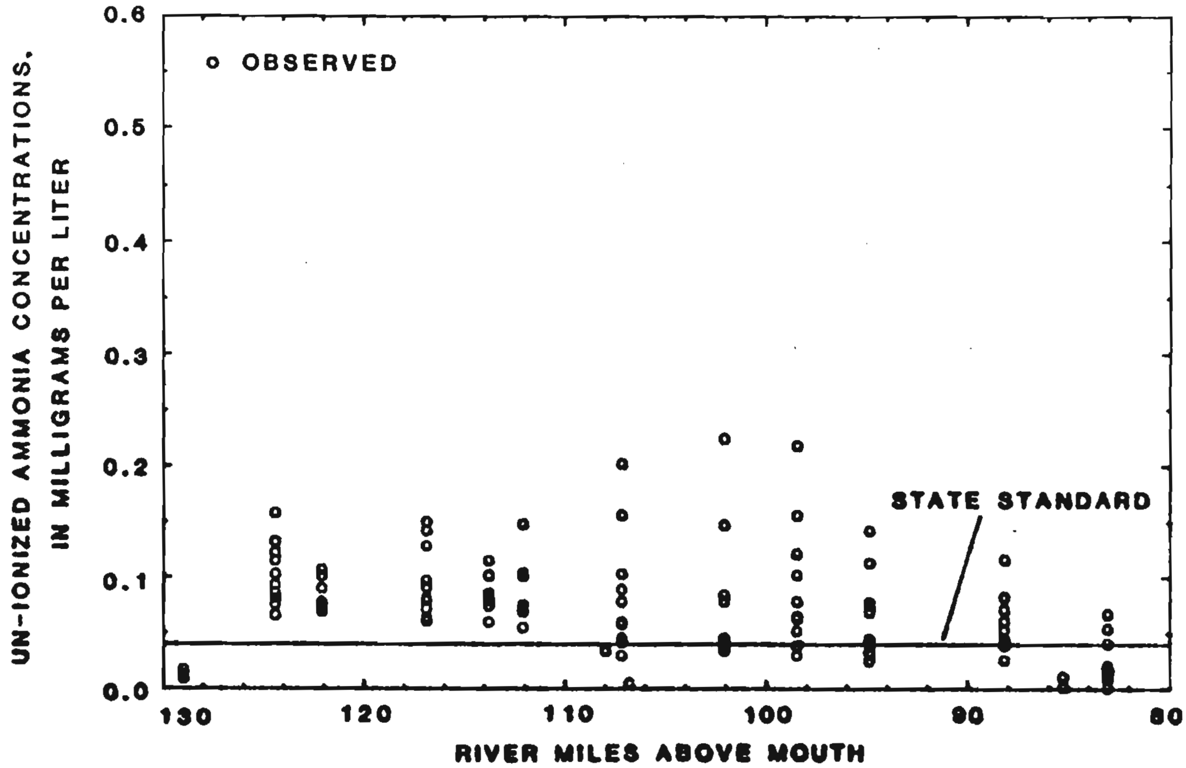

Figure 5.--Un-ionized ammonia concentrations observed during the August 17-18, 1982, diel sampling.

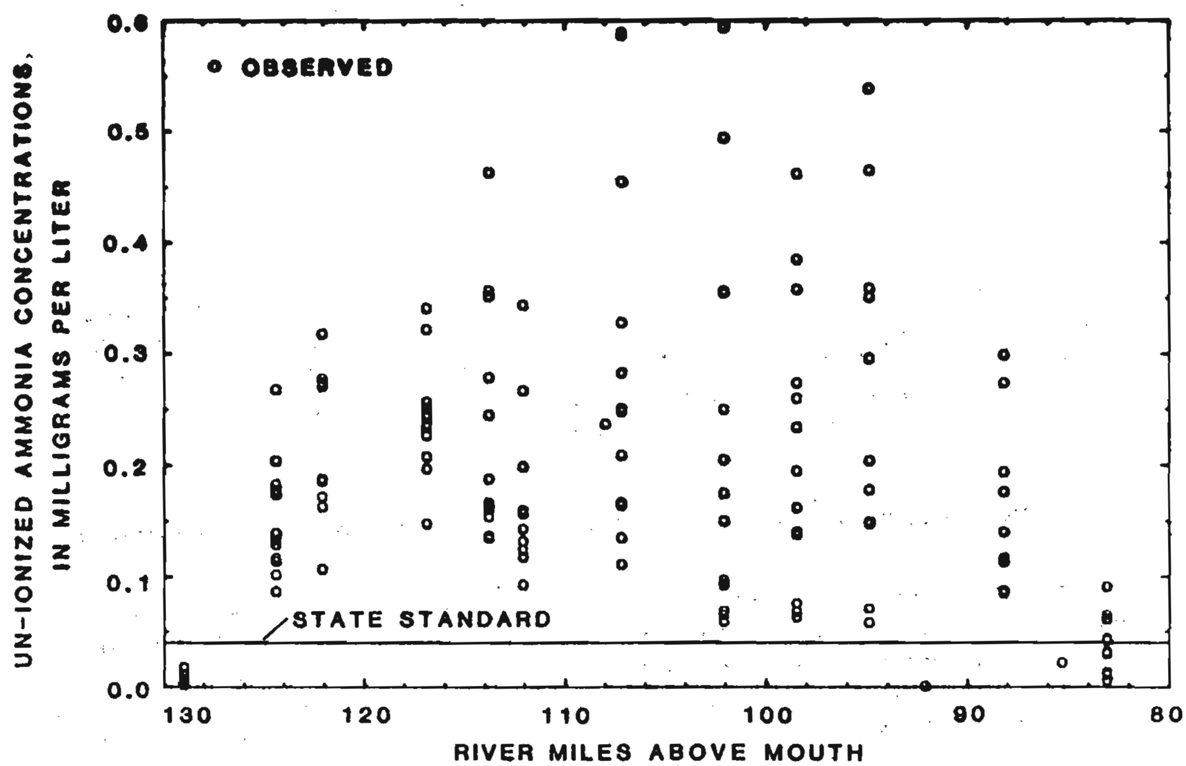

Figure 6.--Un-ionized ammonia concentrations observed during the September 14-15, 1982, diel sampling.

About 4 hours into the September diel sampling, a rainstorm passed over the study area. Precipitation data for September 14 show 1.17 inches of total rainfall at Springfield and 0.43 inch at Decatur (John Vogel, Illinois State Water Survey, oral commun., 1982). Field personnel reported that the precipitation near Decatur began at 1500 hours on September 14 and lasted for about 2 hours. Hourly precipitation data from Springfield are presented in table 4. Despite the unsteadiness introduced by the storm, sampling was continued throughout the 24-hour sampling period and the data later examined to evaluate the effect of the storm. Figure 7 shows the rainfall measured at Springfield and the changes in discharge throughout the diel sampling period for stations at RM 129.0, RM 116.9, RM 102.1, and RM 83.1.

Table 4.--Hourly rainfall intensities recorded at Springfield, Illinois, for the storm of September 14, 1982

Time (hours)	Precipitation (inches)
0000-1200	0.00
1200-1300	.15
1300-1400	.93
1400-1500	.06
1500-1600	.03
1600-2400	.00

The change in ammonia nitrogen concentration at RM 124.4 between the diel data periods can be shown, using a mass-balance relation, to be due primarily to dilution by waters released from Lake Decatur. Daily ammonia nitrogen loads at RM 124.4 were 4.31 tons (August 17-18 data) and 4.56 tons (September 14-15 data), a difference of 5.7 percent.

EVALUATION OF FACTORS AFFECTING DISSOLVED OXYGEN CONCENTRATION

The effects that various instream processes had on DO concentrations were evaluated using model simulations. A one-dimensional, steady-state DO computer model developed by Bauer and others (1979) was used to quantify the effects of instream processes on DO concentrations. The model relates the oxygen deficit at any point to the DO concentration at the upstream boundary of the model, traveltime to that point, mixing and dilution from inflows to the river, and zero and first-order deoxygenation and reoxygenation processes. Figure 8 shows the different processes simulated in the model and their relations to DO concentrations.

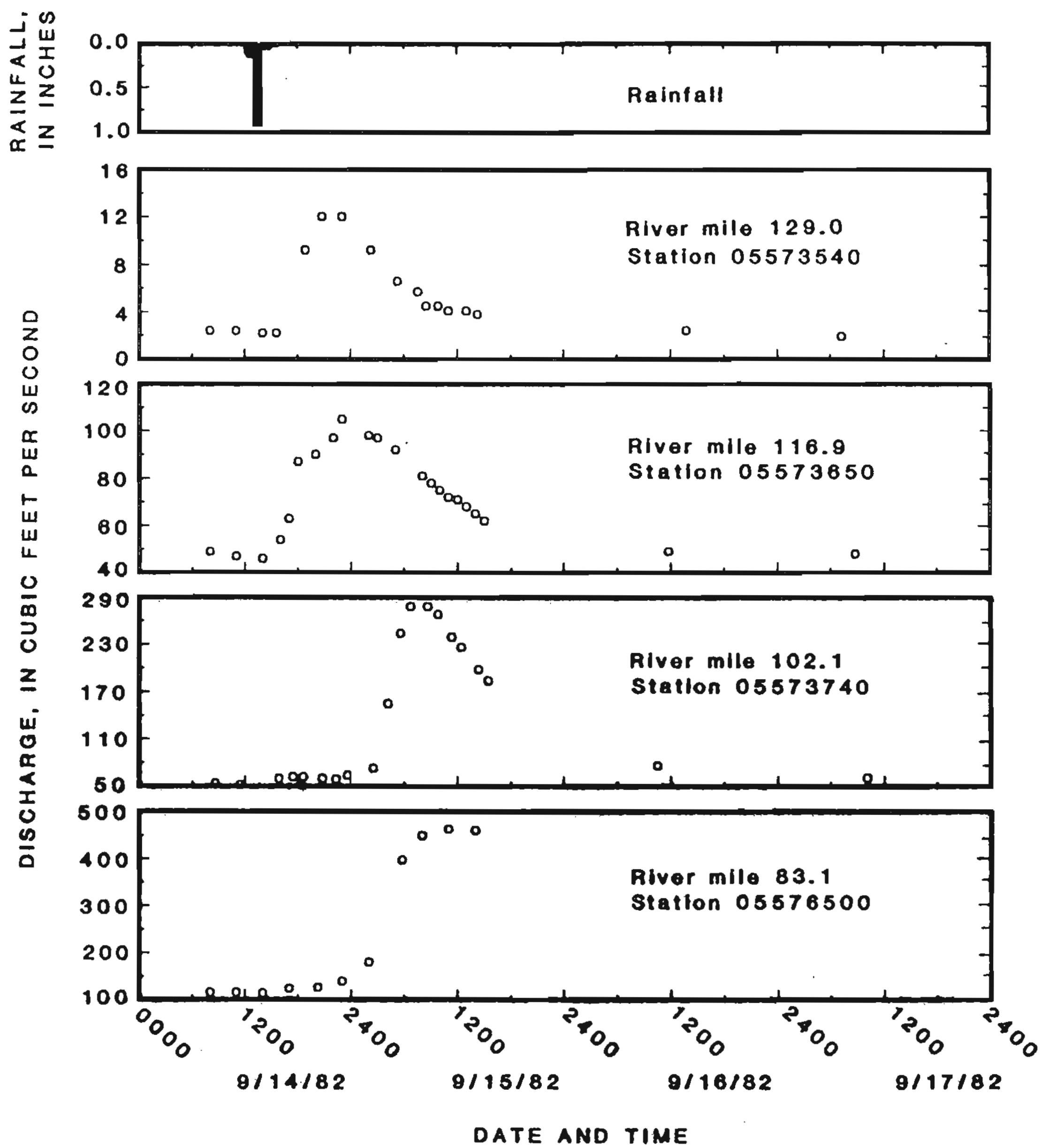

Figure 7.--Rainfall at Springfield and discharge at river miles 129.0, 116.9, 102.1, and 83.1 from September 14-17, 1982.

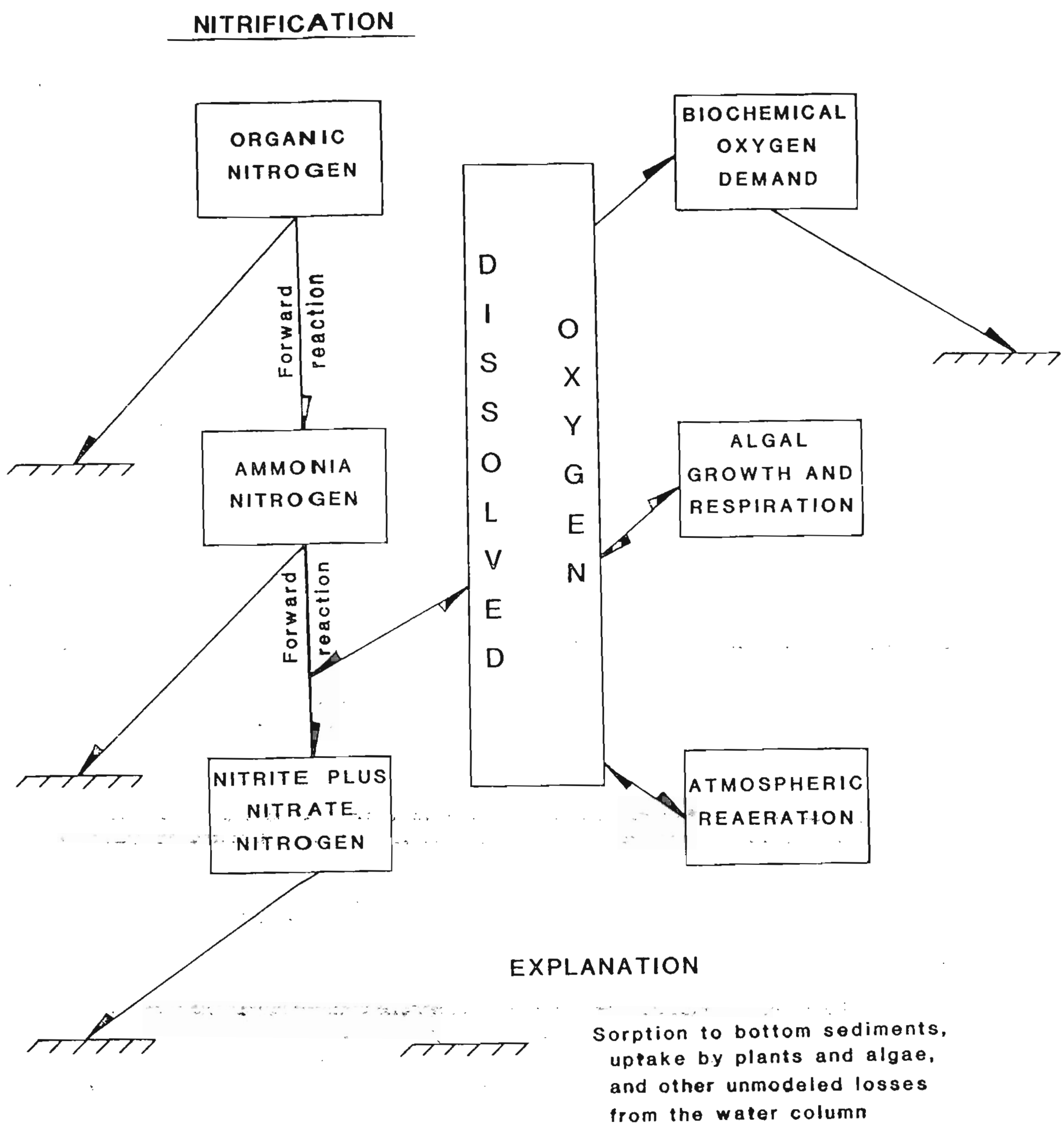

Figure 8.--Relations between dissolved oxygen and deoxygenation and reoxygenation simulated by the computer model.

In the computer model, the river was represented as 16 subreaches (fig. 4). Subreaches are the smallest unit for which model coefficients can be input. As such, subreaches were chosen to represent uniform conditions in the river, with subreach boundaries at locations of sampling sites, inflows to the river, and changes in channel geometry or flow characteristics. Each subreach was subdivided by the model into 1-mile long, uniformly mixed segments.

The most downstream segment of a subreach was allowed to be shorter than 1 mile for subreaches whose length was not a multiple of 1 mile. Values for each model coefficient were the same for all segments in a subreach. Constituent concentrations were allowed to differ between segments.

Model simulation results for each subreach included DO concentration, DO deficit, and changes in DO because of PNET, CBOD decay, and ammonia oxidation. Inflows to each subreach were modeled as entering at the upstream end of the subreach. The effect of atmospheric reaeration on DO in each subreach was calculated as the difference between the simulated total change in DO concentration and that part of the change accounted for by PNET, BOD decay, and ammonia oxidation.

Changes in DO concentration resulting from each process were normalized by traveltimes to allow comparison of processes between subreaches. The net change in DO concentration caused by a specific process in any given subreach depends on the kinetics of the process and on the residence time of the water in the subreach. The effect of a process is therefore greater in reaches with longer traveltimes. Normalization of the changes in DO were made by dividing the change in DO concentration caused by each process, by the traveltime through the subreach.

Inputs to the Model

Types of data input to the computer model were initial and boundary conditions and model coefficients. Initial and boundary conditions include effluent loads, observed concentrations of modeled constituents, streamflow characteristics, channel characteristics, traveltimes, and water temperature. These data define the physical conditions being modeled. Model coefficients describe the rates and magnitudes associated with various instream processes, including PNET, atmospheric reaeration, CBOD decay, nitrification, advection, and settling.

Initial conditions describe the conditions prior to the period being modeled. For a steady-state model, initial conditions provide a starting point for model iterations but will have no effect on the simulated concentrations. The average of the measured values for each consitutent at each site was input as the initial condition for that site and constituent.

Boundary conditions describe the inflow from upstream of the study reach and from seven tributaries to the river. The average of the measured values for each constituent was input as the boundary condition for that constituent and inflow.

For this study, the model was used to simulate dissolved oxygen, ultimate CBOD, ammonia nitrogen, nitrite plus nitrate nitrogen, organic nitrogen, phosphorus, and specific conductance. Nitrite plus nitrate nitrogen was simulated by modifying the model such that nitrite was not oxidized to form nitrate and that the dissolved oxygen used in the oxidation of ammonia to nitrite (4.57 mg (milligrams) DO per milligram of ammonia) is the stoichiometric equivalent amount of oxygen used to react ammonia to nitrite (3.43 mg DO per milligram ammonia) and then nitrite to nitrate (1.14 mg DO per milligram nitrite). These oxygen requirements are all taken from Zison and others (1978).

Model Coefficients

Model coefficients were determined from measured data whenever possible. Coefficients determined from measured data include PNET, reaeration-rate coefficients, traveltimes, and discharges. For the model of the August diel data, coefficients were based on the average of all values measured at each site. Recognizing the unsteadiness introduced to the measured water-quality parameters by the rainstorm in September, the scope of the data used (to calculate PNET and to verify and recalibrate the model) were limited to those data collected before the rain affected the water quality in the study reach. The time the storm began to affect the measured water quality at each site was estimated from the time the storm passed and from discontinuities in the measured stage, specific conductivity, and water temperature values.

Net photosynthetic DO production values ranged from 7.47 to 0.66 (mg/L)/d (milligrams per liter per day) for the first diel sampling, and from 6.75 to -2.57 (mg/L)/d for the second. The maximum and minimum PNET values occurred at RM 98.5 and RM 122.1, respectively, for the first diel sampling. The maximum and minimum PNET values occurred at RM 106.8 and RM 85.3, respectively, for the second. The storm passed through the basin at the time when photosynthetic DO production is typically at its peak. This may have lowered the peak DO values observed, resulting in the negative PNET values. Insufficient data are available to quantify the effect of the storm on PNET.

The estimate of the average discharge was calculated by averaging measured discharges, those from stage-discharge relations (from stage measurements), and those from mass-balance calculations on specific conductance, assuming specific conductance reflects a conservative stream constituent.

The values for discharge used in the computer model were estimated from the stage-discharge relations for the site, using the average of all stage measurements from during the diel sampling. For the September diel sampling, only stage measurements made before the passage of the storm were included in the average for each site.

Predictive equations were used to estimate the reaeration coefficients used in the model. The equations used were those that most closely estimated measured coefficients from the hydraulic conditions at which they were measured. The equation developed by Bennett and Rathbun (1972) yielded constants that most closely matched those measured at discharges similar to those during the August diel sampling, with 90 percent of the values within

± 0.9 (day^{-1}) of the observed constants. The equation developed by O'Connor and Dobbins (1958) best matched coefficients measured at discharges similar to those during the September diel sampling with 90 percent of the values within ± 1.3 (day^{-1}) of the observed constants.

Traveltimes

Traveltimes used in the computer model were calculated by dividing the length of each subreach by an estimate of the average velocity in the subreach. For the model simulating the August data, subreach velocities were estimated by dividing the average discharge in the subreach by the average cross-sectional area of the subreach. For the model describing the September data, subreach velocities were estimated by an equation that related velocity to the average discharge in the subreach. This equation was developed from traveltime data collected at discharges similar to those during the September diel sampling. From these data, discharge in each subreach was estimated as the mean of the discharge measured at each end of the subreach. Velocity through each subreach was estimated by dividing the length of the subreach by the traveltime through the subreach. Linear regression was used to determine the straight line that best estimated velocity from discharge. The equation used to estimate velocity from discharge is

$$V = 0.01284Q - 0.296 \qquad (5)$$

where V is the average velocity in the subreach, in cubic feet per second, and

Q is the average discharge in the subreach, in cubic feet per second.

The linear regression this equation was developed from had a correlation coefficient of 0.98, with 99 percent of the predicted velocities within 0.06 ft/s of those used in developing the equation.

The discharge in the most upstream subreach was an order of magnitude less than the lowest discharge used in developing this regression. The discharge from RM 126.6 to RM 113.6 was about 10 percent less than the lowest discharge used in this regression. The discharge from RM 85.3 to RM 83.1 was 20 percent larger than the largest discharge used in developing the regression. All other discharges were in the range for which the regression was developed.

Reaeration coefficients, traveltimes, and the discharges and subreaches for which they were determined are listed in table 5. Reaeration coefficients and traveltimes in reaches of the river from RM 129.0 to RM 107.2 were measured at discharges similar to those during the August diel data collection. The reaeration coefficients and traveltimes measured downstream from RM 107.2 were measured for discharge conditions similar to those during the September diel data collection.

Table 5.--Traveltimes, reach velocities, and reaeration rate coefficients measured in the Sangamon River

[ft^3/s, cubic feet per second; ft/s, feet per second; dashes indicate no data; reaeration rate coefficient is base 'e' at 20°C]

Subreach	River mile	Date (month/ day	Dis- charge (ft^3/s)	Travel- time based on dye (days)	Travel- time based on gas (days)	Vel- ocity based cn dye (ft/s)	Vel- ocity based on gas (ft/s)	Reaer- ation coef- ficient area method (1/day)	Reaer- ation coef- ficient peak method (1/day)
Sangamon River:									
at Route 48 at Decatur	129.0	07/15	105	--	--	--	--	--	--
at Stevens Creek confluence	126.4	07/16	123	0.42	0.37	0.36	0.43	5.20	4.65
at Wyckles Bridge near Wyckles Corners	124.4	07/16	--	.28	.30	.48	.45	2.29	2.67
just upstream of Stevens Creek	126.8	07/20	93	--	--	--	--	--	--
at Wyckles Bridge near Wyckles Corners	124.4	07/20	180	.19	.18	.77	.81	2.75	2.61
at Wyckles Bridge near Wyckles Corners	124.4	07/27	170	--	--	--	--	--	--
near Niantic	116.9	07/28	170	.66	.67	.69	.68	2.70	2.66
at Niantic Bridge near Niantic	113.8	07/27	185	--	--	--	--	--	--
near Mount Auburn	107.2	07/27	206	.58	.58	.70	.70	2.11	2.47
near Niantic	116.9	07/29	170	--	--	--	--	--	--
at Niantic Bridge near Niantic	113.8	07/29	--	.20	.21	.95	.90	2.58	2.51
near Mount Auburn	107.2	08/26	61	--	--	--	--	--	--
near Bolivia	102.1	08/27	70	.59	.59	.53	.53	2.20	2.48
near Dawson	88.2	09/07	78	--	--	--	--	--	--
near Riverton	85.6	09/07	77	.22	.22	.72	.72	2.67	3.08
at Coal Bank Bridge nr Riverton	84.6	09/07	184	.11	.09	,56	.68	6.73	6.75
near Buckhart	94.9	09/08	64	--	--	--	--	--	--
near Dawson	88.2	09/08	74	.78	.76	.52	.54	4.22	4.36
near Bolivia	102.1	09/09	62	--	--	--	--	--	--
at Roby	98.5	09/09	62	.42	.40	.52	.55	3.51	3.32
near Buckhart	94.9	09/10	63	.42	.40	.52	.55	2.66	3.67
at Stevens Creek confluence	126.4	10/27	41	--	--	--	--	--	--
at Wyckles Bridge near Wyckles Corners	124.4	10/27	49	.45	.43	.29	.28	3.16	5.22
near Niantic	116.9	11/16	62	--	--	--	--	--	--
at Niantic Bridge near Niantic	113.8	11/17	67	.46	.47	.41	.40	.87	.98

Model Simulations

The model was initially calibrated using the August diel data to account for the effects of instream processes that were not measured. Initial conditions, boundary conditions, and any model coefficients determined from observed data were input to the model and were not changed during the calibration process. Inputs for each subreach included the average depth, width, cross-sectional area, length, traveltime, water temperature, and point-source discharges and constituent concentrations. Coefficients input and held constant for each subreach were PNET, the atmospheric reaeration rate, and ultimate CBOD decay and oxidation rates. The ultimate CBOD decay rate was assumed to equal the oxidation rate for this study (see glossary for definition of these terms).

The model was calibrated by changing the values of model coefficients that were not calculated from measured data. Model coefficients were adjusted to cause simulated constituent concentrations to approximate observed data. Unmeasured model coefficients were always set to values within ranges suggested by Zison and others (1978). Model coefficients determined through the model calibration process were the forward reaction rates of organic nitrogen to form ammonia nitrogen, of ammonia nitrogen to form nitrite plus nitrate nitrogen, and decay rates for organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, and phosphorus.

The phosphorus and organic nitrogen decay rates were adjusted to cause the simulated concentrations of these constituents to resemble the concentrations measured from river-water samples. The forward reaction rate of organic nitrogen to form ammonia nitrogen was set equal to the organic nitrogen decay rate in all subreaches. The ammonia nitrogen decay rate was then adjusted to cause the simulated ammonia nitrogen concentrations to resemble those measured from river-water samples. The forward reaction rate of ammonia nitrogen to form nitrite plus nitrate nitrogen was calibrated by adjusting it to cause the simulated DO concentrations to resemble those observed in the river. Calibration of the ammonia nitrogen forward reaction rate was limited in that this coefficient must always be less than or equal to the ammonia nitrogen decay rate. Finally, the nitrite plus nitrate nitrogen decay rate was adjusted to cause the simulated nitrite plus nitrate nitrogen concentrations to resemble those measured from river-water samples.

Coefficients used in the model calibrated to the August diel data set are listed in table 6, and the boundary conditions input to the model are listed in table 7. Figure 9 shows steady-state DO concentrations predicted by the model and concentrations observed in the river. Predicted DO concentrations simulate the 24-hour average concentration at each site. Simulated and observed phosphorus, organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, and chlorophyll-a (observed only) concentrations, and ultimate CBOD, discharge, and specific conductance values are shown in figure 10, 11, 12, 13, 14, 15, 16, and 17, respectively.

Ultimate CBOD's simulated by the model calibrated to the August data are less than measured values. All point sources of CBOD were sampled and ultimate CBOD's and rate constants associated with them were input to the model. The reason that CBOD increased rather than decreased with distance downstream is not known.

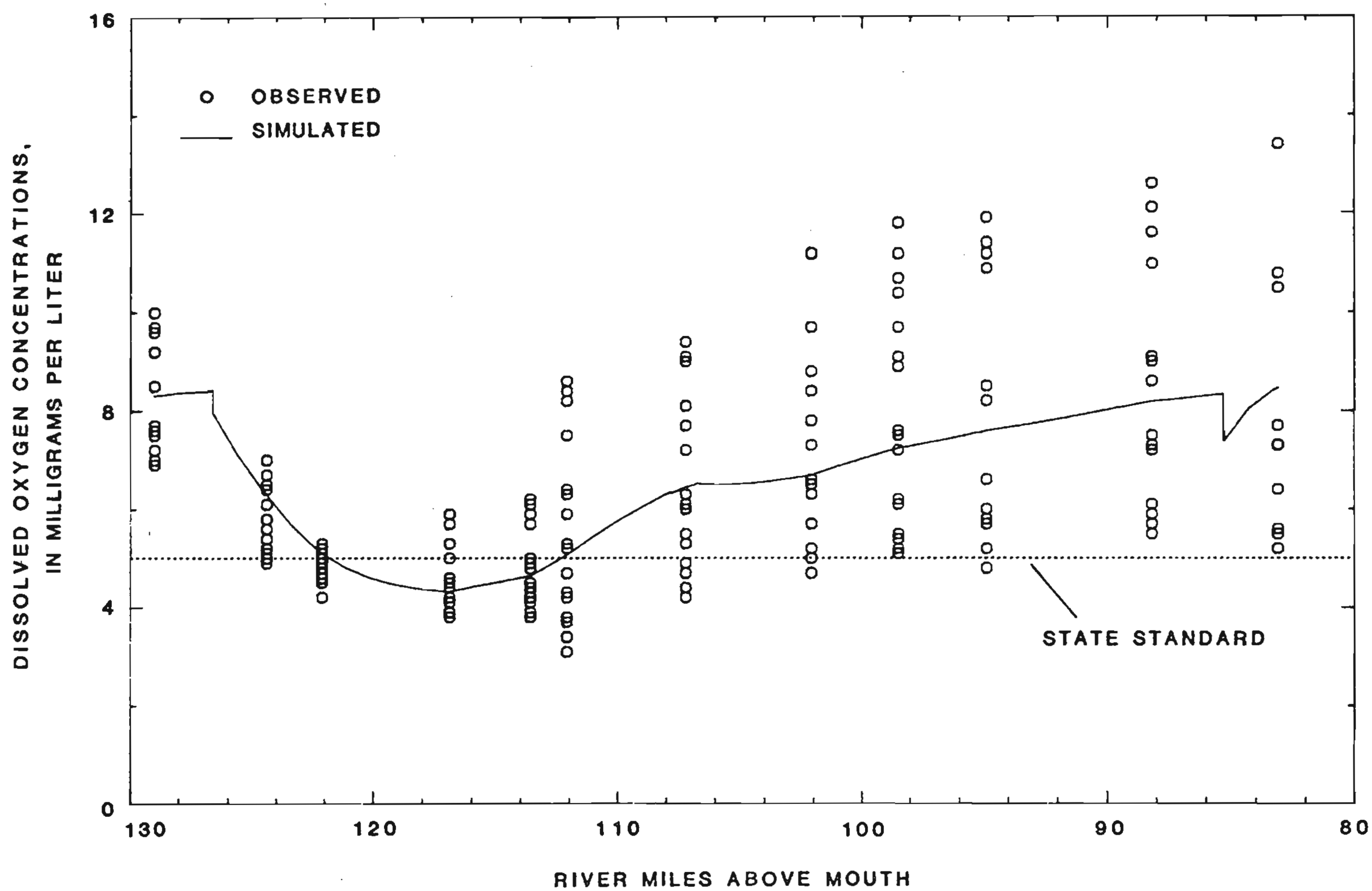

Figure 9.--Simulated and observed dissolved oxygen concentrations during the August 17-18, 1982, diel sampling.

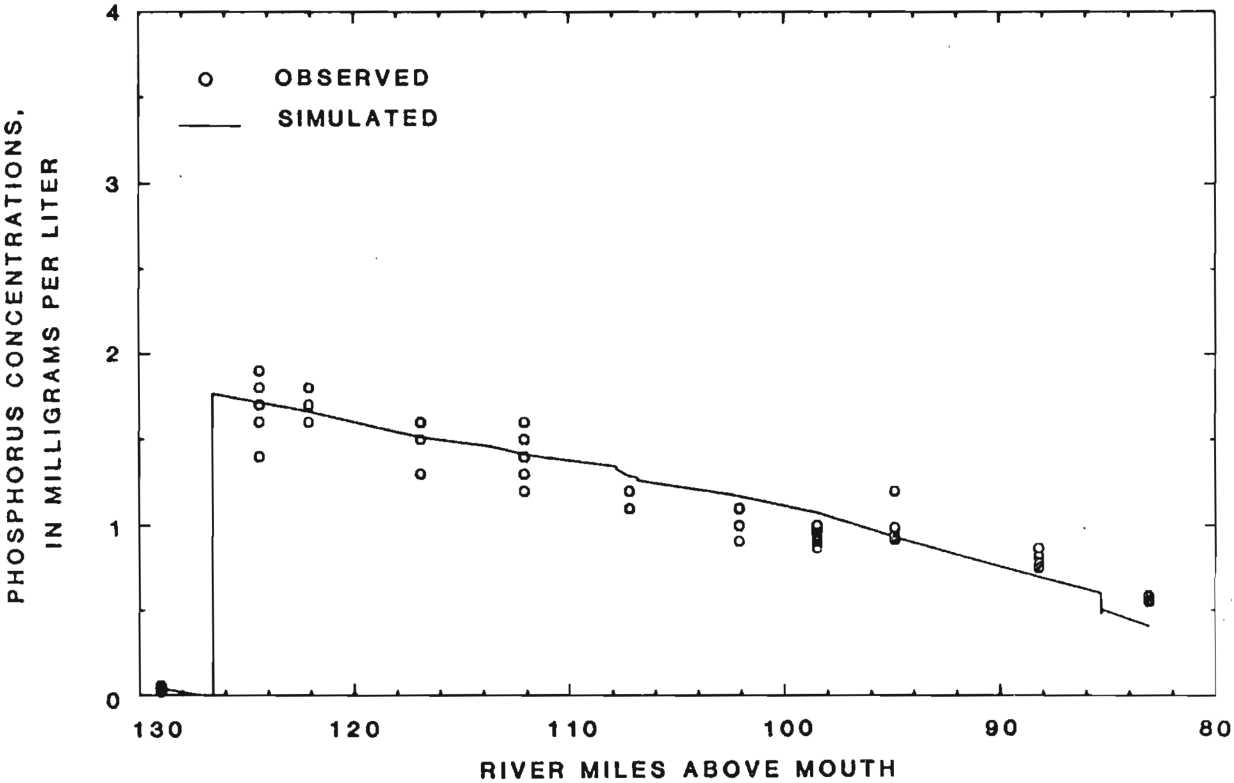

Figure 10.--Simulated and observed phosphorus concentrations during the August 17-18, 1982, diel sampling.

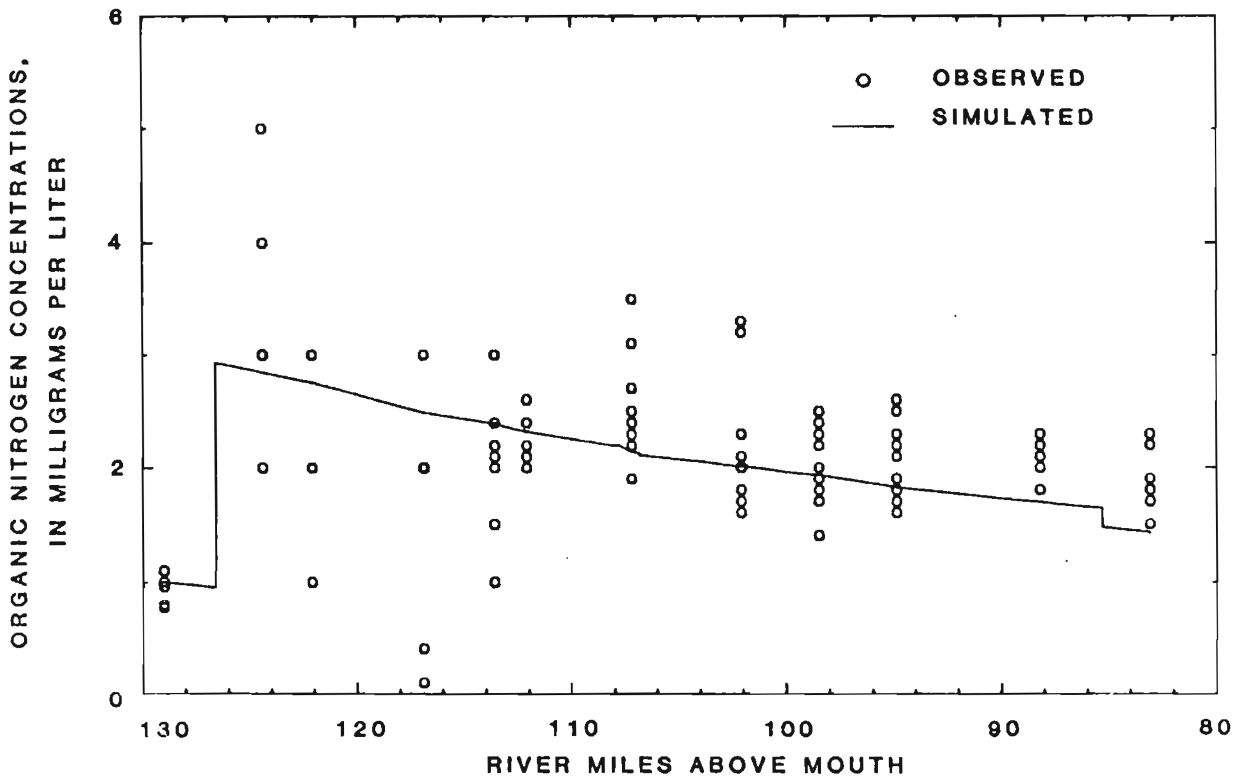

Figure 11.--Simulated and observed organic nitrogen concentrations during the August 17-18, 1982, diel sampling.

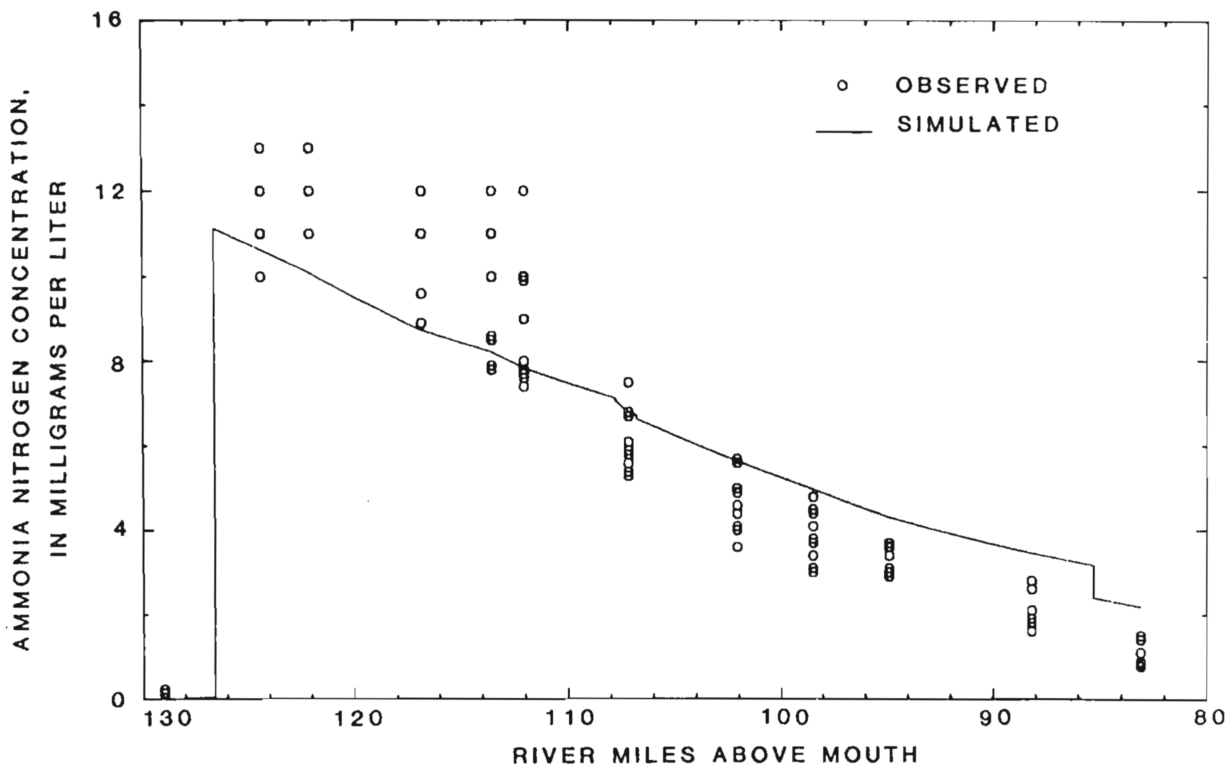

Figure 12.--Simulated and observed ammonia nitrogen concentrations during the August 17-18, 1982, diel sampling.

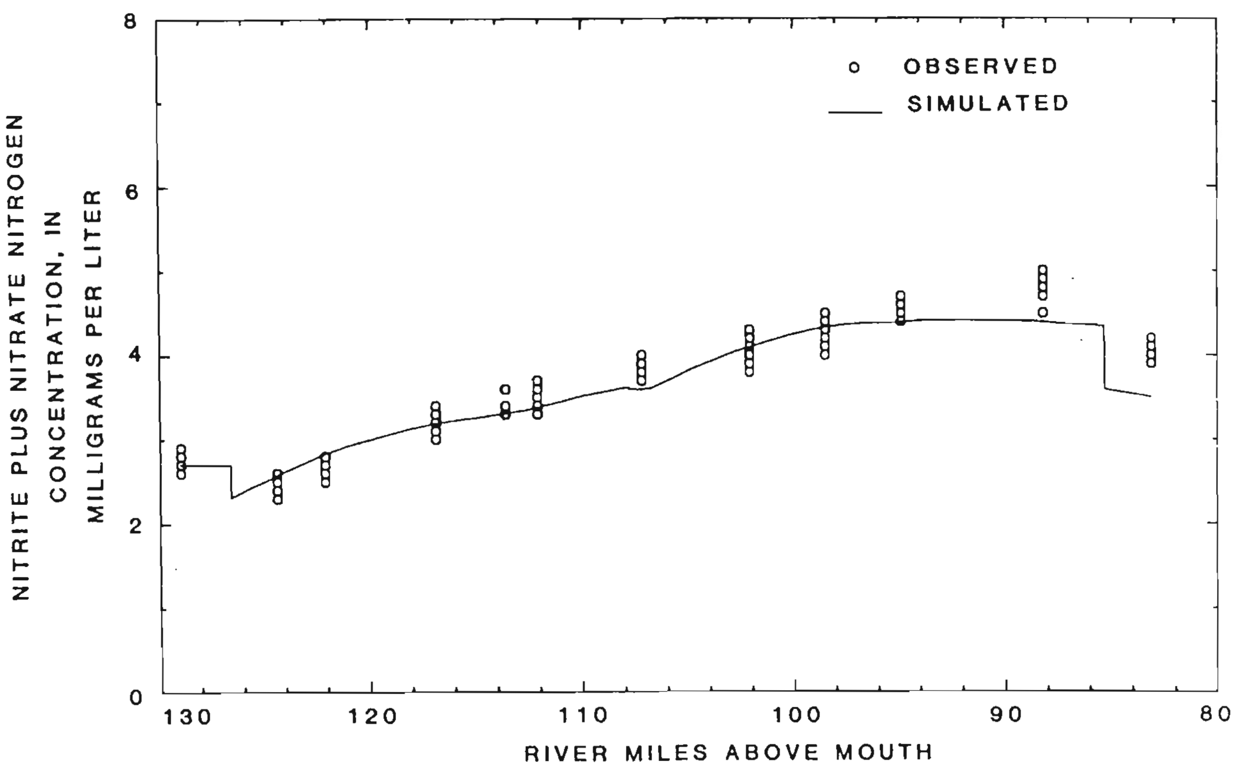

Figure 13.--Simulated and observed nitrite plus nitrate nitrogen concentrations during the August 17-18, 1982, diel sampling.

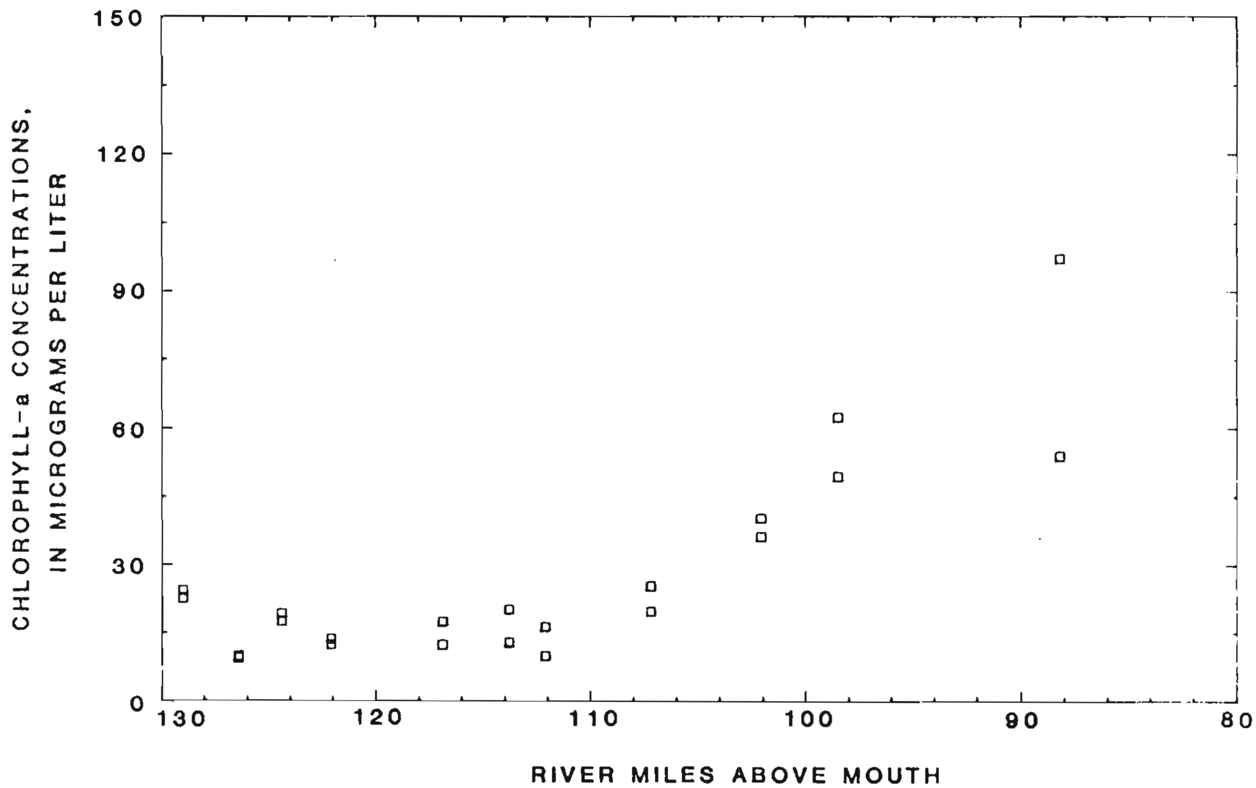

Figure 14.--Chlorophyll-a concentrations observed during the August 17-18, 1982, diel sampling.

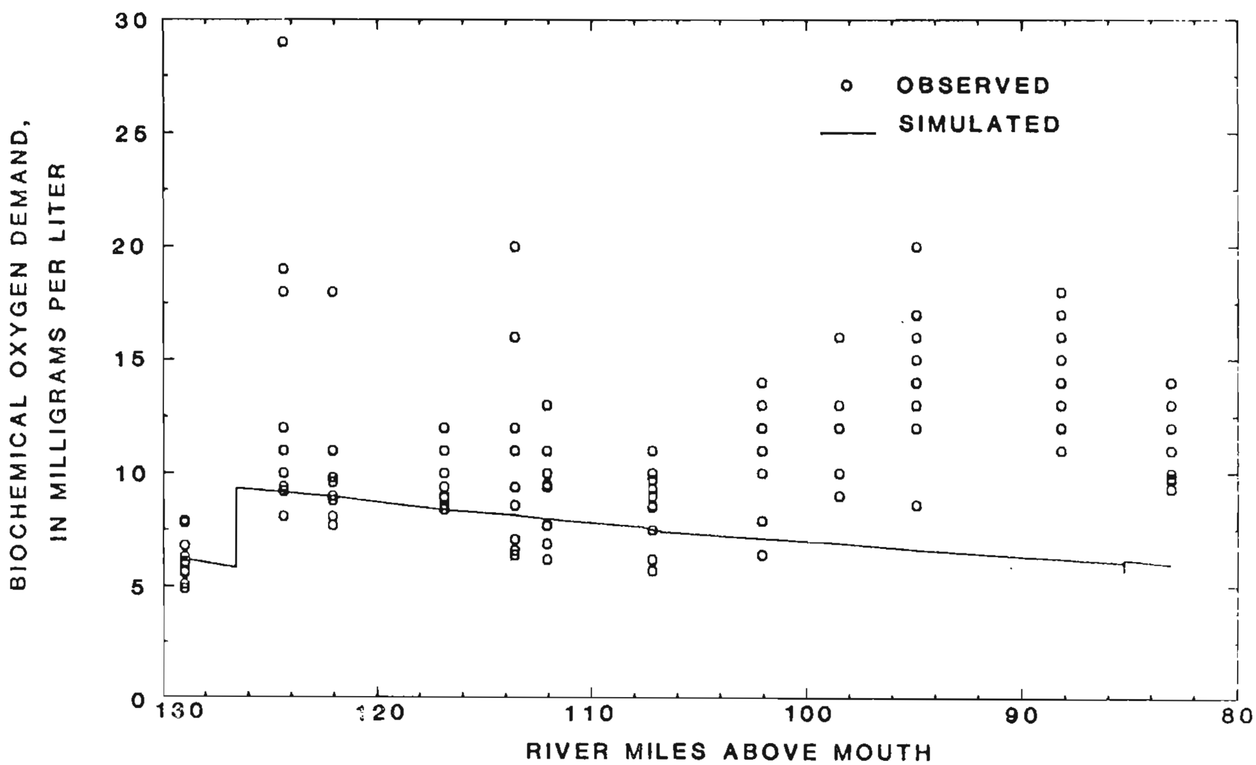

Figure 15.--Simulated and observed carbonaceous biochemical oxygen demand during the August 17-18, 1982, diel sampling.

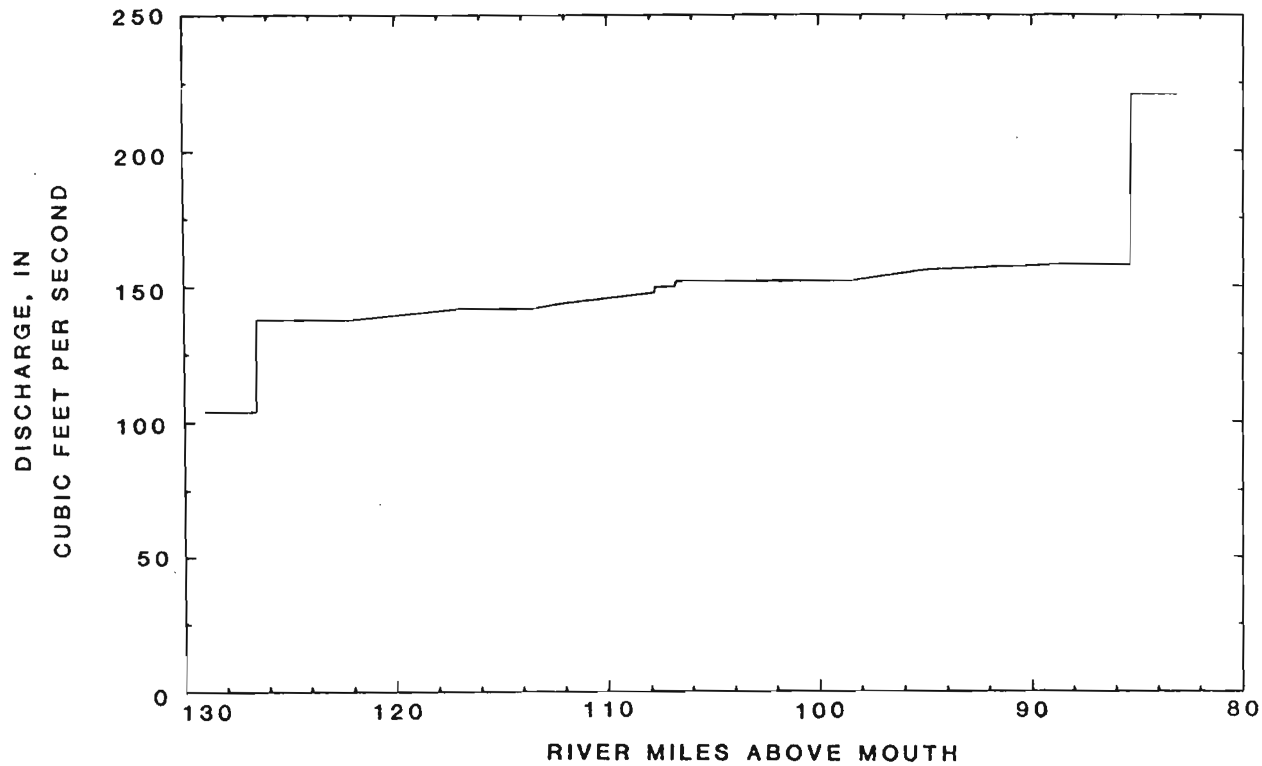

Figure 16.--Discharges used in the computer model of the data observed during the August 17-18, 1982, diel sampling.

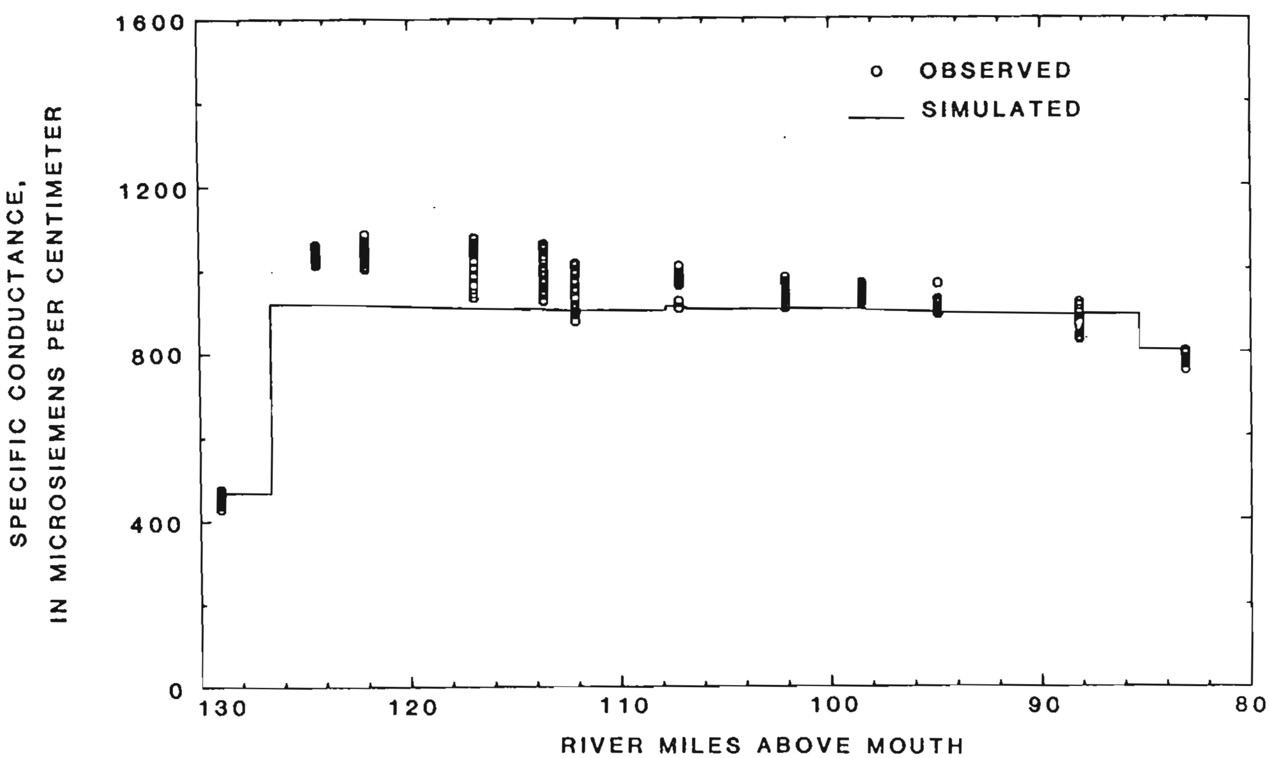

Figure 17.--Simulated and observed specific conductance during the August 17-18, 1982, diel sampling.

Table 6.--Rates and coefficients used in the model calibrated to the data measured during the August 17-18, 1982, diel sampling

[All rates base 'e' at 20°C; (mg/L)/d, milligrams per liter per day; 1/day, reciprocal days; °C, degrees Ceslius]

Subreach in model	Up-stream (mile)	Down-stream (mile)	Net photo-synthetic DO pro-duction [(mg/L)/d]	Ultimate CBOD decay rate (1/day)	Organic nitrogen decay rate (1/day)	Ammonia reac-tion rate (1/day)	Ammonia decay rate (1/day)	Nitrite plus nitrate decay rate (1/day)	Phos-phorus decay rate (1/day)	Atmos-pheric reaer-ation rate (1/day)	Travel-time (hours)	Water temper-ature (°C)
1	129.0	126.6	1.55	0.14	0.10	0.00	0.00	0.00	0.05	4.41	7.680	26
2	126.6	124.4	1.26	.08	.10	.15	.18	.30	.05	2.30	4.320	26
3	124.4	122.1	.66	.08	.10	.15	.18	.30	.05	2.12	4.800	26
4	122.1	116.9	.95	.08	.10	.15	.18	.30	.05	2.12	11.040	26
5	116.9	113.6	1.73	.08	.10	.15	.18	.30	.05	2.34	6.240	25
6	113.6	112.1	4.79	.08	.10	.18	.20	.30	.05	2.43	3.120	25
7	112.1	107.8	6.81	.10	.10	.20	.20	.30	.05	2.43	8.640	25
8	107.8	107.2	5.83	.10	.10	.20	.20	.30	.05	2.43	1.200	25
9	107.2	106.8	5.83	.10	.10	.25	.30	.30	.05	3.52	.720	25
10	106.8	102.1	7.22	.10	.10	.35	.35	.30	.05	3.52	7.920	25
11	102.1	98.5	7.47	.09	.10	.35	.35	.30	.05	3.88	6.240	25
12	98.5	94.9	6.98	.09	.10	.35	.35	.30	.05	3.06	6.000	25
13	94.9	88.2	7.03	.10	.10	.35	.35	.30	.05	3.15	10.800	25
14	88.2	85.3	6.63	.12	.10	.35	.35	.30	.05	2.97	4.560	25
15	85.3	85.29	6.63	.12	.10	.35	.35	.30	.05	6.13	.240	25
16	85.29	83.1	6.84	.13	.10	.35	.35	.30	.05	6.13	5.040	25

Table 7.--Characteristics and constituent concentrations input as boundary conditions to the model of the data measured during the August 17-18, 1982, diel sampling

[ft^3/s, cubic feet per second; mg/L, milligrams per liter; µS/cm, microsiemens per centimeterat 25°C]

Description	Outfall location (river mile)	Dis-charge (ft^3/s)	Dis-solved oxygen (mg/L)	Ultimate bio-chemical oxygen demand (mg/L)	Organic nitrogen (mg/L)	Ammonia (mg/L)	Nitrite plus nitrate (mg/L)	Phos-phorus (mg/L)	Specific conduct-ance (µS/cm)
Headwaters--release from Lake Decatur	129.0	104	8.3	6.2	1.0	0	2.7	0.04	468
Stevens Creek	126.6	34	6.5	20	9.0	45	1.1	7.2	2,300
Long Point Slough	107.8	2.2	4.1	10	2.5	2.8	2.1	.29	2,130
Mosquito Creek	106.8	2.0	8.1	2.9	.6	.18	2.2	.07	513
Buckhart Creek	--	--	--	--	--	--	--	--	--
Clear Creek	--	--	--	--	--	--	--	--	--
South Fork Sangamon River	85.3	45	4.8	4.3	1.0	.18	2.0	.06	573
Sugar Creek	85.29	18	4.4	12	1.2	1.3	1.0	.80	616

Comparisons between observed ultimate CBOD's, observed chlorophyll-a concentrations, and diel variations in DO concentrations show that the increase in ultimate CBOD occurs in that part of the river where the effect of algae and aquatic plants is greatest. It is possible that the increase in CBOD was a result of decay, in the sample bottles, of algae that were killed in the process of chilling, shipping, and incubating (in darkness) the sample.

The instream death and decay of algae would act as a nonpoint source of CBOD. However, because some of the dead plant material is transported out of the study reach and not all the algae die off at the same time, instream CBOD from this source is much less than what was measured in samples.

Based on these assumptions, the model was calibrated by using CBOD's measured from point sources to the river. The actual CBOD in the river was probably somewhere between that simulated by the model and the measured values. The model was adjusted to simulate measured CBOD in order to determine how much effect these higher CBOD values would have on simulated DO concentrations. The DO simulated by forcing model output to equal measured CBOD's should provide an upper limit on the effect of CBOD.

The largest change in simulated DO concentration, 0.42 mg/L, caused by inputting measured CBOD's, occurred for a region where DO concentrations were well above the State's minimum DO standard. The effect in areas where simulated DO concentrations were near the standard was very slight (0.0 to 0.04 mg/L). Measured DO concentrations, those predicted by the calibrated model and those predicted by the adjusted model, are presented in figure 18.

After the model was calibrated to the August data, boundary and initial conditions were changed to match those determined from data collected during the September diel sampling, in an attempt to verify the model. Model verification determines the transferability of the model to conditions other than those for which it was calibrated by using it to simulate constituent concentrations resulting from initial and boundary conditions different from those for which the model was calibrated. Coefficients from the calibrated model were used in the verification. If simulated constituent concentrations approximate measured concentrations, the model is considered verified over the range of conditions bounded by the conditions calibrated and verified to. However, the stream conditions in September were significantly different from those in August. In September, discharge at RM 126.4 was 71 percent lower (from 138 to 40 ft^3/s) and ammonia nitrogen concentration was 3.8 times higher (from 11 to 43 mg/L) than in August. Dissolved oxygen and ammonia nitrogen concentrations predicted by the model, after substituting boundary and initial conditions from the September data set, were far below the values observed in the stream, and nitrite plus nitrate nitrogen concentrations were significantly overestimated. These results imply that the forward-reaction rate of ammonia nitrogen to nitrite plus nitrate nitrogen used in model calibration was higher than the instream rate during the September diel sampling.

Significant difference in water chemistry between August and September prevented the development of one model to simulate conditions for both periods. Because these differences precluded model verification, attempts were made to recalibrate the model to simulate the September data. By using measured values, where available, and varying other coefficients with the ranges

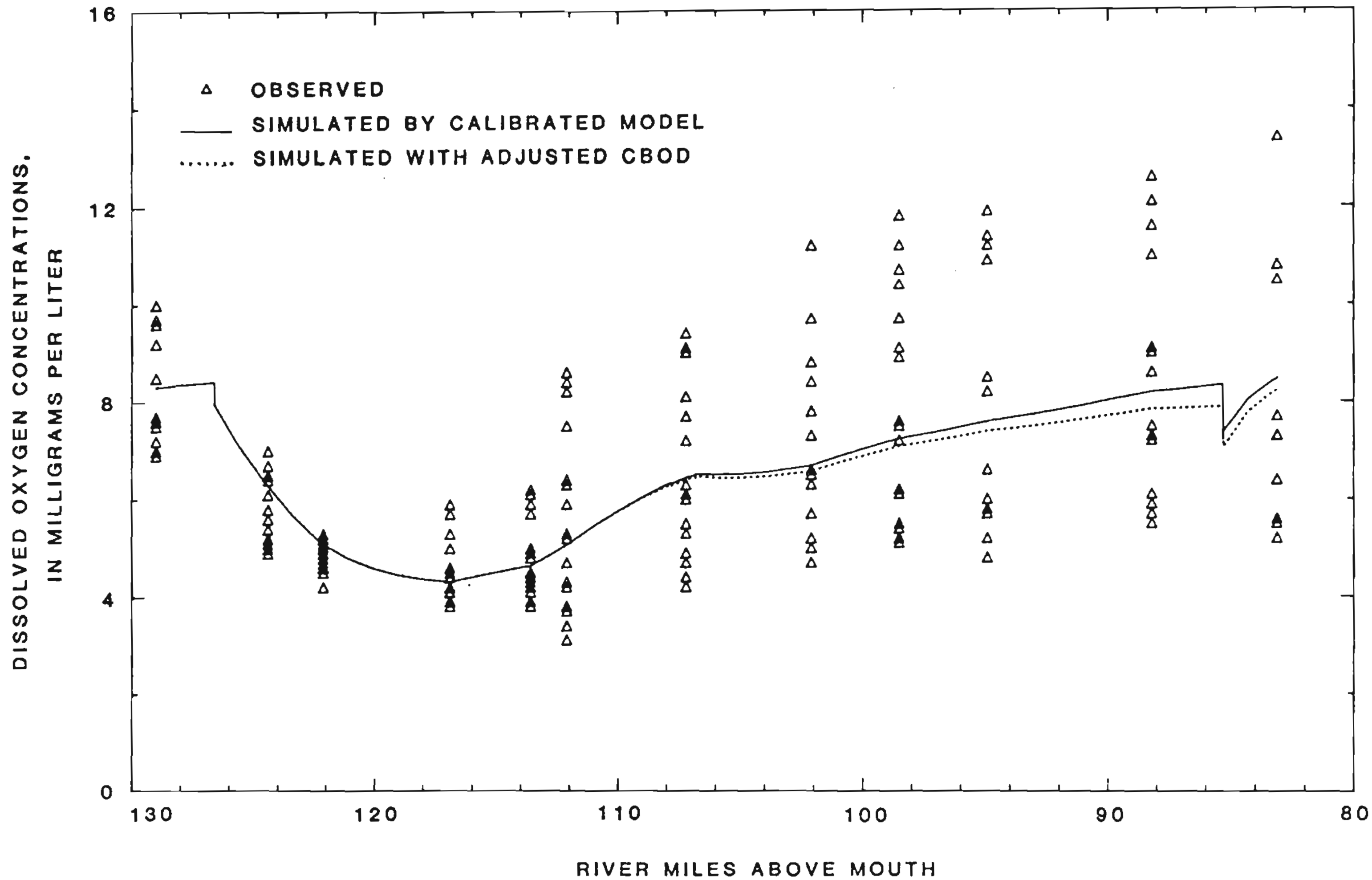

Figure 18.--Dissolved oxygen concentrations observed in the river, simulated by the calibrated model, and simulated by the model that simulates CBOD concentrations observed during the August 17-18, 1982, diel sampling.

suggested by Zison and others (1978), the model was calibrated to simulate the September data. The simulated values matched the measured data for all consitutents except DO. The simulated DO agreed with the measured values in the upstream 14.5 miles of the study reach (RM 126.6 to RM 112.1), but greatly underestimated the observed DO downstream from RM 112.1. The reason why DO could not be accurately simulated is not clearly known.

The rainstorm that occurred during the September sampling may have affected the photosynthetic DO production and thus the PNET calculations to the extent that the data collected were not sufficiently representative of a steady-state system. The storm passed through the study area at the time of peak photosynthetic DO productivity and had the effect of "quenching" the peak DO concentrations. The diminished DO concentrations result in negative values in PNET calculations for reaches of the river where, by estimating the chlorophyll-a concentrations, the PNET should have been greatest.

The rates and coefficients used in the model that best simulated all constituents except DO are given in table 8, and the boundary conditions input to the model are listed in table 9. The simulated steady-state DO concentrations and the concentrations observed in the river are shown in figure 19. The simulated and observed phosphorus, organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, chlorophyll-a (observed only) concentrations, ultimate CBOD, discharge, and specific conductance are shown in figures 20, 21, 22, 23, 24, 25, 26, and 27, respectively.

The forward reaction rate of ammonia nitrogen to form nitrite plus nitrate nitrogen ranged from 0.02 to 0.20 (day^{-1}) for this model, as compared to 0.15 to 0.35 (day^{-1}) for that in the model calibrated to the August data. The reason for the change in this reaction rate is not known. Possibly insufficient Nitrosomonas population in the headwaters or toxic effects from the high ammonia nitrogen concentration on the Nitrosomonas led to a low reaction rate until the population could increase in response to the high ammonia nitrogen concentration. Further study is needed to determine what relation, if any, exists between this rate and the ammonia nitrogen concentration, for the range of ammonia nitrogen concentrations observed in this study.

The forward reaction rate of ammonia nitrogen to nitrite plus nitrate nitrogen was identified through the calibration procedure as the most critical model coefficient with respect to predicting DO concentrations in the river.

Process Evaluation

Figure 28 shows reoxygenation and deoxygenation due to ammonia nitrogen oxidation, BOD decay, PNET, and atmospheric reaeration, as simulated by the calibrated model. This plot shows changes in DO concentration, in each reach, due to each of these processes. A DO concentration profile for the stream is included to illustrate the net effect of all processes on the simulated DO concentrations. This plot reflects the actual change in DO in each reach, allowing comparison of the relative importance of each process within a reach. This plot also shows the reaches in which each process had the greatest effect

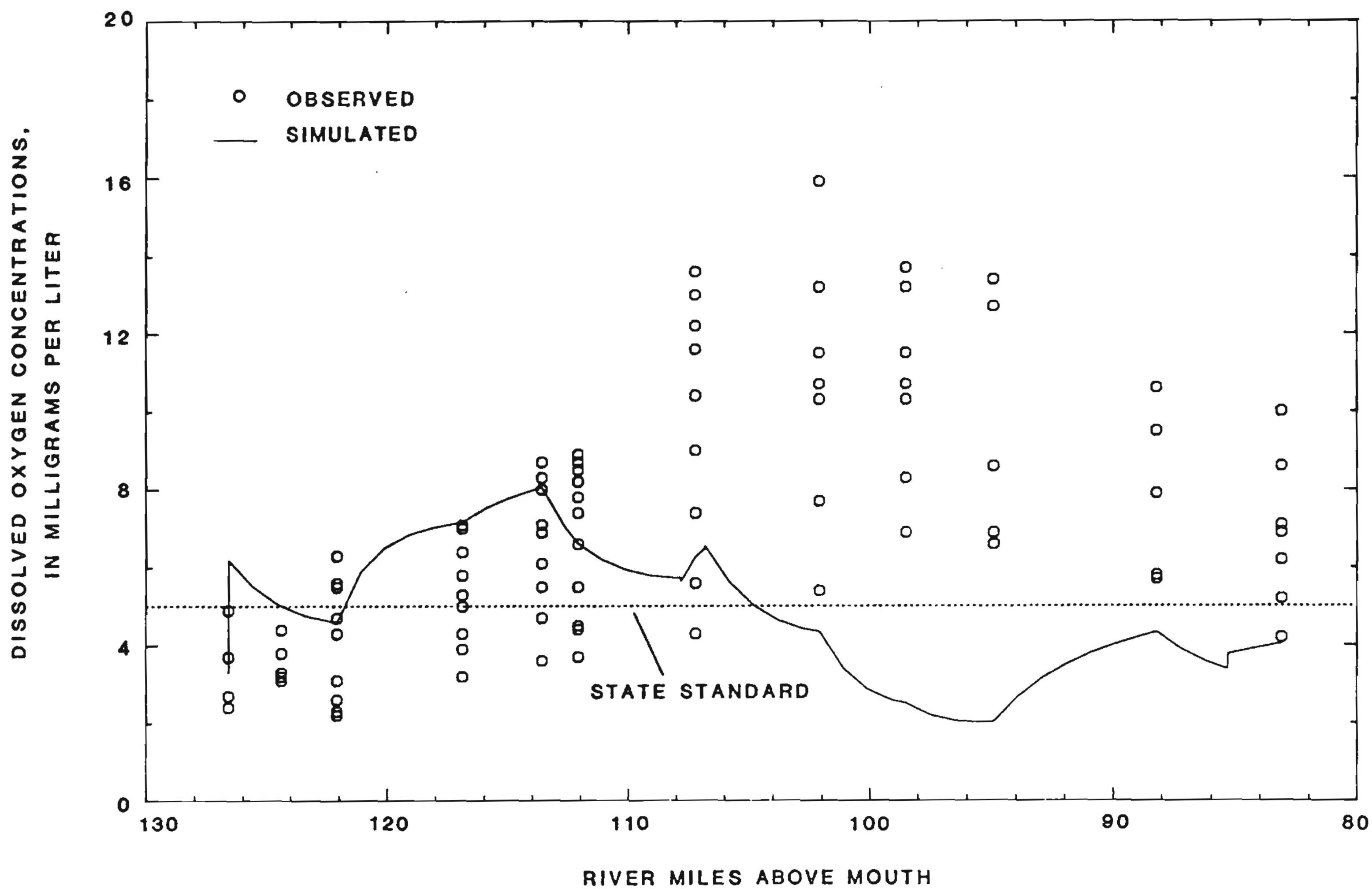

Figure 19.--Simulated and observed dissolved oxygen concentrations during the September 14-15, 1982, diel sampling.

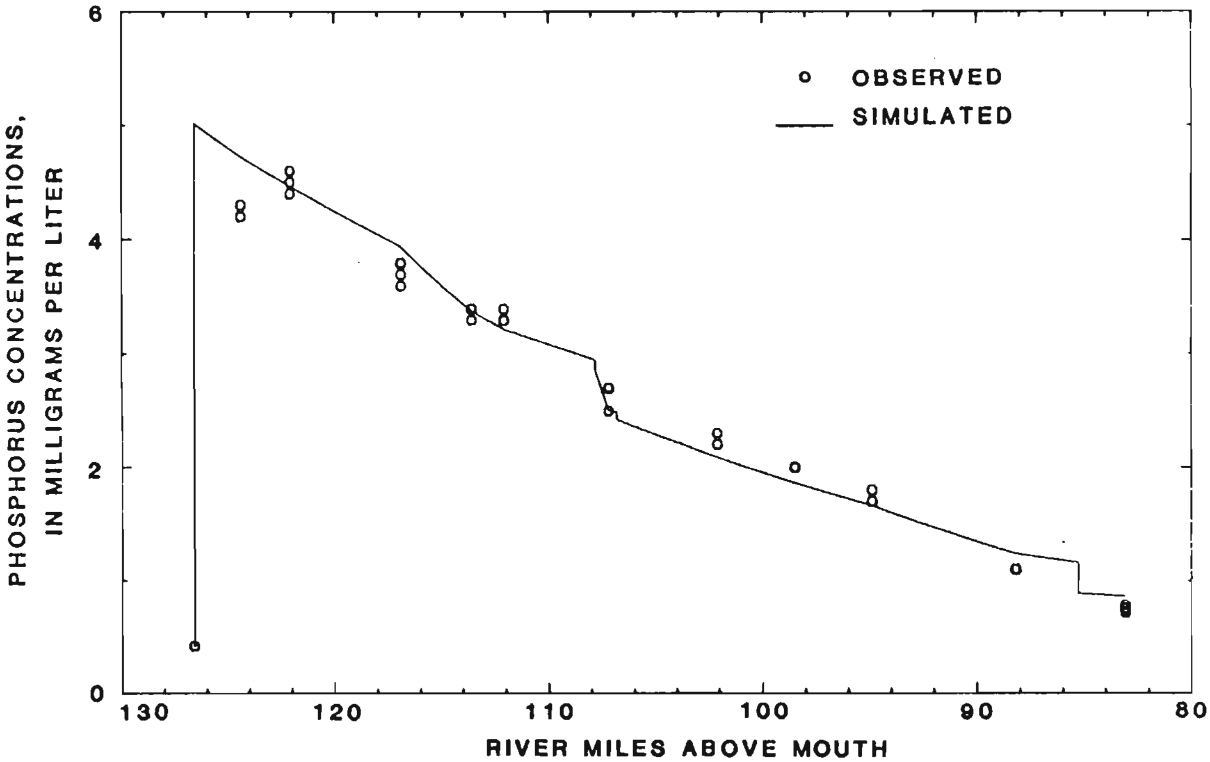

Figure 20.--Simulated and observed phosphorus concentrations during the September 14-15, 1982, diel sampling.

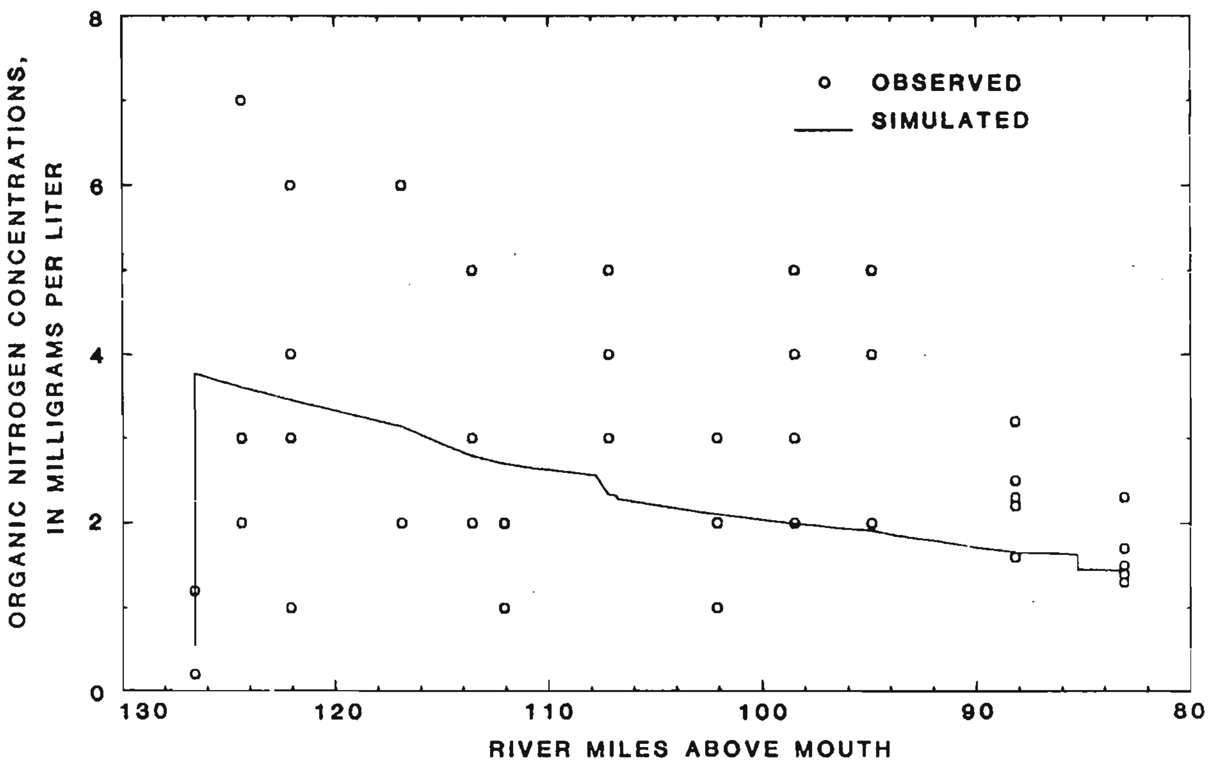

Figure 21.--Simulated and observed organic nitrogen concentrations during the September 14-15, 1982, diel sampling.

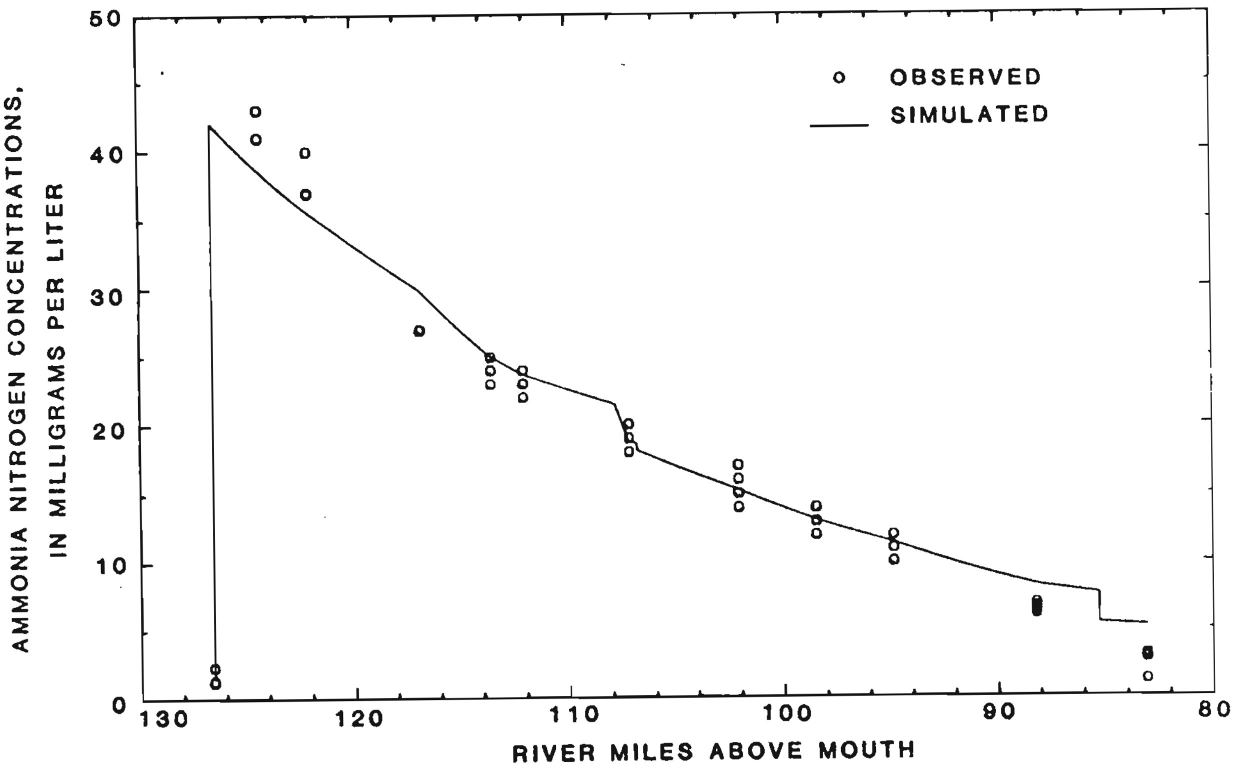

Figure 22.--Simulated and observed ammonia nitrogen concentrations during the September 14-15, 1982, diel sampling.

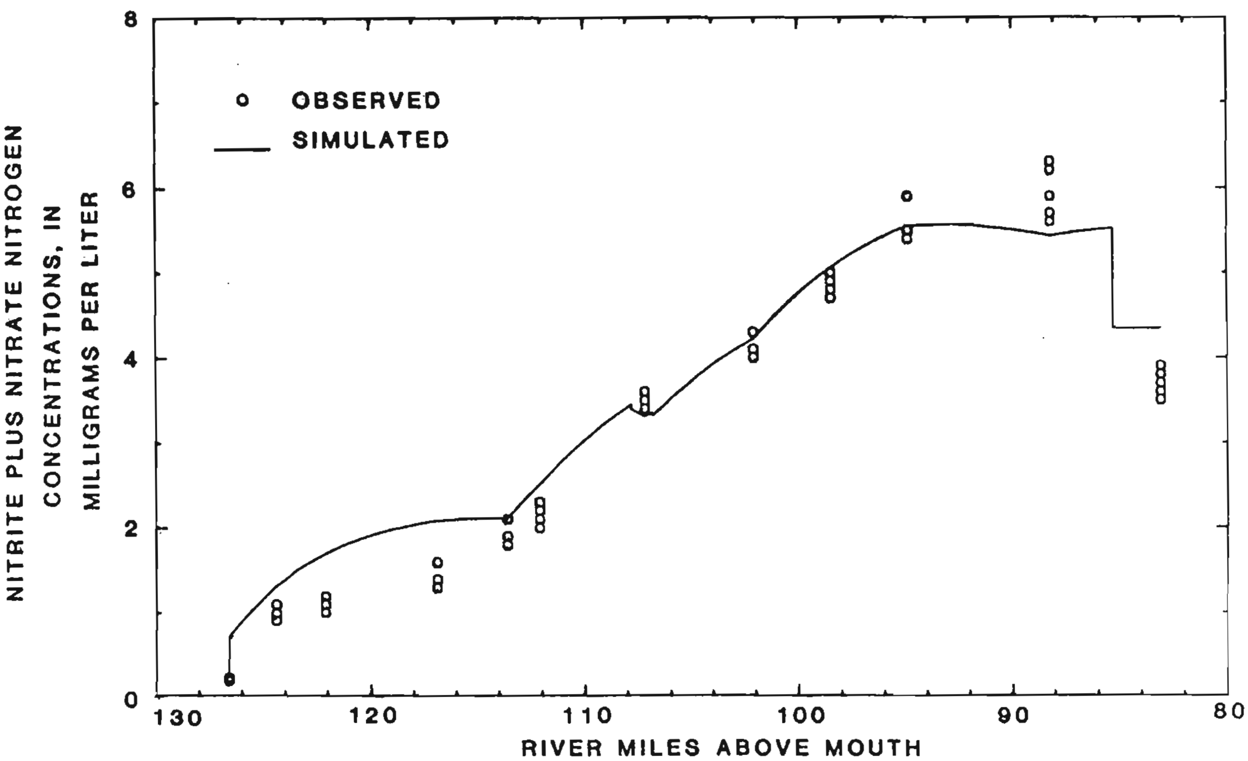

Figure 23.--Simulated and observed nitrite plus nitrate nitrogen concentrations during the September 14-15, 1982, diel sampling.

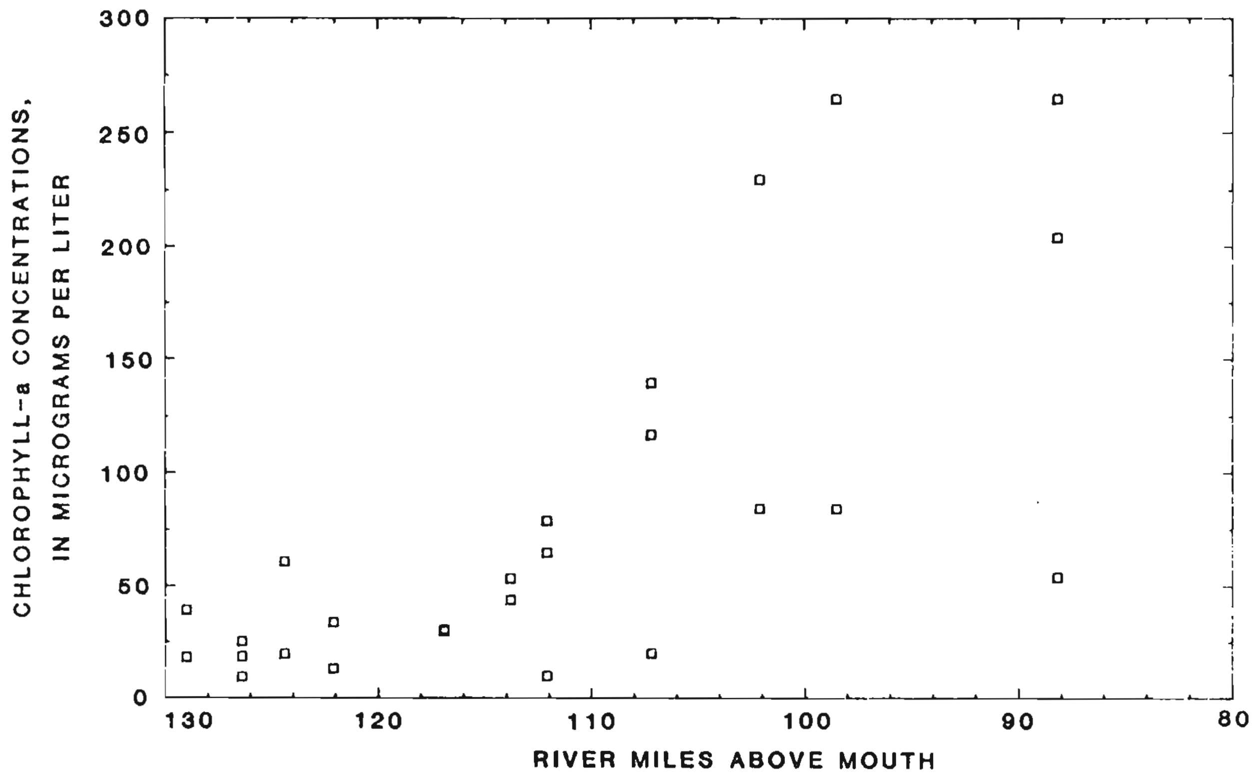

Figure 24.--Chlorophyll-a concentrations observed during the September 14-15, 1982, diel sampling.

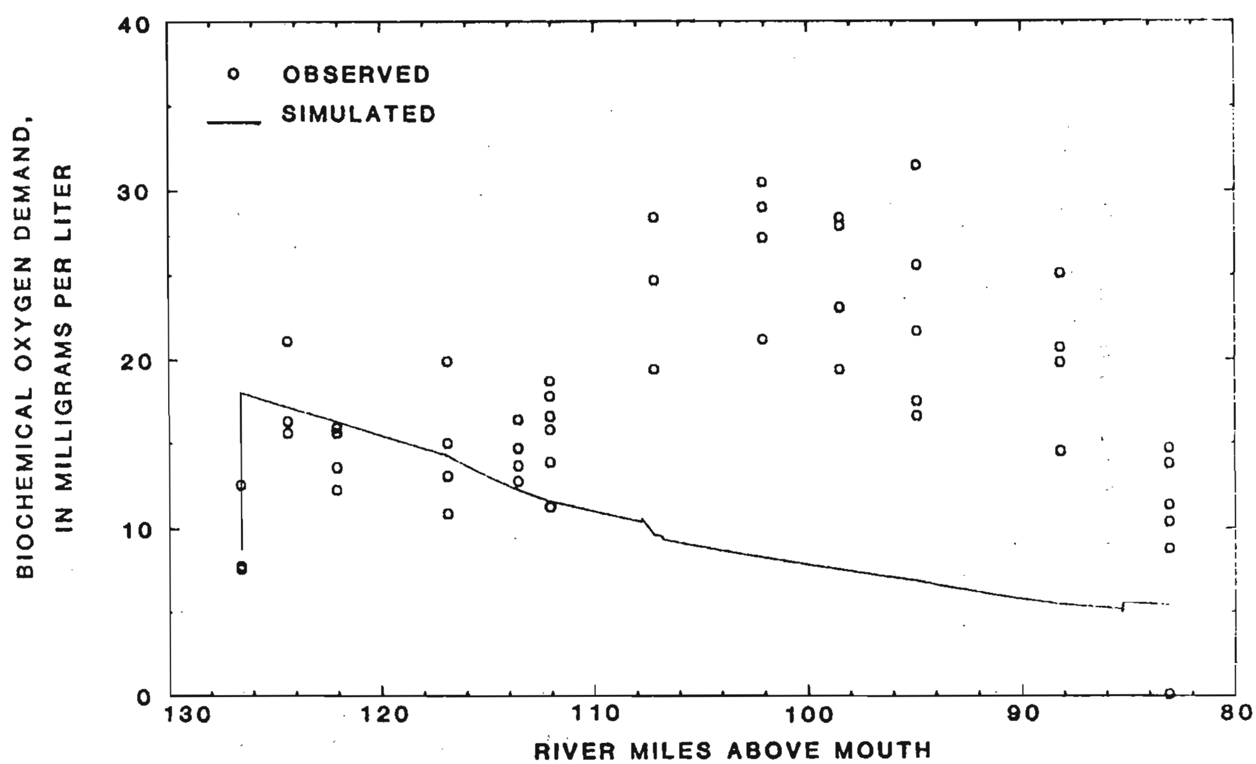

Figure 25.--Simulated and observed carbonaceous biochemical oxygen demand during the September 14-15, 1982, diel sampling.

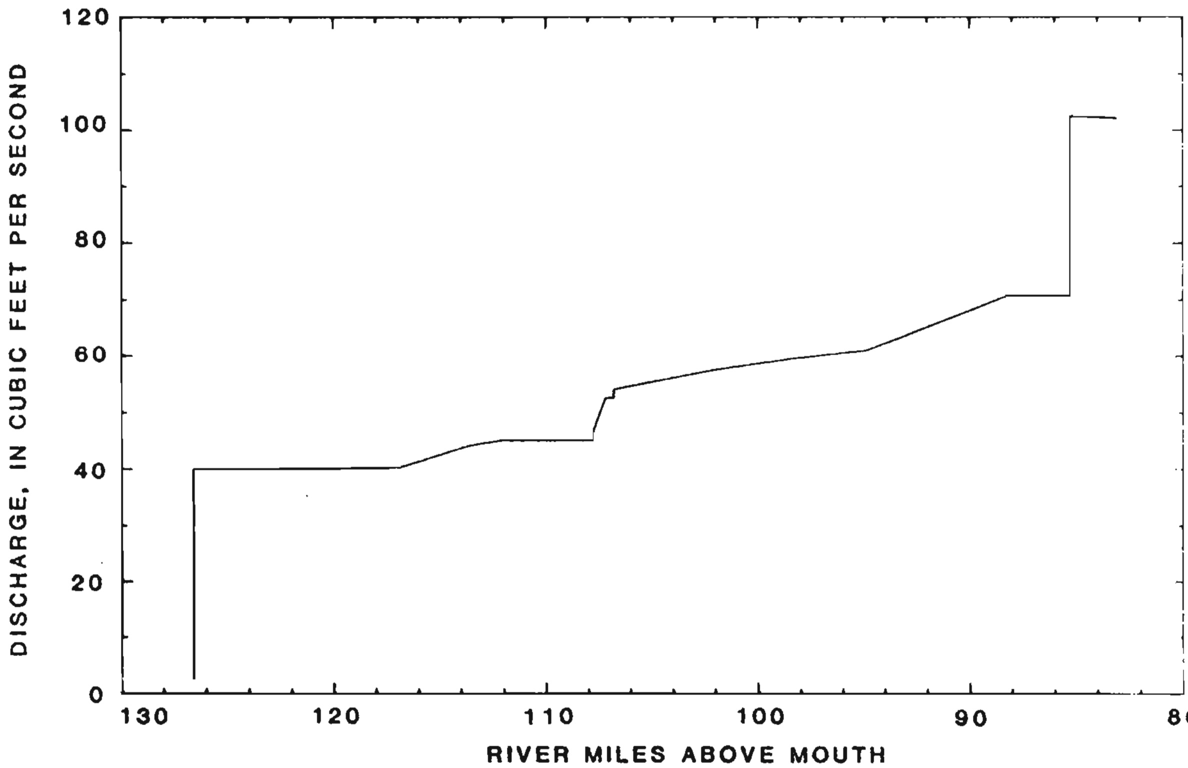

Figure 26.--Discharges used in the computer model of the data observed during the September 14-15, 1982, diel sampling.

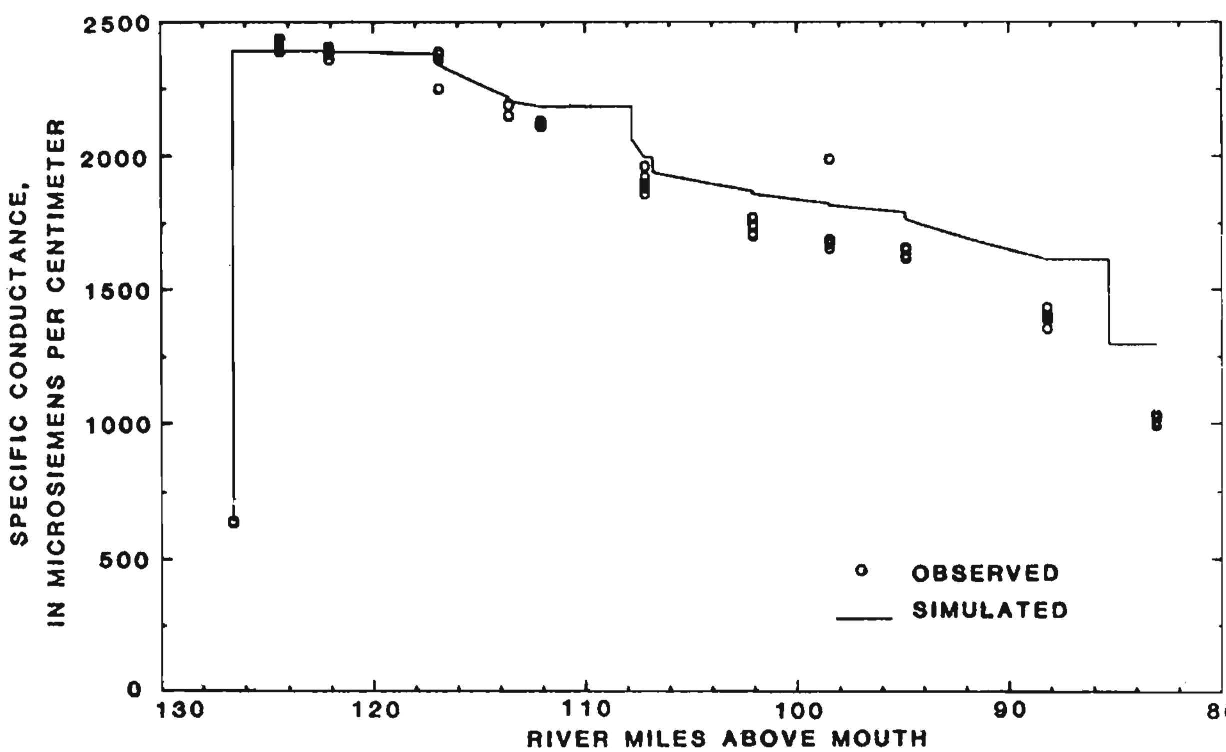

Figure 27.--Simulated and observed specific conductance during the September 14-15, 1982, diel sampling.

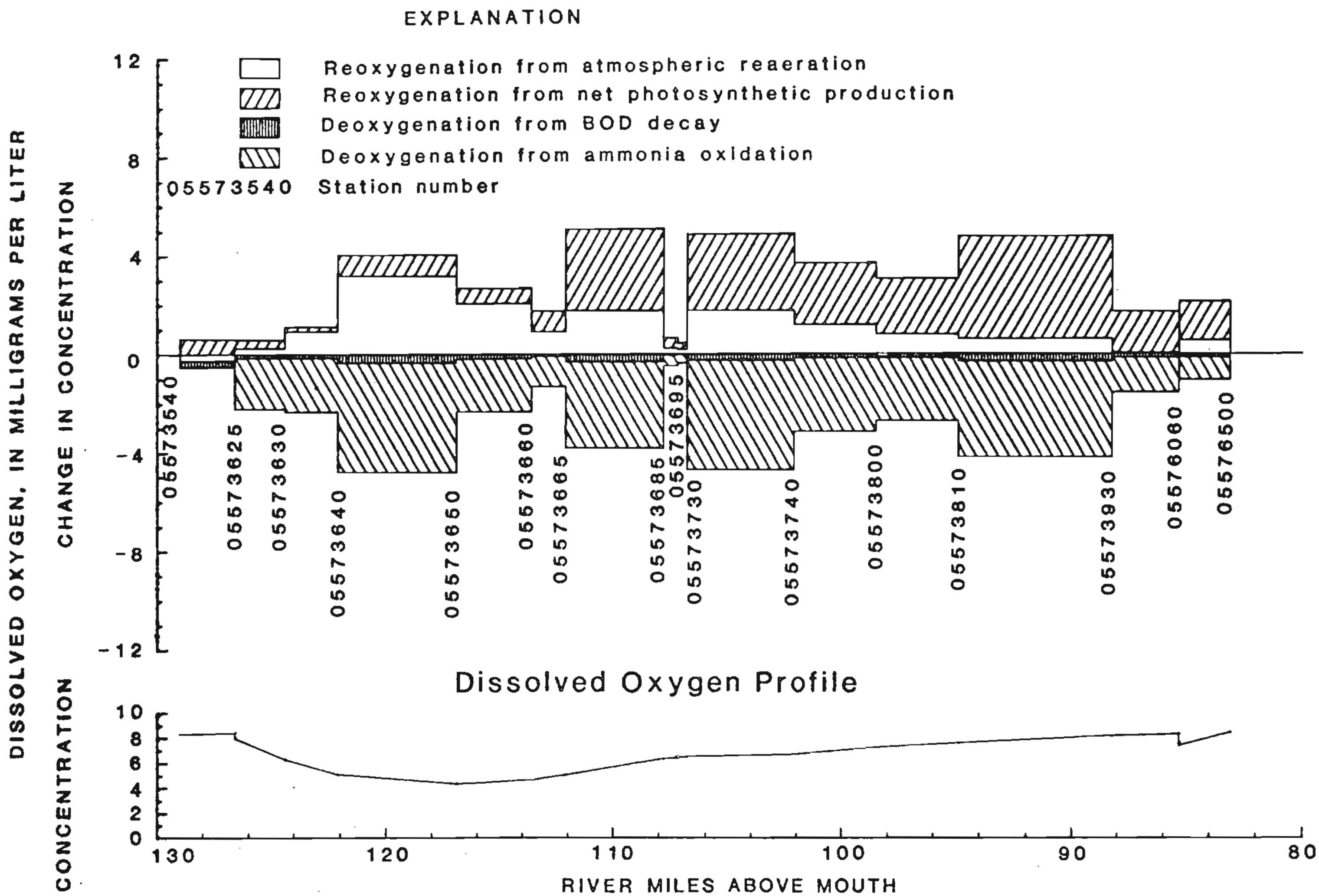

Figure 28.--Amounts of deoxygenation and reoxygenation, and the simulated dissolved oxygen profile during the August 17-18, 1982, diel sampling.

Table 8.--Rates and coefficients used in the model calibrated to the data measured during the September 14-15, 1982, diel sampling

[All rates base 'e' at 20°C; (mg/L)/d, milligrams per liter per day; 1/day, reciprocal days; °C, degrees Ceslius]

Subreach in model	Up-stream (mile)	Down-stream (mile)	Net photo-synthetic DO pro-duction [(mg/L)/d]	Ultimate CBOD decay rate (1/day)	Organic nitrogen decay rate (1/day)	Ammonia reac-tion rate (1/day)	Ammonia decay rate (1/day)	Nitrite plus nitrate decay rate (1/day)	Phos-phorus decay rate (1/day)	Atmos-pheric reaer-ation rate (1/day)	Travel-time (hours)	Water temper-ature (°C)
1	126.61	126.6	3.22	0.15	0.04	0.02	0.08	0.25	0.00	0.44	0.010	24
2	126.6	124.4	2.41	.06	.04	.02	.08	.25	.02	3.20	14.700	27
3	124.4	122.1	1.97	.06	.04	.02	.08	.25	.02	2.91	15.300	26
4	122.1	116.9	2.28	.07	.04	.02	.08	.25	.02	2.88	34.700	25
5	116.9	113.6	3.52	.08	.04	.02	.08	.25	.02	2.85	19.400	24
6	113.6	112.1	3.76	.10	.04	.06	.08	.25	.02	2.85	7.900	24
7	112.1	107.8	5.03	.10	.04	.06	.08	.25	.02	2.85	22.500	24
8	107.8	107.2	6.73	.10	.04	.06	.08	.25	.02	2.85	2.600	24
9	107.2	106.8	6.75	.10	.04	.06	.08	.25	.02	2.02	1.500	24
10	106.8	102.1	2.84	.10	.04	.12	.12	.25	.02	2.02	16.400	24
11	102.1	98.5	-1.62	.12	.04	.18	.18	.25	.02	3.04	11.500	24
12	98.5	94.9	-2.33	.14	.04	.18	.18	.25	.02	2.85	11.000	24
13	94.9	88.2	-2.48	.17	.04	.18	.18	.25	.02	3.86	17.900	24
14	88.2	85.3	-2.57	.17	.04	.20	.20	.25	.02	2.58	7.000	24
15	85.3	85.29	-2.57	.17	.04	.20	.20	.25	.02	2.21	.020	24
16	85.29	83.1	- .727	.18	.04	.20	.20	.25	.02	1.66	3.100	24

Table 9.--Characteristics and constituent concentrations input as boundary conditions to the model of the data measured during the September 14-15, 1982, diel sampling

[ft^3/s, cubic feet per second; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C]

Description	Outfall location (river mile)	Dis-charge (ft^3/s)	Dis-solved oxygen (mg/L)	Ultimate bio-chemical oxygen demand (mg/L)	Organic nitrogen (mg/L)	Ammonia (mg/L)	Nitrite plus nitrate (mg/L)	Phos-phorus (mg/L)	Specific conduct-ance (µS/cm)
Headwaters--release from Lake Decatur	126.61	2.7	3.3	8.8	0.55	1.5	0.22	0.41	646
Stevens Creek	126.6	37.3	6.4	18.7	4.0	45	.74	5.35	2,520
Long Point Slough	107.8	1.6	3.1	16.1	3.0	19	1.6	.39	2,210
Mosquito Creek	106.8	1.5	8.1	2.9	.6	.18	2.2	.07	513
Buckhart Creek	--	--	--	--	--	--	--	--	--
Clear Creek	--	--	--	--	--	--	--	--	--
South Fork Sangamon River	85.3	22.5	4.8	4.3	1.0	.18	2.0	.06	573
Sugar Creek	85.29	9.2	4.4	12.0	1.2	1.3	1.0	.80	616

on DO. However, because these changes are dependent on the traveltime through each reach, comparisons between reaches do not illustrate the behavior of the processes with increasing distance from the headwaters.

Figure 29 shows the rate of change of DO concentration due to each of these four processes. These rates were determined by dividing the change in DO by the traveltime through the reach. As these rates are independant of traveltime, they reflect the second-order kinetics; the increase or decrease of the process with increasing distance from the headwaters.

The reoxygenation/deoxygenation plots (figs. 28 and 29) show that the oxidation of ammonia nitrogen to nitrite plus nitrate nitrogen is the major deoxygenation process occurring in those reaches that have the lower 24-hour average DO concentrations during August. Oxidation of ammonia nitrogen accounts for the low DO in all reaches where DO concentrations are below the Illinois standard of 5.0 mg/L. These plots also show that the DO required to satisfy CBOD was negligible compared to the other demands exerted on DO concentrations during August.

Net photosynthetic DO production was a significant factor in determining the DO concentration profile. In August, the effect of PNET was negligible compared to ammonia oxidation and atmospheric reaeration in the upstream 15.2 miles of the study reach but increased rapidly from RM 113.8 to RM 112.1. Downstream of RM 112.1, PNET became the dominant reoxygenation process.

Atmospheric reaeration was the most widely varying process, as its rate and magnitude depend primarily on the magnitude of the DO deficit. Atmospheric reaeration was the primary reoxygenation process in reaches with the larger DO deficits. Atmospheric reaeration and PNET tended to offset each other; reaeration was low when PNET was large, and reaeration rates were large when PNET was low.

SUMMARY

Dissolved oxygen concentrations and the processes that affect them in the 45.9-mile reach of the Sangamon River downstream of Decatur were quantified by using instream measurements, laboratory analyses of water samples, and computer-model simulations. Processes that affect DO concentrations were the oxidation of ammonia nitrogen and carbonaceous organic matter, atmospheric reaeration, and production and respiration by aquatic plants and algae.

The effects of algae and other aquatic plants on DO concentrations were quantified as the net DO production over a 24-hour period on the basis of measured diel variations in the DO concentrations.

Traveltimes were determined by measuring the time required for a dye tracer to pass between sites. Reaeration rates were determined by measuring ethylene lost from the stream during the measured traveltime. Predictive equations were used to estimate reaeration coefficients for discharge conditions other than those at which the coefficients were measured.

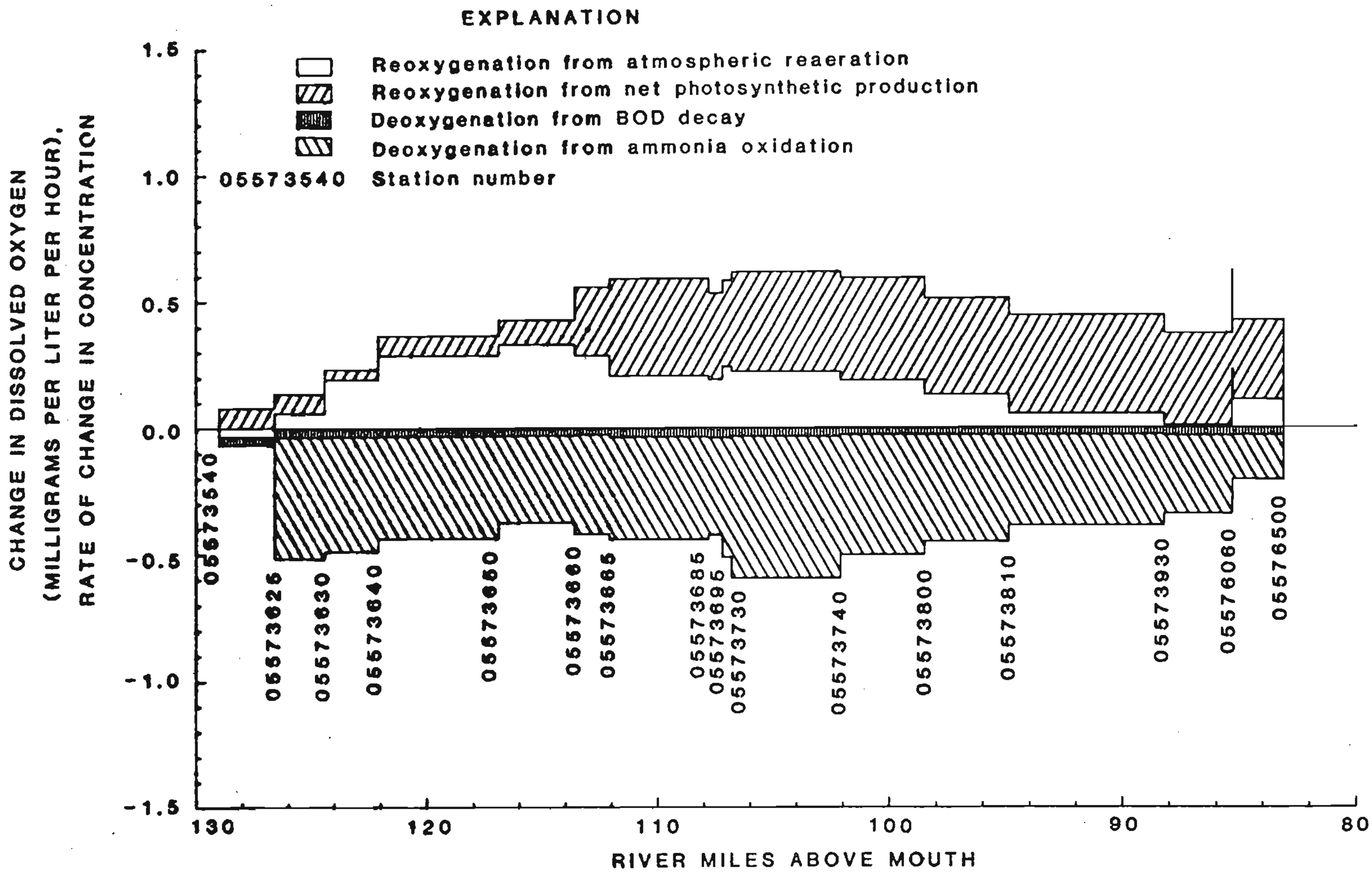

Figure 29.--Rates of deoxygenation and reoxygenation during the August 17-18, 1982, diel sampling.

A one-dimensional, steady-state computer model was used to simulate the DO in the river. In the model, organic nitrogen and ammonia nitrogen concentrations were decreased by hydrolysis and oxidation and by a decay term that included settling to the riverbed and uptake by algae and other plants. Nitrite plus nitrate nitrogen concentrations in the model were increased by oxidation of ammonia nitrogen and by point-source to the river, and were decreased by a decay term that accounted for algal uptake and settling to the riverbed.

The un-ionized ammonia standard was exceeded in much of the study reach during the two synoptic sampling periods and during both diel samplings. The elevated un-ionized ammonia nitrogen concentrations in the river are due to the elevated ammonia nitrogen concentrations in the wastewater treatment facility effluent and the pH and temperature of the river water. Other water-quality standards exceeded in the study reach include the maximum ammonia nitrogen and minimum DO standards. Simulation results from the computer modeling showed that most water-quality standards exceeded were due to the elevated ammonia nitrogen concentration in the wastewater treatment facility effluent.

Reaeration rate coefficients and traveltimes for reaches upstream from RM 107.2 were measured during discharge conditions similar to those of the August diel sampling. An equation developed by Bennett and Rathbun was used to predict reaeration-rate coefficients for the reaches downstream from RM 107.2 for the August conditions. Downstream from RM 107.2, reaeration rates and traveltimes were measured during discharge conditions similar to those of the September diel sampling. An equation developed by O'Conner and Dobbins was used to predict reaeration coefficients for reaches upstream from RM 107.2 for the September conditions.

The model was initially calibrated with data collected during the August diel sampling. Model coefficients that represent the forward reaction rates of organic nitrogen to ammonia nitrogen and ammonia nitrogen to nitrite plus nitrate nitrogen, and decay rates for organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, and phosphorous were adjusted to make the predicted DO, organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, and phosphorus concentrations resemble those observed throughout the study reach.

Conditions in the river during September were different from those during August. At the mouth of Stevens Creek, the discharge was much lower and ammonia nitrogen concentrations were much higher in September than they were in August. Model simulations based on model coefficients used for the August data could not accurately reproduce the water quality observed during the September diel sampling. Model coefficients that describe the forward reaction rates of organic nitrogen to ammonia nitrogen and nitrite plus nitrate nitrogen and the organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, and phosphorus decay rates had to be adjusted in order to reasonably simulate the organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, and phosphorus concentrations observed in September. Model coefficients that would enable model simulated DO concentrations to reasonably reproduce observed values were not developed.

Graphs showing the rates and magnitudes of reoxygenation and deoxygenation due to ammonia oxidation, BOD decay, PNET, and atmospheric reaeration were developed and used to describe the effect of each of these processes on the DO concentrations in the river and to illustrate the relative magnitude of these processes. From these graphs, oxidation of ammonia nitrogen to nitrite plus nitrate nitrogen was identified as the most important process that caused DO concentrations to be below the Illinois water-quality standard. Atmospheric reaeration was identified as the most important reoxygenation process in river reaches with low DO.

CONCLUSIONS

Results presented in this report show that, for the warm-weather, low-flow conditions described herein, DO concentrations in some parts of the study reach fall to levels below the Illinois water-quality standards and that un-ionized ammonia concentrations exceeded the maximum level specified in the Illinois standards throughout most of the study reach. Model simulations showed that oxidation of ammonia nitrogen to form nitrite plus nitrate nitrogen was the predominant cause of the low DO concentrations observed in the river, and that atmospheric reaeration was the primary process that increased the DO in those river reaches with the lowest DO concentrations.

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GLOSSARY

Decay coefficient - The coefficient that controls the rate at which constituent concentrations (reactants) decrease due to modeled processes such as forward reaction or oxidation (of CBOD) and unmodeled processes such as settling and uptake by aquatic plants and algae. This coefficient affects only the constituent whose decay rate it describes. This coefficient must always be equal to or greater than the forward reaction or oxidation rate for that constituent.

Forward reaction rate coefficient - The coefficient that describes the rate at which a reactant, a water-quality constituent, reacts to form the product in a reaction. This coefficient describes the rate at which the product is increased due to the reaction and has no effect on the concentration of the reactant. However, if oxygen is also a reactant, the magnitude of the coefficient will affect the oxygen demand created by the reaction.

Oxidation rate - This coefficient describes the rate at which DO is consumed by the decay of CBOD. This coefficient has no effect on the ultimate CBOD.

TABLE 10

Table 10.--Selected constituent concentrations measured in the Sangamon River on August 17-18 and September 14-17, 1982

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25°C; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, Phosphorus; <, less than; dashes indicate no data]

Site number	Date (month/day)	Time (hours)	Stream flow instantaneous (ft^3/s)	Specific conductance (µS/cm)	Temperature (°C)	pH (standard units)	Oxygen, dissolved (mg/L)	Oxygen demand, biochemical ultimate carbonaceous (mg/L)	Nitrogen, ammonia + organic total (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Chlorophyll-a phytoplankton acid method (µg/L)
05573540	08/17	0800	--	475	24.5	7.8	7.4	--	1.1	<0.10	2.80	0.02	--
	08/17	0920	105	--	23.5	--	--	--	--	--	--	--	--
	08/17	0950	--	465	24.5	7.7	8.6	--	--	--	--	--	--
	08/17	1100	--	471	25.5	7.8	9.0	6.0	1.1	<.10	2.90	.05	--
	08/17	1240	--	470	26.5	7.9	9.4	--	--	--	--	--	--
	08/17	1400	--	472	27.0	7.9	9.8	7.8	1.0	.23	2.80	.04	22.7
	08/17	1550	--	470	27.0	8.0	9.8	--	--	--	--	--	--
	08/17	1700	--	475	27.0	8.0	9.5	5.7	1.1	.14	2.80	.05	--
	08/17	1830	--	476	26.5	7.9	9.0	--	--	--	--	--	--
	08/17	2005	--	462	26.0	7.9	7.5	4.9	1.1	<.10	2.70	.04	--
	08/17	2325	--	456	25.0	8.0	7.4	6.7	1.0	<.10	2.70	.05	--
	08/18	0220	--	442	25.0	7.7	7.0	5.1	.8	<.10	2.60	.04	--
	08/18	0505	--	440	24.5	7.6	6.7	5.5	1.1	<.10	2.70	.03	--
	08/18	0625	--	452	24.5	7.8	6.7	--	--	--	--	--	--
	08/18	0705	--	430	24.5	7.9	6.8	--	--	--	--	--	--
	08/18	0800	--	468	24.5	7.8	7.3	5.9	1.0	<.10	2.70	.06	--
	08/18	0955	--	469	25.0	7.8	7.8	--	--	--	--	--	--
	08/18	1100	--	467	25.5	7.9	8.3	6.3	1.0	.37	2.70	.02	24.4
	09/14	0800	--	638	22.5	6.8	2.7	7.3	2.3	2.30	.20	.41	--
	09/14	0945	--	640	22.5	7.0	2.4	--	--	--	--	--	--
	09/14	1100	--	636	23.0	7.0	2.7	12	2.5	1.30	.20	.41	--
	09/14	1255	--	641	24.0	7.1	3.7	--	--	--	--	--	--
	09/14	1400	--	640	26.0	7.2	4.9	7.8	1.4	1.20	.10	.41	--
	09/14	1535	--	680	25.0	7.2	6.3	--	--	--	--	--	--
	09/14	1700	--	648	25.0	7.4	6.6	7.5	2.0	1.20	.20	.41	--
	09/14	1850	--	737	24.5	7.2	2.8	--	--	--	--	--	--
	09/14	2045	--	648	22.0	6.6	4.2	8.7	2.3	1.60	.30	.21	--
	09/14	2300	--	525	22.0	7.0	4.8	9.5	1.9	.49	.60	.22	--
	09/15	0215	--	481	22.0	6.7	3.3	7.8	1.9	.63	.40	.30	--
	09/15	0515	--	490	22.0	6.8	2.2	10	2.0	.79	.30	.32	--

	09/15	0730	--	515	21.5	7.0	1.7	--	--	--	--	--	--
	09/15	0825	--	519	21.5	6.9	1.5	9.0	2.1	.90	.30	.32	--
	09/15	0950	--	527	21.5	7.1	1.5	--	--	--	--	--	--
	09/15	1100	--	534	22.0	7.0	1.2	12	2.5	1.00	.20	.33	--
	09/15	1300	--	538	22.0	7.1	1.4	--	--	--	--	--	--
	09/15	1415	--	530	23.0	6.8	1.5	17	2.9	1.10	.20	.41	--
	09/16	1345	--	579	20.5	7.1	2.4	8.6	2.0	.94	.30	.38	--
	09/17	0715	--	284	18.5	6.8	2.1	5.4	2.6	1.30	.20	.35	--
05573620	08/17	1155	--	854	21.5	7.5	6.9	3.0	.6	<.10	.60	.06	--
	09/14	0930	--	900	21.5	7.2	5.0	4.8	.5	.16	.10	.05	--
05573625	08/17	0900	--	1,980	27.0	6.7	6.6	35	56	47.0	1.80	6.20	--
	08/17	1010	35	1,990	27.0	6.6	6.9	--	--	--	--	--	--
	08/17	1120	--	1,960	27.5	6.7	6.8	27	53	45.0	1.80	6.20	--
	08/17	1305	--	1,900	28.5	6.6	6.8	--	--	--	--	--	--
	08/17	1450	--	1,890	29.0	6.8	6.9	20	59	45.0	1.70	6.40	9.79
	08/17	1600	--	1,900	29.0	6.7	6.8	--	--	--	--	--	--
	08/17	1645	--	1,870	29.0	6.7	6.5	--	--	--	--	--	--
	08/17	1720	--	1,890	29.0	6.7	6.6	80	51	44.0	1.60	6.70	--
	08/17	2106	--	2,460	29.0	6.8	6.3	64	51	44.0	1.50	6.60	--
	08/18	0010	--	2,480	28.0	6.9	6.3	17	49	44.0	1.50	6.50	--
	08/18	0310	--	2,450	27.5	6.8	6.0	22	47	45.0	1.30	6.50	--
	08/18	0535	--	2,410	27.0	6.8	5.8	23	50	44.0	1.10	6.50	--
	08/18	0845	--	--	26.5	6.8	6.3	29	48	43.0	.90	5.20	--
	08/18	1010	--	1,950	27.0	6.7	6.2	--	--	--	--	--	--
	08/18	1130	--	1,930	27.5	6.8	6.3	18	49	44.0	.90	6.40	9.38
	09/14	0845	29	2,520	27.0	6.7	6.4	15	47	44.0	.70	5.00	--
	09/14	1000	--	2,500	27.0	6.7	6.3	--	--	--	--	--	--
	09/14	1130	--	2,500	27.5	6.7	6.5	16	46	45.0	.60	5.60	--
	09/14	1315	--	2,500	28.5	6.7	6.5	--	--	--	--	--	--
	09/14	1445	--	2,540	29.0	6.8	6.3	18	50	43.0	.80	5.30	25.2
	09/14	1545	--	2,530	28.5	6.8	6.3	--	--	--	--	--	--
	09/14	1800	--	2,520	28.5	6.8	6.2	14	48	43.0	.70	5.50	--
	09/14	1915	--	2,470	28.0	6.8	6.1	--	--	--	--	--	--
	09/14	2145	--	2,400	27.5	6.8	6.4	18	44	41.0	.80	5.10	--
	09/15	0005	--	2,330	27.0	6.8	6.5	17	44	43.0	.70	4.90	--
	09/15	0315	--	2,200	26.5	6.7	6.5	16	43	38.0	.50	4.60	--
	09/15	0600	--	2,120	26.5	6.7	6.4	--	39	39.0	.40	4.70	--
	09/15	0855	--	2,020	26.0	6.8	6.7	20	39	33.0	.50	4.60	--
	09/15	1005	--	2,080	26.0	6.7	6.9	--	--	--	--	--	--
	09/15	1140	--	2,100	26.5	6.7	6.8	20	39	34.0	.40	4.50	--

Table 10.--Selected constituent concentrations measured in the Sangamon River on August 17-18 and September 14-17, 1982--Continued

Site number	Date (month/ day)	Time (hours)	Stream flow instan- taneous (ft^3/s)	Spe- cific con- duct- ance (µS/cm)	Temper- ature (°C)	pH (stand- ard units)	Oxygen, dis- solved (mg/L)	Oxygen demand, bio- chemical ultimate carbon- aceous (mg/L)	Nitro- gen, am- monia + organic total (mg/L as N)	Nitro- gen, ammonia dis- solved (mg/L as N)	Nitro- gen, NO_2+NO_3 dis- solved (mg/L as N)	Phos- phorus, dis- solved (mg/L as P)	Chloro- phyll-a phyto- plank- ton acid method (µg/L)
05573625	09/15	1315	--	2,120	27.0	6.7	6.9	--	--	--	--	--	--
(Cont.)	09/15	1445	--	2,150	27.0	6.7	6.7	20	42	39.0	0.50	4.60	18.4
	09/16	1315	--	2,490	26.0	6.7	6.4	19	41	39.0	.20	4.20	--
	09/17	0745	--	2,510	25.5	6.6	6.5	21	42	39.0	.10	4.30	--
05573630	08/17	0930	--	1,060	25.0	7.0	5.6	29	16	11.0	2.60	1.70	--
	08/17	1035	--	1,040	25.0	7.1	5.7	--	--	--	--	--	--
	08/17	1205	139	1,030	26.0	7.1	5.6	10	15	13.0	2.60	1.60	--
	08/17	1340	--	1,010	26.5	7.1	5.9	--	--	--	--	--	--
	08/17	1520	--	1,020	27.0	7.0	6.3	9.1	14	11.0	2.60	1.60	19.4
	08/17	1630	--	1,030	27.5	7.2	6.5	--	--	--	--	--	--
	08/17	1800	--	1,050	27.5	7.2	6.8	11	15	11.0	2.60	1.70	--
	08/17	1905	--	1,060	27.0	7.2	6.8	--	--	--	--	--	--
	08/17	2240	--	1,040	26.5	7.3	6.2	10	15	12.0	2.60	--	--
	08/18	0045	--	1,050	26.0	7.2	6.3	12	15	13.0	2.50	1.80	--
	08/18	0350	--	1,050	25.5	7.1	5.4	19	15	12.0	2.40	1.90	--
	08/18	0600	--	1,040	25.0	7.2	5.0	17	14	12.0	2.40	1.90	--
	08/18	0650	--	1,040	25.0	7.2	4.9	--	--	--	--	--	--
	08/18	0720	--	1,030	25.0	7.2	4.7	--	--	--	--	--	--
	08/18	0930	--	1,050	25.0	7.1	4.8	9.4	14	11.0	2.30	1.40	--
	08/18	1200	--	1,020	25.5	7.1	5.2	8.1	13	11.0	2.30	1.60	17.6
	09/14	0920	--	2,440	26.0	6.8	3.2	16	46	43.0	1.10	4.20	--
	09/14	1020	40	2,430	26.0	6.8	3.1	--	--	--	--	--	--
	09/14	1155	--	2,420	26.5	6.8	3.3	21	50	43.0	.90	4.30	--
	09/14	1330	--	2,390	26.5	6.8	3.8	--	--	--	--	--	--
	09/14	1515	--	2,400	27.0	6.8	4.4	16	43	41.0	.90	4.30	--
	09/14	1605	--	2,350	27.0	6.9	5.1	--	--	--	--	--	--
	09/14	1830	--	2,310	27.0	7.0	5.2	16	42	39.0	.90	4.90	--
	09/14	1935	--	2,270	27.0	7.0	4.8	--	--	--	--	--	--
	09/14	2225	--	2,240	26.5	6.9	4.1	15	41	39.0	1.10	4.90	--

	09/15	0045	--	2,070	26.0	6.9	4.3	13	39	36.0	.90	4.50	--
	09/15	0355	--	1,750	25.0	6.8	1.9	12	29	27.0	.60	3.40	--
	09/15	0650	--	1,990	25.0	6.8	0.2	15	34	34.0	<.10	4.10	--
	09/15	0920	--	1,980	25.0	6.8	0.1	22	39	30.0	<.10	4.10	--
	09/15	1020	--	1,950	25.0	6.8	0.3	--	--	--	--	--	--
	09/15	1205	--	1,910	25.0	6.8	0.8	21	40	31.0	.10	3.80	--
	09/15	1330	--	1,890	25.0	6.8	1.4	--	--	--	--	--	--
	09/15	1515	--	1,860	25.5	6.9	2.7	17	35	27.0	.30	4.10	--
	09/17	0810	--	2,160	23.0	6.7	3.6	20	39	33.0	.40	3.60	--
05573640	08/17	0800	--	679	24.5	7.0	4.4	11	16	13.0	2.80	1.70	--
	08/17	0900	--	1,060	24.5	7.0	4.5	--	--	--	--	--	--
	08/17	1000	--	667	25.0	7.0	4.6	--	--	--	--	--	--
	08/17	1100	--	1,060	25.0	7.0	4.7	9.5	15	13.0	2.80	1.70	--
	08/17	1200	--	1,060	25.5	7.0	4.8	--	--	--	--	--	--
	08/17	1300	--	1,060	26.0	7.1	4.7	--	--	--	--	--	--
	08/17	1400	--	1,050	26.5	7.1	5.0	8.8	14	13.0	2.80	1.70	12.4
	08/17	1500	--	1,010	27.0	7.1	4.9	--	--	--	--	--	--
	08/17	1600	135	652	26.5	7.1	5.1	--	--	--	--	--	--
	08/17	1700	--	658	26.5	7.1	5.1	9.0	14	12.0	2.70	1.70	--
	08/17	1800	--	1,010	26.5	7.1	5.0	--	--	--	--	--	--
	08/17	1900	--	645	26.5	7.1	5.0	--	--	--	--	--	--
	08/17	2000	--	640	26.5	7.0	5.0	11	13	11.0	2.70	1.60	--
	08/17	2100	--	655	25.5	7.1	4.6	--	--	--	--	--	--
	08/17	2200	--	1,010	26.5	7.1	4.8	--	--	--	--	--	--
	08/17	2300	--	1,020	26.0	7.1	4.8	9.7	14	11.0	2.60	1.60	--
	08/17	2400	--	1,030	26.0	7.0	4.6	--	--	--	--	--	--
	08/18	0100	--	1,010	26.0	7.0	4.4	--	--	--	--	--	--
	08/18	0200	--	1,050	25.5	7.0	4.4	7.6	15	12.0	2.60	1.80	--
	08/18	0300	--	1,030	25.5	7.1	4.0	--	--	--	--	--	--
	08/18	0400	--	775	25.0	7.1	4.2	--	--	--	--	--	--
	08/18	0500	--	1,040	25.0	7.1	4.3	8.0	15	12.0	2.60	1.80	--
	08/18	0600	--	1,080	24.5	7.0	4.3	--	--	--	--	--	--
	08/18	0700	--	1,090	24.5	7.0	4.4	--	--	--	--	--	--
	08/18	0800	--	690	24.5	7.0	4.6	--	13	12.0	2.50	1.80	--
	08/18	0900	--	1,070	24.5	7.0	4.7	--	--	--	--	--	--
	08/18	1000	--	686	24.5	7.1	4.6	--	--	--	--	--	--
	08/18	1100	--	--	--	--		18	14	12.0	2.50	1.80	13.6
	08/18	1200	--	1,060	25.5	7.1	4.8	--	--	--	--	--	--
	08/18	1300	--	1,050	26.0	7.1	4.9	--	--	--	--	--	--
	09/14	0800	--	2,400	25.0	7.1	2.2	16	41	37.0	1.10	4.4	--
	09/14	0900	--	2,400	24.5	7.0	2.3	--	--	--	--	--	--
	09/14	1000	--	2,390	.0	7.0	2.6	--	--	--	--	--	--
	09/14	1100	--	2,390	25.0	7.1	3.1	15	40	37.0	1.00	4.5	--
	09/14	1200	--	2,380	25.5	7.0	4.3	--	--	--	--	--	--

Table 10.--Selected constituent concentrations measured in the Sangamon River on August 17-18 and September 14-17, 1982--Continued

Site number	Date (month/ day)	Time (hours)	Stream flow instan- taneous (ft^3/s)	Spe- cific con- duct- ance (µS/cm)	Temper- ature (°C)	pH (stand- ard units)	Oxygen, dis- solved (mg/L)	Oxygen demand, bio- chemical ultimate carbon- aceous (mg/L)	Nitro- gen, am- monia + organic total (mg/L as N)	Nitro- gen, ammonia dis- solved (mg/L as N)	Nitro- gen, NO_2+NO_3 dis- solved (mg/L as N)	Phos- phorus, dis- solved (mg/L as P)	Chloro- phyll-a phyto- plank- ton acid method (µg/L)
05573640 (Cont.)	09/14	1300	--	2,380	26.5	7.2	5.5	--	--	--	--	--	--
	09/14	1400	--	2,410	26.5	7.1	6.3	14	43	32.0	1.10	4.60	--
	09/14	1500	--	2,410	26.5	7.1	6.3	--	--	--	--	--	--
	09/14	1600	--	2,390	26.0	7.1	5.6	--	--	--	--	--	--
	09/14	1700	--	2,360	26.0	7.1	4.7	12	41	40.0	1.20	4.60	--
	09/14	1800	--	2,200	25.5	7.0	4.3	--	--	--	--	--	--
	09/14	1900	--	1,600	24.0	7.1	4.6	--	--	--	--	--	--
	09/14	2000	--	1,060	23.5	7.1	5.0	13	21	16.0	1.10	1.80	--
	09/14	2100	--	1,330	23.5	7.1	4.4	--	--	--	--	--	--
	09/14	2200	--	1,630	24.0	7.0	4.0	--	--	--	--	--	--
	09/14	2300	--	1,890	24.0	7.0	3.9	10	34	29.0	1.10	3.70	--
	09/14	2400	--	2,020	24.5	7.0	4.1	--	--	--	--	--	--
	09/15	0100	--	2,030	24.5	7.0	3.9	--	--	--	--	--	--
	09/15	0200	--	1,950	24.0	7.0	3.7	11	34	33.0	1.10	4.00	--
	09/15	0300	--	1,950	24.0	7.0	3.7	--	--	--	--	--	--
	09/15	0400	--	1,970	24.0	7.0	3.7	--	--	--	--	--	--
	09/15	0500	--	2,010	24.0	7.0	3.6	8.8	38	33.0	1.10	4.20	--
	09/15	0600	--	2,040	24.0	7.0	3.4	--	--	--	--	--	--
	09/15	0700	--	2,070	24.5	7.0	3.1	--	--	--	--	--	--
	09/15	0800	--	2,100	24.5	7.0	2.9	9.9	40	33.0	1.20	4.40	--
	09/15	0900	--	2,110	24.5	7.0	3.0	--	--	--	--	--	--
	09/15	1000	--	2,100	24.5	7.0	2.9	--	--	--	--	--	--
	09/15	1100	--	2,050	24.5	7.0	3.0	13	38	30.0	1.10	4.20	--
	09/15	1200	--	1,970	24.5	7.1	3.0	--	--	--	--	--	--
	09/15	1300	--	1,980	24.5	7.0	3.4	--	--	--	--	--	--
	09/15	1400	--	1,850	24.5	--	--	10	34	25.0	.89	3.60	--
	09/15	1500	--	1,850	24.5	--	--	--	--	--	--	--	--
05573650	08/17	0800	--	936	24.5	7.1	3.9	8.9	10	8.90	3.20	1.30	--
	08/17	0930	--	946	24.5	7.1	4.0	--	--	--	--	--	--
	08/17	1100	--	966	25.0	7.2	4.4	10	13	9.60	3.20	1.30	--
	08/17	1330	--	1,010	26.0	7.3	5.1	8.4	14	11.0	3.30	1.50	12.4
	08/17	1445	142	--	27.0	--	--	--	--	--	--	--	--

08/17	1500	--	1,040	26.5	7.3	5.5	--	--	--	--	--	--
08/17	1600	--	1,050	27.0	7.3	5.7	--	--	--	--	--	--
08/17	1700	--	1,060	27.0	7.3	5.7	8.4	13	11.0	3.40	1.60	--
08/17	1750	--	1,060	27.0	7.3	5.7	--	--	--	--	--	--
08/17	2008	--	1,080	27.0	7.2	5.1	9.4	14	12.0	3.30	1.60	--
08/17	2122	--	1,080	26.5	7.1	4.8	--	--	--	--	--	--
08/17	2300	--	1,080	26.0	7.1	4.3	12	14	12.0	3.20	1.60	--
08/18	0208	--	1,060	25.0	7.0	3.7	12	14	12.0	3.00	1.60	--
08/18	0300	--	1,060	25.0	7.1	3.7	--	--	--	--	--	--
08/18	0403	--	1,050	24.5	7.1	3.7	--	--	--	--	--	--
08/18	0505	--	1,040	24.5	7.1	3.7	8.5	13	11.0	3.00	1.60	--
08/18	0800	--	1,020	24.0	7.0	3.6	11	13	11.0	3.00	1.60	--
08/18	0900	--	983	24.0	7.1	3.9	--	--	--	--	--	--
08/18	1000	--	984	24.5	7.1	4.2	--	--	--	--	--	--
08/18	1100	--	990	25.0	7.1	4.4	8.9	13	11.0	3.00	1.60	17.5
09/14	0800	--	2,380	24.0	7.2	3.2	13	33	27.0	1.30	3.80	--
09/14	0900	--	2,390	24.0	7.2	3.2	--	--	--	--	--	--
09/14	1020	--	1,770	24.0	7.2	3.9	--	--	--	--	--	--
09/14	1100	--	1,790	24.5	7.2	4.3	--	33	27.0	1.30	3.70	--
09/14	1200	--	1,780	25.0	7.3	5.3	--	--	--	--	--	--
09/14	1220	48	--	25.0	--	--	--	--	--	--	--	--
09/14	1400	--	2,360	26.0	7.3	7.0	15	33	27.0	1.40	3.80	--
09/14	1500	--	1,810	26.0	7.3	7.1	--	--	--	--	--	--
09/14	1600	--	1,770	25.5	7.3	6.4	--	--	--	--	--	--
09/14	1700	--	1,720	25.0	7.3	5.8	20	27	27.0	1.30	3.60	--
09/14	1800	--	1,740	25.0	7.3	5.3	--	--	--	--	--	--
09/14	2000	--	2,250	25.0	7.2	5.0	11	29	27.0	1.60	3.80	--
09/14	2200	--	2,090	24.5	--	4.2	--	--	--	--	--	--
09/14	2300	--	1,940	24.0	--	3.7	12	25	24.0	1.40	3.30	--
09/15	0200	--	1,930	24.0	7.2	3.7	11	30	26.0	1.40	3.30	--
09/15	0300	--	2,080	24.0	7.1	3.6	--	--	--	--	--	--
09/15	0500	--	2,180	24.0	7.1	2.7	9.2	32	30.0	1.50	3.70	--
09/15	0800	--	2,210	23.5	7.2	3.2	11	39	30.0	1.60	3.90	--
09/15	0900	--	2,180	23.5	7.2	3.2	--	--	--	--	--	--
09/15	1000	--	2,140	23.5	7.2	3.2	--	--	--	--	--	--
09/15	1100	--	2,050	23.5	7.2	3.5	12	40	29.0	1.50	3.70	--
09/15	1200	--	1,930	23.5	7.2	3.3	--	--	--	--	--	--
09/15	1300	--	1,820	23.5	7.2	3.2	--	--	--	--	--	--
09/15	1400	--	1,330	23.5	7.2	3.2	12	30	23.0	1.40	3.00	--
09/15	1500	--	1,250	24.0	7.2	3.2	--	--	--	--	--	--
09/16	1145	--	1,980	21.5	7.2	3.9	13	34	32.0	1.60	3.90	--
09/17	0845	--	1,820	20.5	7.1	4.4	19	33	27.0	.90	3.80	--

Table 10.--Selected constituent concentrations measured in the Sangamon River on August 17-18 and September 14-17, 1982--Continued

Site number	Date (month/ day)	Time (hours)	Stream flow instan- taneous (ft^3/s)	Spe- cific con- duct- ance (µS/cm)	Temper- ature (°C)	pH (stand- ard units)	Oxygen, dis- solved (mg/L)	Oxygen demand, bio- chemical ultimate carbon- aceous (mg/L)	Nitro- gen, am- monia + organic total (mg/L as N)	Nitro- gen, ammonia dis- solved (mg/L as N)	Nitro- gen, NO_2+NO_3 dis- solved (mg/L as N)	Phos- phorus, dis- solved (mg/L as P)	Chloro- phyll-a phyto- plank- ton acid method (µg/L)
05573660	08/17	0945	--	949	24.0	7.1	4.0	6.6	10	8.50	3.40	1.30	--
	08/17	1000	--	943	24.5	7.2	4.2	--	--	--	--	--	--
	08/17	1130	--	930	25.0	7.2	4.8	12	10	7.80	3.30	1.20	20.3
	08/17	1400	138	927	26.0	7.3	5.5	7.1	10	7.90	3.40	1.20	--
	08/17	1530	--	951	26.5	7.4	5.9	--	--	--	--	--	--
	08/17	1630	--	960	26.5	7.3	6.0	--	--	--	--	--	--
	08/17	1715	--	975	26.5	7.3	5.9	8.6	11	8.60	3.60	1.40	--
	08/17	1805	--	973	26.5	7.3	5.7	--	--	--	--	--	--
	08/17	2046	--	1,030	26.5	7.1	4.8	6.4	12	10.0	3.40	1.40	--
	08/17	2143	--	1,040	26.0	7.1	4.6	--	--	--	--	--	--
	08/17	2330	--	1,050	26.0	7.1	4.3	9.3	13	10.0	3.60	1.50	--
	08/18	0230	--	1,060	25.0	7.1	3.9	11	14	11.0	3.60	1.60	--
	08/18	0345	--	1,050	25.0	7.1	3.8	--	--	--	--	--	--
	08/18	0524	--	1,060	24.5	7.1	3.6	20	14	12.0	3.30	1.60	--
	08/18	0830	--	1,050	23.5	7.0	3.6	16	12	11.0	3.30	1.60	--
	08/18	0930	--	1,010	24.0	7.1	4.1	--	--	--	--	--	--
	08/18	1030	--	997	24.0	7.1	4.3	--	--	--	--	--	--
	08/18	1130	--	988	25.0	7.2	4.7	11	12	11.0	3.20	1.50	12.9
	09/14	0845	--	2,190	23.5	7.3	3.6	16	28	23.0	1.80	3.40	--
	09/14	1000	--	1,650	24.0	7.3	4.7	--	--	--	--	--	--
	09/14	1035	--	1,660	24.0	7.3	5.5	--	--	--	--	--	--
	09/14	1130	--	1,630	24.0	7.4	6.1	15	25	25.0	2.10	3.40	--
	09/14	1230	--	2,150	24.5	7.4	6.9	--	--	--	--	--	--
	09/14	1430	47	1,670	25.5	7.5	8.7	13	27	24.0	1.90	3.40	--
	09/14	1530	--	1,640	22.0	7.5	8.3	--	--	--	--	--	--
	09/14	1630	--	1,630	25.0	7.4	8.0	--	--	--	--	--	--
	09/14	1730	--	1,630	25.0	7.4	7.1	14	26	24.0	1.90	3.30	--
	09/14	1830	--	1,630	24.5	7.4	6.3	--	--	--	--	--	--
	09/14	2030	--	2,030	23.5	--	3.8	8.5	26	22.0	1.80	3.20	--
	09/14	2230	--	1,880	23.5	7.2	3.8	--	--	--	--	--	--

	09/14	2330	--	1,930	23.5	7.1	13.7	11	27	23.0	1.70	3.00	--
	09/15	0230	--	2,060	23.5	7.1	3.4	9.5	26	24.0	1.70	3.30	--
	09/15	0330	--	2,070	23.5	7.1	3.2	--	--	--	--	--	--
	09/15	0530	--	2,010	23.5	7.1	3.3	9.3	24	24.0	1.60	3.20	--
	09/15	0840	--	1,730	23.0	7.1	3.4	11	23	21.0	1.50	3.00	--
	09/15	0930	--	1,750	23.0	7.2	3.3	--	--	--	--	--	--
	09/15	1030	--	1,780	23.0	7.2	3.3	--	--	--	--	--	--
	09/15	1130	--	1,880	23.0	7.2	3.5	17	30	23.0	1.60	3.10	--
	09/15	1230	--	1,900	23.0	7.2	3.7	--	--	--	--	--	--
	09/15	1330	--	1,970	23.5	7.2	4.0	--	--	--	--	--	--
	09/15	1430	--	1,570	23.5	7.3	4.5	14	31	26.0	1.70	3.40	--
	09/15	1530	--	1,570	24.0	7.3	4.9	--	--	--	--	--	--
	09/16	1130	--	1,730	20.5	7.2	3.3	10	24	24.0	1.60	3.10	--
	09/17	0905	--	1,770	20.0	7.1	4.2	10	30	26.0	1.70	3.40	--
05573665	08/17	0800	--	903	24.0	7.1	3.3	--	9.8	7.70	3.40	1.30	--
	08/17	0900	--	903	24.0	7.1	3.3	--	--	--	--	--	--
	08/17	1000	--	893	24.5	7.1	3.6	--	--	--	--	--	--
	08/17	1100	--	698	24.0	7.2	4.0	9.3	10	7.80	3.30	1.30	--
	08/17	1200	--	877	25.0	6.9	4.5	--	--	--	--	--	--
	08/17	1300	--	880	25.5	7.2	5.1	--	--	--	--	--	--
	08/17	1400	--	933	26.0	7.2	5.7	7.7	10	7.40	3.40	1.20	16.4
	08/17	1500	--	935	26.5	7.3	6.1	--	--	--	--	--	--
	08/17	1600	--	917	26.5	7.3	8.2	--	--	--	--	--	--
	08/17	1700	--	911	26.5	7.3	8.4	11	10	7.60	3.30	1.20	--
	08/17	1800	--	916	26.5	7.3	8.0	--	--	--	--	--	--
	08/17	1900	--	908	26.5	7.3	8.0	--	--	--	--	--	--
	08/17	2000	--	900	26.5	7.3	7.3	13	10	8.00	3.50	1.20	--
	08/17	2100	--	910	26.5	7.3	6.2	--	--	--	--	--	--
	08/17	2200	--	932	26.0	7.2	6.0	--	--	--	--	--	--
	08/17	2300	--	951	26.0	7.1	5.1	9.4	11	9.00	3.60	1.40	--
	08/17	2400	--	969	25.5	7.8	5.0	--	--	--	--	--	--
	08/18	0100	--	992	25.5	7.8	4.0	--	--	--	--	--	--
	08/18	0200	--	990	25.0	7.4	4.1	6.9	12	9.90	3.70	1.40	--
	08/18	0300	--	1,000	25.0	7.6	3.5	--	--	--	--	--	--
	08/18	0400	--	1,010	24.5	7.4	3.8	--	--	--	--	--	--
	08/18	0500	--	1,010	24.5	7.1	3.2	6.2	12	10.0	3.70	1.50	--
	08/18	0600	--	1,020	24.0	7.3	2.9	--	--	--	--	--	--
	08/18	0700	--	1,010	24.0	6.7	2.9	--	--	--	--	--	--
	08/18	0800	--	972	23.5	8.3	3.2	10	12	10.0	3.40	1.60	--
	08/18	0900	--	968	23.5	8.1	3.2	--	--	--	--	--	--
	08/18	1000	--	958	23.5	7.1	3.6	--	--	--	--	--	--
	08/18	1100	--	--	--	--	--	9.4	14	11.0	3.40	1.60	9.92
	08/18	1200	--	--	25.0	--	3.8	--	--	--	--	--	--
	08/18	1300	--	--	25.0	--	4.0	--	--	--	--	--	--

Table 10.--Selected constituent concentrations measured in the Sangamon River on August 17-18 and September 14-17, 1982--Continued

Site number	Date (month/day)	Time (hours)	Stream flow instantaneous (ft^3/s)	Specific conductance (µS/cm)	Temperature (°C)	pH (standard units)	Oxygen, dissolved (mg/L)	Oxygen demand, biochemical ultimate carbonaceous (mg/L)	Nitrogen, ammonia + organic total (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Chlorophyll-a phytoplankton acid method (µg/L)
05573665 (Cont.)	09/14	0800	--	2,120	23.5	7.1	3.7	11	25	24.0	2.20	3.30	--
	09/14	0900	--	2,120	23.5	7.0	4.4	--	--	--	--	--	--
	09/14	1000	--	2,120	23.5	7.1	4.5	--	--	--	--	--	--
	09/14	1100	--	2,120	24.0	7.2	5.5	18	25	23.0	2.10	3.30	--
	09/14	1200	--	2,130	24.5	7.3	6.6	--	--	--	--	--	--
	09/14	1300	--	2,130	25.0	7.5	8.2	--	--	--	--	--	--
	09/14	1400	--	2,130	25.0	7.4	8.5	19	24	23.0	2.00	3.30	--
	09/14	1500	--	2,130	25.0	7.4	8.7	--	--	--	--	--	--
	09/14	1600	--	2,130	25.0	7.3	8.9	--	--	--	--	--	--
	09/14	1700	--	2,120	24.5	7.3	8.5	16	25	23.0	2.00	3.30	--
	09/14	1800	--	2,110	24.5	7.2	8.2	--	--	--	--	--	--
	09/14	1900	--	2,110	24.5	7.2	7.8	--	--	--	--	--	--
	09/14	1945	--	--	--	--	--	14	25	23.0	2.30	3.40	--
	09/14	2000	--	2,110	24.5	7.1	7.4	17	22	22.0	2.10	3.30	--
	09/14	2100	--	2,090	24.0	7.1	6.3	--	--	--	--	--	--
	09/14	2200	--	2,080	24.0	7.1	6.7	--	--	--	--	--	--
	09/14	2300	--	2,080	24.0	7.0	6.4	7.5	27	24.0	2.30	3.20	--
	09/14	2400	--	2,080	23.5	7.0	5.8	--	--	--	--	--	--
	09/15	0100	--	2,080	23.5	7.0	5.3	--	--	--	--	--	--
	09/15	0200	--	2,000	23.5	6.9	4.9	8.1	24	22.0	2.10	3.30	--
	09/15	0300	--	1,980	23.0	6.9	4.9	--	--	--	--	--	--
	09/15	0400	--	1,970	23.0	6.9	4.6	--	--	--	--	--	--
	09/15	0500	--	1,940	23.0	6.9	3.5	10	24	23.0	1.70	2.80	--
	09/15	0600	--	1,950	23.0	6.9	4.3	--	--	--	--	--	--
	09/15	0700	--	1,960	23.0	6.9	4.2	--	--	--	--	--	--
	09/15	0800	--	1,960	23.0	7.0	3.0	9.7	26	23.0	1.70	3.20	--
	09/15	0900	--	1,970	23.0	7.1	3.3	--	--	--	--	--	--
	09/15	1000	--	1,960	23.0	7.0	3.3	--	--	--	--	--	--
	09/15	1100	--	1,950	23.0	7.0	3.4	12	29	24.0	1.70	3.20	--
	09/15	1200	--	1,920	23.0	7.0	3.5	--	--	--	--	--	--
	09/15	1300	--	1,870	23.0	7.1	3.7	--	--	--	--	--	--
	09/15	1400	--	1,830	23.0	7.1	4.0	14	26	22.0	1.60	3.00	--

05573685	08/18	0800	2.2	2,130	22.0	7.4	4.1	9.9	5.3	2.80	2.10	.29	--
	09/15	1300	1.6	2,210	22.5	7.4	3.1	--	21	19.0	1.60	.39	--
05573695	08/17	0800	--	908	24.0	7.0	4.5	8.5	7.5	5.30	3.70	1.10	--
	08/17	1100	--	909	25.0	7.1	6.1	9.3	7.5	5.60	3.70	1.20	--
	08/17	1238	--	925	26.0	7.3	7.5	--	--	--	--	--	--
	08/17	1300	--	1,010	26.0	7.4	5.8	--	--	--	--	--	--
	08/17	1400	--	964	27.0	7.6	7.9	11	8.3	5.90	3.90	1.20	25.5
	08/17	1600	--	967	27.5	7.7	8.9	--	--	--	--	--	--
	08/17	1700	--	983	27.5	7.7	9.2	10	8.2	5.80	4.00	1.20	--
	08/17	1830	--	974	27.5	7.6	8.8	--	--	--	--	--	--
	08/17	2015	--	654	27.0	7.4	7.0	9.6	8.5	6.10	3.90	1.10	--
	08/17	2200	--	670	26.0	7.2	5.9	--	--	--	--	--	--
	08/17	2300	--	985	25.5	7.2	5.9	8.5	8.5	5.90	3.90	1.10	--
	08/18	0030	--	975	25.0	7.2	5.1	--	--	--	--	--	--
	08/18	0200	--	672	24.5	7.3	4.5	6.2	9.0	6.70	3.80	1.10	--
	08/18	0330	--	630	24.5	7.1	5.3	--	--	--	--	--	--
	08/18	0500	--	680	24.0	7.2	4.2	5.6	9.5	6.80	3.80	1.10	--
	08/18	0630	--	685	23.5	7.2	4.2	--	--	--	--	--	--
	08/18	0800	--	973	23.5	7.1	4.0	7.5	9.3	6.80	3.80	1.10	--
	08/18	0945	155	982	24.0	7.1	4.7	--	--	--	--	--	--
	08/18	1100	--	993	24.5	7.2	5.8	9.0	11	9.60	3.90	1.20	19.9
	09/14	0800	--	1,890	23.5	7.2	4.3	--	25	20.0	3.60	2.70	--
	09/14	0930	--	1,890	23.5	7.3	5.6	--	--	--	--	--	--
	09/14	1100	--	1,880	24.0	7.4	7.4	19	22	18.0	3.40	2.70	--
	09/14	1230	--	1,860	24.5	7.5	10.4	--	--	--	--	--	--
	09/14	1400	--	1,890	26.0	7.7	13.6	25	21	19.0	3.40	2.70	--
	09/14	1530	--	1,900	25.5	7.7	13.0	--	--	--	--	--	--
	09/14	1700	--	1,900	25.0	7.7	12.2	28	23	20.0	3.50	2.70	--
	09/14	1815	--	1,920	25.0	7.7	11.6	--	--	--	--	--	--
	09/14	2000	--	1,960	24.5	7.6	9.0	--	20	20.0	3.40	2.50	--
	09/14	2145	--	1,970	24.0	7.5	8.1	--	--	--	--	--	--
	09/14	2300	--	2,000	24.0	7.5	7.0	13	24	19.0	3.70	2.70	--
	09/15	0033	--	2,040	23.5	7.4	6.1	--	--	--	--	--	--
	09/15	0200	--	2,060	23.5	7.4	5.5	12	21	19.0	3.40	2.80	--
	09/15	0347	--	1,980	23.0	7.3	4.4	--	--	--	--	--	--
	09/15	0500	--	1,990	23.0	7.2	4.0	10	22	20.0	3.20	2.90	--
	09/15	0625	--	2,090	23.0	7.2	3.6	--	--	--	--	--	--
	09/15	0810	--	1,990	23.0	7.2	3.4	12	52	20.0	3.00	3.00	--
	09/15	0925	--	1,980	23.0	7.3	4.1	--	--	--	--	--	--
	09/15	1100	--	1,980	23.0	7.3	4.3	15	25	20.0	2.80	3.10	--
	09/15	1205	102	1,990	23.5	7.3	5.8	--	--	--	--	--	--
	09/15	1400	--	1,960	23.5	7.4	6.7	15	25	21.0	2.70	3.10	--

Table 10.--Selected constituent concentrations measured in the Sangamon River on August 17-18 and September 14-17, 1982--Continued

Site number	Date (month/ day)	Time (hours)	Stream flow instan- taneous (ft^3/s)	Spe- cific con- duct- ance (µS/cm)	Temper- ature (°C)	pH (stand- ard units)	Oxygen, dis- solved (mg/L)	Oxygen demand, bio- chemical ultimate carbon- aceous (mg/L)	Nitro- gen, am- monia + organic total (mg/L as N)	Nitro- gen, ammonia dis- solved (mg/L as N)	Nitro- gen, NO_2+NO_3 dis- solved (mg/L as N)	Phos- phorus, dis- solved (mg/L as P)	Chloro- phyll-a phyto- plank- ton acid method (µg/L)
05573695	09/15	1510	--	1,950	24.0	7.5	8.1	--	--	--	--	--	--
(Cont.)	09/16	1100	--	1,910	20.5	7.2	4.1	14	23	20.0	2.20	2.80	--
	09/17	0940	--	1,850	19.5	7.1	4.8	10	27	22.0	2.50	3.00	--
05573730	08/18	1015	2.1	513	20.5	7.8	8.1	--	0.8	0.18	2.20	0.07	--
	09/15	1000	96	179	21.0	6.2	4.4	--	2.1	<.10	.90	.54	--
05573740	08/17	0800	--	935	24.0	7.2	5.5	11	7.0	5.00	3.80	1.10	--
	08/17	1115	--	918	25.0	7.2	7.6	12	7.8	4.60	3.90	1.00	--
	08/17	1258	--	908	25.5	7.3	8.6	--	--	--	--	--	--
	08/17	1445	--	930	27.0	7.7	9.5	12	6.2	4.40	4.00	1.00	40.3
	08/17	1630	--	927	27.5	7.9	11.0	--	--	--	--	--	--
	08/17	1730	--	921	27.5	7.9	11.0	14	6.1	4.10	4.10	1.00	--
	08/17	1900	--	945	26.0	7.1	11.0	--	--	--	--	--	--
	08/17	2100	--	935	27.0	7.5	8.2	11	5.6	4.00	4.30	1.10	--
	08/17	2215	--	919	26.5	7.4	7.1	--	--	--	--	--	--
	08/17	2330	--	930	25.5	7.3	6.4	12	6.9	3.60	4.20	.91	--
	08/18	0050	--	960	25.5	7.3	6.3	--	--	--	--	--	--
	08/18	0230	--	954	24.5	7.1	6.1	7.8	6.7	4.60	4.20	1.10	--
	08/18	0400	--	966	24.0	7.1	5.5	--	--	--	--	--	--
	08/18	0530	--	980	24.0	7.2	4.8	6.4	7.2	4.90	4.20	1.00	--
	08/18	0645	--	970	23.0	7.2	4.5	--	--	--	--	--	--
	08/18	0830	--	961	23.0	7.1	5.0	10	7.4	5.70	4.00	1.10	--
	08/18	1000	--	958	23.5	7.2	5.5	--	--	--	--	--	--
	08/18	1130	160	935	25.0	7.4	6.4	13	7.6	5.20	4.20	1.20	36.2
	09/14	0835	--	1,750	23.0	7.3	5.4	27	18	17.0	4.10	2.30	--
	09/14	0945	--	1,740	23.5	7.5	7.7	--	--	--	--	--	--
	09/14	1125	--	1,740	24.5	7.6	10.7	21	19	16.0	4.00	2.30	--
	09/14	1245	--	1,710	25.5	7.8	13.2	--	--	--	--	--	--
	09/14	1430	--	1,770	26.0	7.8	15.9	31	17	15.0	4.30	2.20	--
	09/14	1550	--	1,700	25.0	7.8	11.5	--	--	--	--	--	--
	09/14	1725	--	1,700	24.5	7.8	10.3	29	15	14.0	4.00	2.20	--

	09/14	1835	--	1,730	24.5	7.8	10.2	--	--	--	--	--	--
	09/14	2045	--	1,760	24.0	7.7	7.6	15	17	13.0	4.10	2.20	--
	09/14	2218	--	1,760	23.5	7.6	6.9	--	--	--	--	--	--
	09/14	2342	--	1,780	23.5	7.5	6.4	12	20	15.0	4.20	2.10	--
	09/15	0049	--	1,810	23.0	7.6	6.0	--	--	--	--	--	--
	09/15	0227	--	1,820	23.0	7.4	5.0	14	17	16.0	4.20	2.10	--
	09/15	0408	--	1,860	22.5	7.3	5.0	--	--	--	--	--	--
	09/15	0531	--	1,830	22.5	7.3	5.0	14	19	15.0	3.60	2.20	--
	09/15	0642	--	1,380	22.5	7.4	5.0	--	--	--	--	--	--
	09/15	0835	--	986	22.5	7.3	4.7	12	9.2	6.60	2.20	1.10	--
	09/15	0945	--	961	22.5	7.2	4.6	--	--	--	--	--	--
	09/15	1120	--	988	22.5	7.2	4.2	17	9.9	7.60	2.10	1.30	--
	09/15	1224	--	1,010	22.5	7.2	4.5	--	--	--	--	--	--
	09/15	1420	--	1,080	23.0	7.2	4.7	19	11	8.50	2.10	1.50	--
	09/15	1526	193	1,110	23.0	7.3	5.6	--	--	--	--	--	--
	09/16	1030	--	1,440	19.5	7.3	5.1	14	16	12.0	2.40	1.90	--
	09/17	1005	--	1,540	19.0	7.2	5.4	12	18	15.0	2.70	2.20	--
05573800	08/17	0117	--	927	25.5	7.6	9.5	--	--	--	--	--	--
	08/17	0900	--	925	24.0	7.2	6.0	--	6.2	4.50	4.10	1.00	--
	08/17	1145	--	932	25.0	7.4	8.8	12	6.1	4.40	4.00	1.00	--
	08/17	1530	--	950	27.0	7.8	11.0	13	6.1	3.70	4.10	.94	12.4
	08/17	1630	--	955	27.0	8.0	11.6	--	--	--	--	--	--
	08/17	1800	--	941	27.5	7.9	10.5	16	6.0	4.10	4.20	.96	--
	08/17	1915	--	946	26.5	7.3	10.2	--	--	--	--	--	--
	08/17	2130	--	937	26.5	7.8	8.7	12	5.3	3.00	4.30	.87	--
	08/17	2355	--	934	26.0	7.6	7.3	12	5.3	3.10	4.40	.91	--
	08/18	0115	--	945	25.0	7.5	7.0	--	--	--	--	--	--
	08/18	0300	--	945	25.0	7.5	5.9	10	5.9	3.40	4.50	.93	--
	08/18	0415	--	920	24.5	7.5	5.3	--	--	--	--	--	--
	08/18	0545	--	960	24.0	7.4	5.0	8.9	5.2	3.80	4.40	.96	--
	08/18	0700	--	967	23.5	7.2	4.9	--	--	--	--	--	--
	08/18	0900	--	957	23.5	7.1	5.2	12	6.3	4.50	4.30	1.00	--
	08/18	1018	--	960	23.5	7.4	5.3	--	--	--	--	--	--
	08/18	1200	--	946	25.0	7.6	7.4	--	6.8	4.40	4.30	1.10	49.4
	08/18	1240	150	--	24.5	--	--	--	--	--	--	--	--
	09/14	0900	--	1,690	23.5	7.5	6.9	19	17	14.0	5.00	2.00	--
	09/14	1000	--	1,690	23.5	7.6	8.3	--	--	--	--	--	--
	09/14	1150	--	1,680	24.0	7.7	10.7	28	16	14.0	4.90	2.00	--
	09/14	1300	--	1,660	25.0	7.9	13.2	--	--	--	--	--	--
	09/14	1500	--	1,690	25.5	7.7	13.7	28	17	12.0	4.80	2.00	--
	09/14	1610	--	1,670	25.0	7.9	11.5	--	--	--	--	--	--
	09/14	1745	--	1,680	24.5	7.8	10.3	23	17	13.0	4.70	2.00	--

Table 10.--Selected constituent concentrations measured in the Sangamon River on August 17-18 and September 14-17, 1982--Continued

Site number	Date (month/day)	Time (hours)	Stream flow instantaneous (ft^3/s)	Specific conductance (µS/cm)	Temperature (°C)	pH (standard units)	Oxygen, dissolved (mg/L)	Oxygen demand, biochemical ultimate carbonaceous (mg/L)	Nitrogen, ammonia + organic total (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Chlorophyll-a phytoplankton acid method (µg/L)
05573800 (Cont.)	09/14	1850	--	1,700	24.5	7.8	9.3	--	--	--	--	--	--
	09/14	2115	--	1,740	24.0	7.6	6.6	16	16	12.0	4.50	1.90	--
	09/14	2230	--	1,760	23.5	7.6	6.6	--	--	--	--	--	--
	09/14	2400	--	1,760	23.5	7.6	5.5	15	18	13.0	4.70	2.10	--
	09/15	0100	--	1,760	23.5	7.5	5.5	--	--	--	--	--	--
	09/15	0248	--	1,750	23.0	7.5	4.5	14	17	12.0	4.60	2.00	--
	09/15	0426	--	1,750	22.5	7.4	4.5	--	--	--	--	--	--
	09/15	0553	--	1,750	22.5	7.4	4.5	13	16	13.0	4.40	2.00	--
	09/15	0658	--	1,750	22.5	7.4	4.3	--	--	--	--	--	--
	09/15	0855	--	1,770	22.5	7.3	4.8	33	19	14.0	4.20	2.20	--
	09/15	0955	--	1,750	22.5	7.4	5.0	--	--	--	--	--	--
	09/15	1140	--	1,350	22.5	7.4	5.2	16	14	11.0	3.10	1.50	--
	09/15	1226	--	1,150	22.5	7.4	5.2	--	--	--	--	--	--
	09/15	1442	--	986	23.0	7.3	5.1	16	9.6	6.60	2.30	1.20	--
	09/15	1540	--	987	23.5	7.3	5.9	--	--	--	--	--	--
	09/16	0940	110	--	19.5	--	--	--	--	--	--	--	--
	09/16	1015	--	1,340	19.5	7.2	4.8	15	14	10.0	2.50	1.80	--
	09/17	1030	--	1,510	19.5	7.2	5.4	13	16	12.0	2.70	2.00	--
05573810	08/17	0930	--	928	24.0	7.3	5.6	13	5.4	3.70	4.40	.99	--
	08/17	1200	--	966	25.0	7.5	8.0	14	6.0	3.70	4.40	1.20	--
	08/17	1515	--	926	26.0	7.7	10.7	16	5.7	3.60	4.50	.94	--
	08/17	1600	--	928	27.0	7.8	11.7	--	--	--	--	--	85.6
	08/17	1815	--	893	27.0	7.8	11.2	20	5.9	3.40	4.50	.94	--
	08/17	1900	--	893	27.0	7.8	10.9	--	--	--	--	--	--
	08/17	2200	--	925	26.0	7.6	7.4	15	5.0	3.10	4.60	.93	--
	08/18	0045	--	917	25.0	7.4	5.8	14	5.2	3.00	4.60	.92	--
	08/18	0330	--	893	24.5	7.3	5.0	12	4.6	2.90	4.70	.92	--
	08/18	0630	--	892	23.5	7.2	4.6	8.6	4.5	2.90	4.50	.92	--

	08/18	0915	--	898	23.0	7.3	5.5	17	4.8	3.00	4.60	.92	--
	08/18	1245	156	903	25.0	7.6	8.3	17	6.0	3.20	4.70	1.10	64.0
	09/14	1000	--	1,660	23.0	7.5	6.9	--	--	--	--	--	--
	09/14	1300	--	1,650	25.0	7.9	13.4	32	14	12.0	5.40	1.70	--
	09/14	1515	--	1,630	25.5	7.9	12.7	26	15	10.0	5.50	1.70	--
	09/14	1845	--	1,620	24.5	7.8	8.6	22	12	10.0	5.50	1.70	--
	09/14	2130	--	1,630	24.0	7.7	6.6	17	15	11.0	5.90	1.80	--
	09/15	0030	--	1,630	23.0	7.5	5.0	14	15	11.0	5.60	1.80	--
	09/15	0215	--	--	--	--	--	--	--	--	--	--	--
	09/15	0500	--	1,650	22.5	7.4	4.0	--	15	12.0	5.20	1.80	--
	09/15	0700	--	1,650	22.5	7.4	3.9	13	17	12.0	4.80	1.80	--
	09/15	0930	--	1,670	22.5	7.4	4.4	16	16	12.0	4.70	1.90	--
	09/15	1215	--	1,710	22.5	7.5	6.0	18	16	13.0	4.40	2.00	--
	09/15	1500	--	1,660	23.0	7.7	9.5	20	16	14.0	3.90	1.90	--
	09/16	0945	--	1,250	19.5	7.2	4.3	--	14	9.00	2.40	1.60	--
	09/17	1200	107	--	20.0	--	--	--	--	--	--	--	--
	09/17	1050	--	1,470	19.5	7.2	5.4	15	14	11.0	3.20	1.90	--
05573890	09/16	1230	24	264	19.0	6.8	4.6	--	2.6	.38	2.20	.74	--
05573930	08/17	0845	--	911	24.0	7.4	5.7	11	4.8	2.80	4.50	.87	--
	08/17	1045	--	900	24.0	7.5	7.3	--	--	--	--	--	--
	08/17	1145	--	920	25.0	7.6	8.4	12	4.7	2.60	4.50	.82	--
	08/17	1430	--	871	26.0	7.8	11.4	16	4.4	2.10	4.70	.79	--
	08/17	1615	--	862	27.0	8.0	12.4	--	--	--	--	--	--
	08/17	1730	--	830	27.0	8.0	11.9	17	4.0	1.80	4.90	.75	97.3
	08/17	1915	--	834	27.0	7.9	10.8	--	--	--	--	--	--
	08/17	2100	--	876	26.0	7.8	8.8	14	3.9	1.80	5.00	.77	--
	08/17	2400	--	879	25.5	7.6	7.1	14	3.9	1.80	5.00	.76	--
	08/18	0300	--	864	25.0	7.6	5.9	13	3.6	1.80	4.80	.78	--
	08/18	0545	--	877	24.0	7.4	5.3	12	3.7	1.90	4.80	.78	--
	08/18	0830	--	843	24.0	7.4	5.5	15	4.0	1.90	4.70	.76	--
	08/18	1030	--	867	24.0	7.5	7.0	--	--	--	--	--	--
	08/18	1200	--	865	25.0	7.7	8.9	18	3.8	1.80	4.90	.90	53.9
	08/19	1315	158	--	25.0	--	--	--	--	--	--	--	--
	09/14	0900	--	1,430	23.5	7.5	5.8	15	8.5	6.90	6.30	1.10	--
	09/14	1145	--	1,410	25.0	7.7	9.5	25	8.9	6.60	5.70	1.10	--
	09/14	1445	--	1,400	26.0	7.9	10.6	20	9.3	6.10	5.90	1.10	--
	09/14	1615	--	1,350	24.5	7.8	7.9	--	--	--	--	--	--
	09/14	1800	--	1,390	24.5	7.7	7.9	21	8.5	6.30	5.60	1.10	--

Table 10.--Selected constituent concentrations measured in the Sangamon River on August 17-18 and September 14-17, 1982--Continued

Site number	Date (month/ day)	Time (hours)	Stream flow instan- taneous (ft^3/s)	Spe- cific con- duct- ance (µS/cm)	Temper- ature (°C)	pH (stand- ard units)	Oxygen, dis- solved (mg/L)	Oxygen demand, bio- chemical ultimate carbon- aceous (mg/L)	Nitro- gen,am- monia + organic total (mg/L as N)	Nitro- gen, ammonia dis- solved (mg/L as N)	Nitro- gen, NO_2+NO_3 dis- solved (mg/L as N)	Phos- phorus, dis- solved (mg/L as P)	Chloro- phyll-a phyto- plank- ton acid method (µg/L)
05573930	09/14	2100	--	1,390	24.0	7.6	5.7	15	9.0	6.50	6.20	1.10	--
(Cont.)	09/14	2145	--	1,390	23.5	7.5	5.5	--	--	--	--	--	--
	09/14	2345	--	1,400	23.5	7.5	4.9	12	10	6.80	6.20	1.20	--
	09/15	0315	--	1,420	23.0	7.5	4.8	13	9.5	7.20	6.00	1.10	--
	09/15	0415	--	1,420	23.0	7.5	4.7	--	--	--	--	--	--
	09/15	0615	--	1,410	23.0	7.4	4.1	11	8.9	6.70	6.20	1.10	--
	09/15	0900	--	1,430	22.5	7.4	4.5	12	10	6.90	5.90	1.10	--
	09/15	1030	--	1,420	23.0	7.4	4.7	--	--	--	--	--	--
	09/15	1145	--	1,410	23.0	7.4	5.3	12	9.7	6.90	5.50	1.00	--
	09/15	1430	--	1,510	23.5	7.8	9.8	15	11	8.20	5.80	1.30	--
	09/16	1340	197	--	21.5	--	--	--	--	--	--	--	--
	09/17	1100	--	--	--	--	--	12	8.2	2.60	3.40	1.10	--
05576060	08/19	1115	45	573	23.5	7.2	4.8	4.3	1.2	0.18	2.00	0.06	--
	09/16	1500	152	363	21.0	7.0	4.5	--	1.7	<.10	.90	.12	--
05576250	08/19	0945	19	616	23.5	7.2	4.4	12	2.5	1.30	1.00	.80	--
	09/16	1600	17	440	22.5	7.0	4.3	--	5.5	4.30	.90	2.20	--
05576500	08/17	0700	--	--	--	--	--	--	--	--	--	--	--
	08/17	0800	--	802	23.0	7.3	5.3	9.2	3.0	1.50	3.90	.56	--
	08/17	1030	--	801	24.0	7.4	6.4	--	--	--	--	--	--
	08/17	1100	--	801	24.0	7.4	7.1	12	3.1	1.40	3.90	.58	--
	08/17	1400	--	794	25.0	7.7	10.6	14	3.1	1.40	4.00	.59	--
	08/17	1700	--	757	26.0	8.0	13.2	14	3.4	1.10	4.00	.59	97.0
	08/17	2000	--	800	26.0	7.9	10.3	14	3.3	1.10	4.10	.56	--
	08/17	2300	--	784	25.5	7.6	7.5	11	2.7	.88	4.00	.55	--
	08/18	0100	--	--	--	--	--	--	--	--	--	--	--
	08/18	0200	--	773	24.5	7.4	6.1	10	2.6	.82	4.10	.59	--

08/18	0500	--	776	24.0	7.4	5.4	9.7	2.7	.83	4.20	.56	--
08/18	0800	--	780	23.0	7.3	5.0	9.7	2.7	.88	4.00	.55	--
08/18	1000	--	774	24.0	7.4	6.2	--	--	--	--	--	--
08/18	1100	--	770	24.0	7.5	7.1	13	2.7	<.10	4.00	.56	48.8
08/19	0915	235	--	23.0	--	--	--	--	--	--	--	--
09/14	0800	--	1,040	23.0	7.3	4.2	8.8	4.8	3.10	3.60	.78	--
09/14	1100	--	1,020	23.5	7.4	6.9	10	4.5	3.10	3.50	.75	--
09/14	1400	--	1,020	25.0	7.7	10.0	14	4.4	3.10	3.70	.72	--
09/14	1700	--	1,000	24.5	7.6	8.6	15	4.4	2.90	3.80	.71	--
09/14	2015	--	1,010	24.0	7.6	7.1	11	5.1	2.80	3.90	.75	--
09/14	2215	--	996	24.0	7.5	6.2	--	--	--	--	--	--
09/14	2300	--	991	23.5	7.5	5.2	10	3.8	2.60	4.00	.73	--
09/15	0100	--	--	--	--	--	--	--	--	--	--	--
09/15	0200	--	945	23.5	7.3	4.3	7.6	4.5	2.90	3.60	.79	--
09/15	0400	--	--	--	--	--	--	--	--	--	--	--
09/15	0545	--	693	22.5	7.3	4.7	5.8	2.7	1.40	2.20	.42	--
09/15	0800	--	638	22.5	7.3	5.3	5.7	2.3	1.10	1.90	.33	--
09/15	1100	--	635	22.0	7.3	4.9	7.7	3.2	1.20	2.10	.38	--
09/15	1400	--	491	21.5	7.0	3.8	13	2.1	1.20	1.70	.37	--
09/15	1615	--	505	22.0	7.0	4.3	--	--	--	--	--	--
09/17	1000	--	--	--	--	--	9.0	5.1	2.90	2.20	.70	--
09/17	1020	321	--	19.0	--	--	--	--	--	--	--	--

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