ASSESSMENT OF LOW-FLOW WATER QUALITY

IN THE DU PAGE RIVER, ILLINOIS

By W. O. Freeman, A. R. Schmidt, and J. 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 the International System of Units (SI), the data may be converted by using the following factors:

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
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 foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

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

$$°F = 9/5°C + 32$$

ASSESSMENT OF LOW-FLOW WATER QUALITY IN THE DU PAGE RIVER, ILLINOIS

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ABSTRACT

Relations between several stream processes and concentrations of dissolved oxygen and other constituents were evaluated for a 70.3-mile reach of the Du Page River in northeastern Illinois, by comparing measured data with computer-simulated data. Measurements, made during periods of low flow, were used to calibrate and verify the QUAL-II one-dimensional, steady-state, water-quality model (Southeast Michigan Council of Governments' version). Equations for prediction of reaeration rates and traveltimes were developed from values that were measured using a steady-state, gas tracer technique. Water samples were collected from the river and known inflows during two 24-hour (diel) periods in July and August 1983 and analyzed for up to 60 constituents.

Diel dissolved-oxygen concentrations in the East Branch Du Page River were as low as 0.9 milligram per liter. During the two diel periods, the lower 8 miles of the East Branch had low dissolved-oxygen concentrations. Maximum diel dissolved-oxygen concentrations throughout this subreach were seldom above the State's minimum standard of 5 milligrams per liter. Model simulations indicated that, although ammonia oxidation played a role in dissolved-oxygen depletion, the most important factor in this subreach was sediment oxygen demand. In the East Branch, the maximum total iron concentration was 4,099 micrograms per liter compared to the State standard of 1,000 micrograms per liter, and the maximum total dissolved-solids concentration was 1,440 milligrams per liter compared to the State standard of 1,000 milligrams per liter. The maximum ammonia concentration for the two diel periods was 8.0 milligrams per liter as nitrogen, and the pH and water temperature of the stream were such that the calculated un-ionized ammonia concentration exceeded the State general use water-quality standard of 0.04 milligram per liter at three sites during both periods. Wastewater treatment facility effluent was the major input of ammonia to the river during these low-flow periods.

Some subreaches of the West Branch and the Main Stem Du Page River had dissolved-oxygen concentrations as low as 2.1 milligrams per liter, but unlike the East Branch, this was only for a short period during the day. Model simulations indicated this was caused by inflows with low dissolved-oxygen concentrations and by algal respiration. High total dissolved-solids concentrations (maximum 1,190 milligrams per liter) were measured at most sites along the West Branch and Main Stem. Ammonia concentrations in the West Branch and Main Stem were very low; the maximum concentration was 1.0 milligram per liter as nitrogen. High iron concentrations (up to 2,175 micrograms per liter) were measured in samples from the upper West Branch.

INTRODUCTION

Many areas in Illinois have had an increase in population and urban development since the late 1960's and early 1970's. Growth and development invariably have an impact on nearby rivers. Good management plans are important for the protection of these surface-water resources. In 1976, the U.S. General Accounting Office noted that there is an urgent need for resource assessments in most river basins in the United States (Comptroller General, 1976). Because of the many possible management strategies available, it is important to assess the probable impact of each in order to choose the appropriate ones. A better understanding of the chemical, physical, and biological interactions which control the quality of the river is needed to determine the impact of these various management strategies. Accurate and complete water-quality data are required to aid in river management. The U.S. Geological Survey (Survey) was urged to perform intensive river-quality assessments by the U.S. General Accounting Office in 1981 (Comptroller General, 1981). River-quality assessments, a major thrust of the Survey, are described by Velz (1976) as the "science and art of identifying significant resource problems, defining them with relevant data, and developing methods for evaluating the impacts of planning alternatives on each specific problem." The best approach to implement this involves describing stream processes using a computer model and then using the model to explore cause and effect relations in the stream.

The Illinois Environmental Protection Agency (IEPA) has the primary responsibility for reviewing water-quality standards and suggesting point-source discharge limits needed to achieve those standards in Illinois waters. This report is the result of a cooperative study by the Survey and the IEPA describing the low-flow water quality of the Du Page River and calibrating and verifying a model to be used by the IEPA in evaluating management strategies for the basin. Some of the goals of the Federal-State cooperative water-resources program are to collect the data needed to evaluate the quantity, quality, and use of water resources in the United States, and to identify the availability and the physical, chemical, and biological characteristics of surface and ground water through analytical and interpretative investigations. This report helps to fulfill these goals and thus provides some of the necessary information for the best use and management of the Nation's water resources.

Purpose and Scope

The purpose of this report is to describe the water quality of the Du Page River during low-flow periods; to identify the river subreaches where State water-quality standards are not met; to identify environmental factors in those reaches which contribute to water-quality degradation; and to use a mathematical model to aid in understanding how present or modified management actions affect water quality.

The scope of the investigation was to evaluate water quality during two periods of approximately steady-state, low-flow conditions. Chemical, physical, and biological measurements were made during low-flow periods in July and August 1983. The measurements were used to evaluate the average daily trends of constituent concentrations and to calibrate and verify the Southeast Michigan Council of Governments' version of the QUAL-II steady-state, water-quality model as described by the National Council of the Paper Industry for Air and Stream Improvement (1982). The model was used to simulate the effects of factors such as biochemical oxygen demand (BOD), sediment oxygen demand (SOD), and algae growth and respiration, along with the effects of the streamflow and channel characteristics, on the dissolved-oxygen (DO), ammonia-nitrogen, nitrite- plus nitrate-nitrogen, and phosphorus concentrations in the river. The model was used to identify environmental factors causing water-quality standards in a stream subreach to be exceeded and thereby indicate possible actions to reduce the impact of these factors.

Study Area

The Du Page River drains 376 square miles (mi^2) in Cook, Du Page, Grundy, Kane, Kendall, and Will Counties in northeastern Illinois (fig. 1). The study reach extends 70.3 river miles from near the headwaters of the East and West Branches to a point 12 river miles upstream from the mouth of the Du Page River (fig. 2). Table 1 lists the data-collection sites referred to in figure 2. The study reach drains 322 mi^2. There are 17 major tributaries to the river, 6 of which receive wastewater treatment facility (WWTF) effluent (table 2). The watersheds of the East and West Branches are predominantly urban and the remaining area is predominantly agricultural.

Three Survey stream-gaging stations on the Du Page River continuously record stream stage. Two of the stations (Survey station numbers 05539900 and 05540095) are located on the West Branch at river mile (RM) 49.2 and RM 38.9; the third station (05540500) is on the Main Stem at RM 10.6 (fig. 2). The station on the Main Stem Du Page River is 1.4 miles downstream of the study reach, and discharge values determined from stage readings at this station were used as an index of flow in the entire river for this study.

The average discharges at the gaging station on the Du Page River at Shorewood (05540500) during the two 24-hour (diel) studies on July 18-19 and August 8-9, 1983, were 229 and 124 cubic feet per second (ft^3/s), respectively. The 7-day, 10-year low-flow value for this site is 78 ft^3/s (Singh, 1983). During low-flow periods, the headwater of the East Branch is the effluent discharged from the Bloomingdale WWTF and the headwater of the West Branch is the effluent discharged from the Metropolitan Sanitary District of Greater Chicago's Hanover Park WWTF. During these low-flow periods, the streamflow of the Du Page River is composed primarily of treated wastewater.

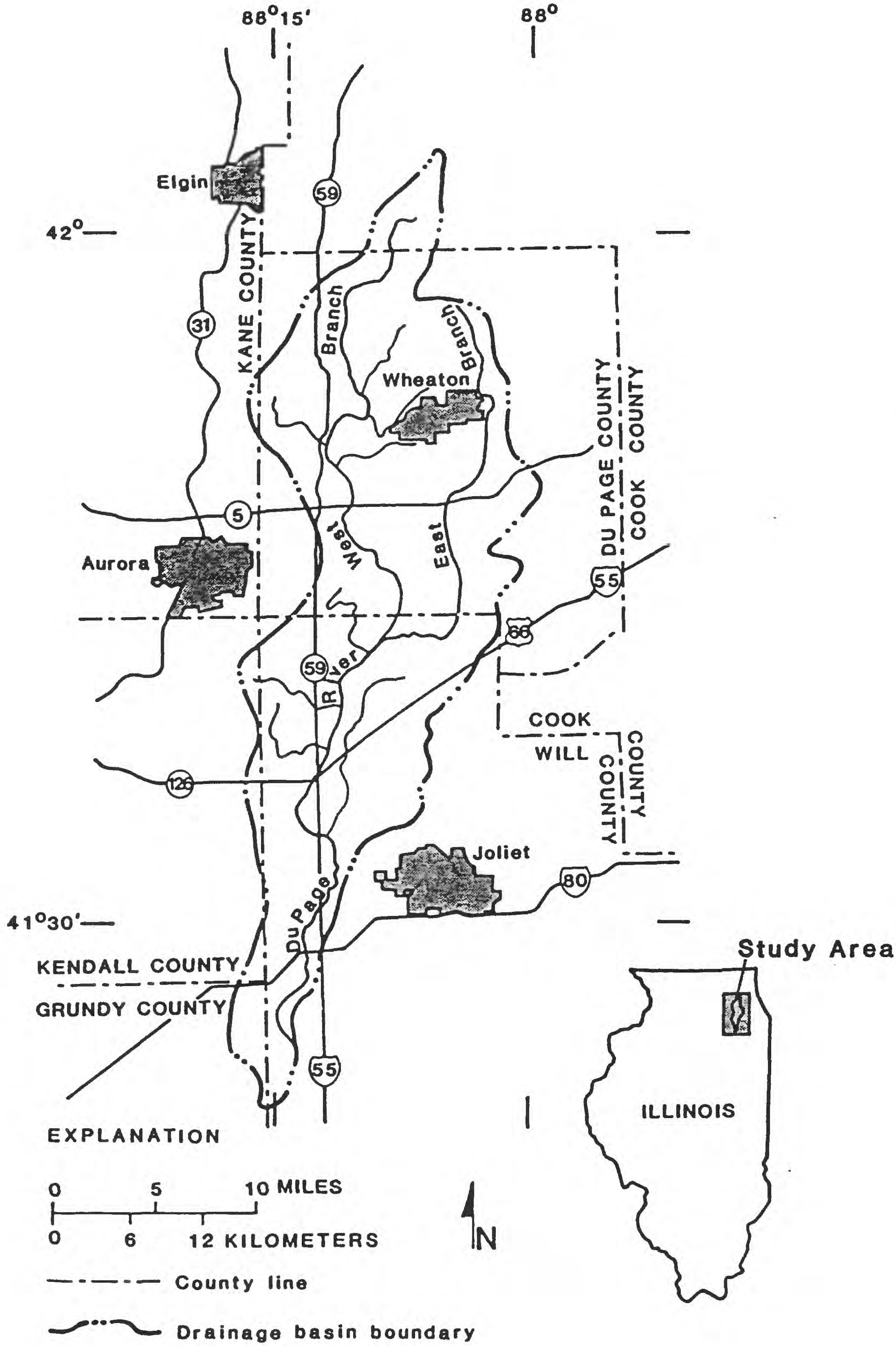


Figure 1.--Location of the Du Page River basin in northeastern Illinois.

Table 1.--Data-collection sites

[Site numbers correspond to those in figure 2 of this report]

Site No.	Station No.	River mile above mouth	Station name and location
1	05540138	23.67	East Branch Du Page River at Bloomingdale wastewater treatment facility at Bloomingdale Lat: 41°56'18" Long: 88°03'43"
2	05540143	22.07	East Branch Du Page River at Fullerton Avenue near Addison Lat: 41°55'05" Long: 88°03'09"
3	05540147	[1]21.46	Armitage Ditch at Glendale Heights wastewater treatment facility near Lombard Lat: 41°54'40" Long: 88°03'07"
4	05540150	19.95	East Branch Du Page River at Glen Ellyn Lat: 41°53'25" Long: 88°03'04"
5	05540153	18.50	East Branch Du Page River at Hill Avenue at Lombard Lat: 41°53'00" Long: 88°02'11"
6	05540156	16.92	East Branch Du Page River at Roosevelt Road at Glen Ellyn Lat: 41°51'35" Long: 88°02'44"
7	05540160	14.78	East Branch Du Page River near Downers Grove Lat: 41°49'54" Long: 88°02'51"
8	05540170	13.06	East Branch Du Page River at Morton Arboretum at Lisle Lat: 41°49'00" Long: 88°04'19"
9	05540210	11.66	East Branch Du Page River at Route 34 Bridge at Lisle Lat: 41°48'02" Long: 88°04'53"
10	05540230	10.64	East Branch Du Page River at Lisle Lat: 41°47'09" Long: 88°04'45"
11	05540235	10.08	East Branch Du Page River at 59th Street at Lisle Lat: 41°46'40" Long: 88°04'43"

Table 1.--Data-collection sites--Continued

Site No.	Station No.	River mile above mouth	Station name and location
12	05540242	8.72	East Branch Du Page River at Hobson Road near Lisle Lat: 41°45'33" Long: 88°04'21"
13	05540245	7.99	East Branch Du Page River at 75th Street near Lisle Lat: 41°44'58" Long: 88°04'13"
14	05540247	[1]7.39	Crabtree Creek at Woodridge wastewater treatment facility near Lisle Lat: 41°44'34" Long: 88°04'14"
15	05540250	5.59	East Branch Du Page River at Barbers Corners Lat: 41°43'05" Long: 88°04'14"
16	05540255	4.39	East Branch Du Page River at gravel pit near Barbers Corners Lat: 41°42'45" Long: 88°05'21"
17	05540260	1.60	East Branch Du Page River near Naperville Lat: 41°42'40" Long: 88°07'41"
18	05540263	0.02	East Branch Du Page River near mouth near Naperville Lat: 41°42'08" Long: 88°08'50"
19	05539855	58.64	West Branch Du Page River at Metropolitan Sanitary District of Greater Chicago Hanover Park wastewater treatment facility at Hanover Park Lat: 42°00'02" Long: 88°08'10"
20	05539860	58.58	West Branch Du Page River at Walnut Avenue at Hanover Park Lat: 41°59'58" Long: 88°08'11"
21	05539865	57.83	West Branch Du Page River at Hanover Park Lat: 41°59'22" Long: 88°08'03"
22	05539875	55.42	West Branch Du Page River at Jefferson Street near Hanover Park Lat: 41°58'00" Long: 88°09'07"

Table 1.--Data-collection sites--Continued

Site No.	Station No.	River mile above mouth	Station name and location
23	05539890	51.76	West Branch Du Page River near Wayne Lat: 41°56'31" Long: 88°10'51"
24	05539900	49.19	West Branch Du Page River near West Chicago Lat: 41°54'39" Long: 88°10'44"
25	05539960	[2]47.05	Klein Creek at County Farm Road near Carol Stream Lat: 41°53'55" Long: 88°09'03"
26	05539980	46.98	West Branch Du Page River at Geneva Road at Winfield Lat: 41°53'13" Long: 88°09'34"
27	05540005	45.55	West Branch Du Page River at Beecher Road at Winfield Lat: 41°52'10" Long: 88°09'48"
28	05540066	41.41	West Branch Du Page River at Mack Road near West Chicago Lat: 41°50'33" Long: 88°11'56"
29	05540092	39.81	Spring Brook at Morris Court at Warrenville Lat: 41°49'52" Long: 88°11'08"
--	05540095	38.90	West Branch Du Page River near Warrenville (not a data-collection site) Lat: 41°49'22" Long: 88°10'23"
30	05540100	38.81	West Branch Du Page River at Warrenville Lat: 41°49'03" Long: 88°10'16"
31	05540117	36.87	West Branch Du Page River at McDowell Grove at Naperville Lat: 41°47'45" Long: 88°11'15"
32	05540120	35.65	West Branch Du Page River at Naperville Lat: 41°46'54" Long: 88°10'30"
33	05540123	33.33	West Branch Du Page River at Hillside Road at Naperville Lat: 41°45'57" Long: 88°08'51"

Table 1.--Data-collection sites--Continued

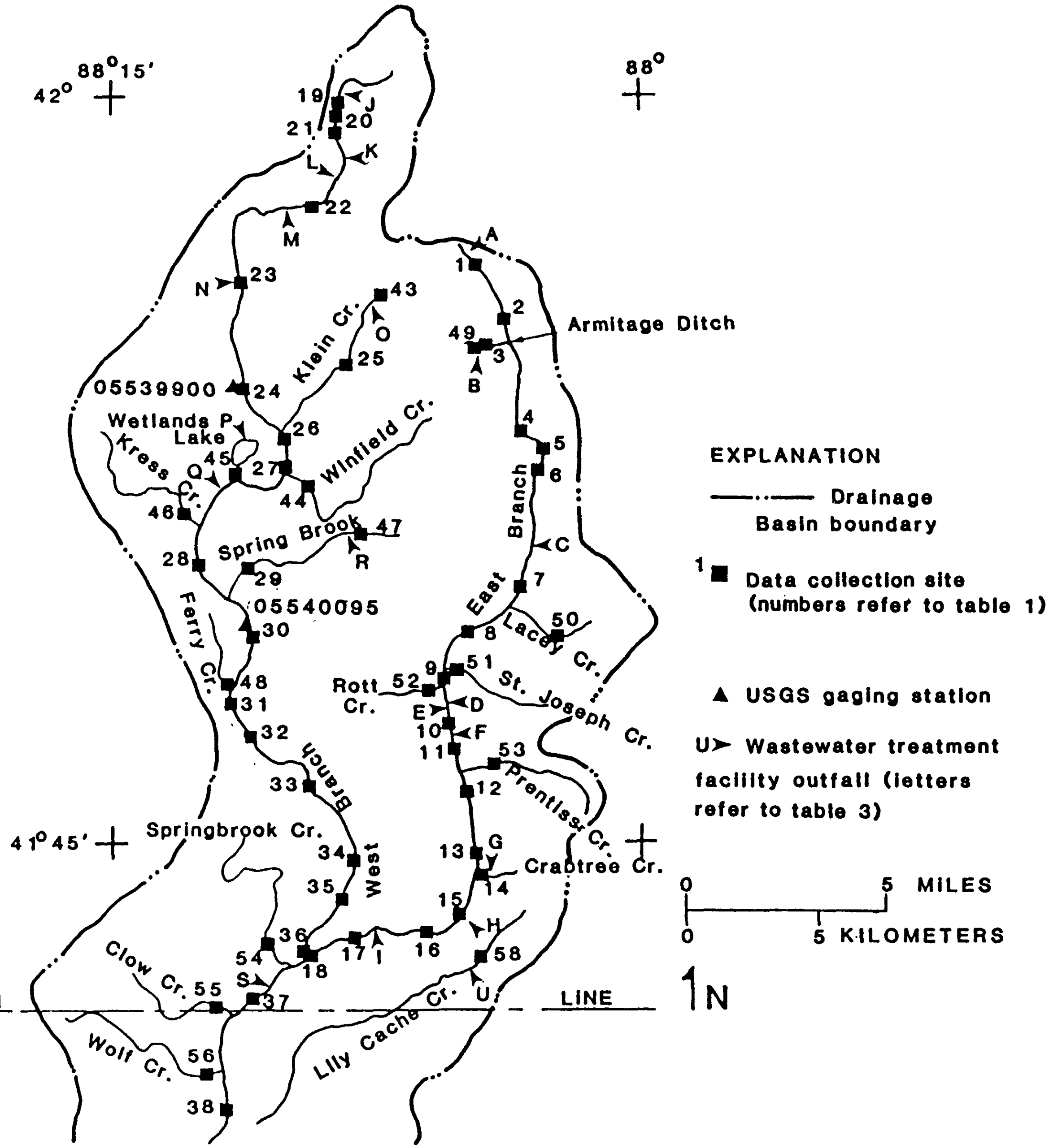
Map No.	Station No.	River mile above mouth	Station name and location
34	05540126	31.57	West Branch Du Page River at 75th Street at Naperville Lat: 41°44'55" Long: 88°07'45"
35	05540130	29.50	West Branch Du Page River near Naperville Lat: 41°43'13" Long: 88°07'55"
36	05540135	27.86	West Branch Du Page River near mouth near Naperville Lat: 41°42'08" Long: 88°08'51"
37	05540290	26.25	Du Page River near Naperville Lat: 41°41'24" Long: 88°09'58"
38	05540304	23.05	Du Page River at 127th Street near Plainfield Lat: 41°39'07" Long: 88°10'53"
39	05540325	19.93	Du Page River at State Route 59 at Plainfield Lat: 41°37'01" Long: 88°12'11"
40	05540340	15.26	Du Page River at State Route 59 near Plainfield Lat: 41°34'16" Long: 88°12'04"
41	05540400	14.56	Lily Cache Creek near Plainfield Lat: 41°35'14" Long: 88°10'40"
42	05540480	12.00	Du Page River at Black Road at Shorewood Lat: 41°32'10" Long: 88°10'54"
--	05540500	10.60	Du Page River at Shorewood (Not a data collection site) Lat: 41°31'20" Long: 88°11'35"
43	05539945	[2]47.05	Klein Creek at Thunderbird Terrace at Carol Stream Lat: 41°54'37" Long: 88°07'46"
44	05540023	[2]45.10	Winfield Creek at Summit Drive at Winfield Lat: 41°52'01" Long: 88°09'44"
45	05540027	[2]44.06	Wetlands Lake at Barnes Avenue at West Chicago Lat: 41°52'18" Long: 88°10'43"
46	05540063	[2]41.80	Kress Creek at State Route 59 near West Chicago Lat: 41°51'12" Long: 88°12'08"

Table 1.--Data-collection sites--Continued

Site No.	Station No.	River mile above mouth	Station name and location
47	05540085	[2]39.81	Spring Brook at Wheaton wastewater treatment facility at Wheaton Lat: 41°50'49" Long: 88°08'29"
48	05540115	[2]36.80	Ferry Creek at McDowell Grove at Naperville Lat: 41°47'55" Long: 88°11'07"
49	05540146	[1]21.46	Armitage Ditch at Armitage Avenue near Lombard Lat: 41°54'40" Long: 88°03'17"
50	05540165	[1]14.60	Lacey Creek at Lacey Road at Downers Grove Lat: 41°48'58" Long: 88°01'47"
51	05540205	[1]11.90	St. Joseph Creek at Dumoulin Avenue at Lisle Lat: 41°48'06" Long: 88°04'49"
52	05540225	[1]11.50	Rott Creek near Short Street at Lisle Lat: 41°47'39" Long: 88°05'06"
53	05540240	[1]9.60	Prentiss Creek near Lisle Lat: 41°46'47" Long: 88°04'11"
54	05540280	[2]27.10	Spring Brook near Naperville Lat: 41°42'29" Long: 88°10'01"
55	05540294	[2]25.50	Clow Creek at Book Road near Plainfield Lat: 41°41'11" Long: 88°11'10"
56	05540302	[2]23.70	Wolf Creek at Book Road near Plainfield Lat: 41°39'50" Long: 88°11'06"
57	05540320	[2]20.20	West Norman Drain at Plainfield Lat: 41°37'20" Long: 88°12'09"
58	05540353	[2]14.56	Lily Cache Creek at Briar Cliff Road near Barbers Corners Lat: 41°41'54" Long: 88°04'28"

[1] River miles indicate the location of the mouth of the tributary above the mouth of the East Branch Du Page River.

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



42° 88°15'
88°
41°45'
EXPLANATION
Drainage
Basin boundary
1 Data collection site (numbers refer to table 1)
USGS gaging station
U Wastewater treatment facility outfall (letters refer to table 3)
0 5 MILES
0 5 KILOMETERS
N
MATCH LINE
Armitage Ditch
East Branch
West Branch
Klein Cr.
Winfield Cr.
Spring Brook
Kress Cr.
Ferry Cr.
Wetlands Lake
Lacey Cr.
St. Joseph Cr.
Rott Cr.
Prentiss Cr.
Crabtree Cr.
Springbrook Cr.
Clow Cr.
Wolf Cr.
Lily Cache Cr.
05539900
05540095

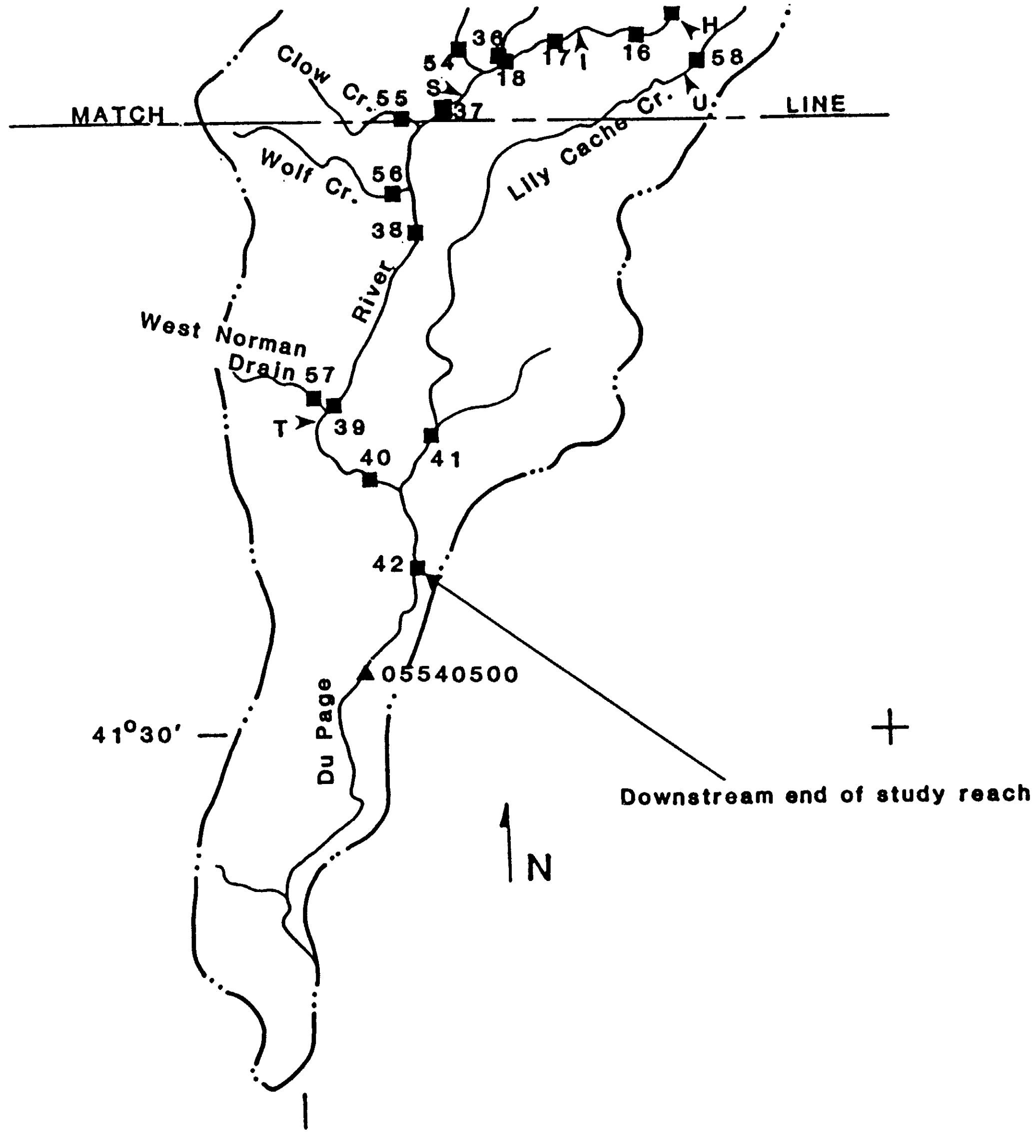


Figure 2.--Du Page River basin showing the locations of the data-collection sites and the wastewater treatment facility outfalls.

Table 2.--Drainage areas and average flows for Du Page River tributaries

Tributary name	Drainage area at the mouth (square miles)	Tributary contains treated wastewater from these facilities	Average flow near the mouth (cubic feet per second) during the diel studies	
			July diel	August diel
Armitage Ditch	2.18	Glendale Heights	4.84	4.42
Lacey Creek	2.98	None	1.52	.00
St. Joseph Creek	11.8	None	.01	.00
Rott Creek	4.98	None	3.38	.38
Prentiss Creek	6.48	None	.57	.65
Crabtree Creek	1.63	Woodridge	8.11	6.47
Klein Creek	9.68	Carol Stream	1.57	3.00
Winfield Creek	8.90	None	.00	.00
Wetlands Lake	.65	Winfield	.90	.70
Kress Creek	18.2	None	5.87	1.07
Spring Brook	7.01	Wheaton	10.8	10.3
Ferry Creek	10.8	None	3.76	.08
Spring Brook	12.3	None	6.48	.57
Clow Creek	4.72	None	4.20	.03
Wolf Creek	5.90	None	4.00	.00
West Norman Drain	8.30	None	3.16	.09
Lily Cache Creek	43.1	Citizen's Utility No. 1	28.7	16.7

Acknowledgments

The authors wish to acknowledge the assistance provided by the Illinois Environmental Protection Agency in helping organize and execute this study, especially during the diel data collections. Acknowledgment is also given to all the local wastewater treatment facilities for providing access to their facilities for sampling.

Special acknowledgment is given to Allen F. Panek, Springbrook Water Reclamation Facility, for providing space for our field operations and to the Naperville Police Department for maintaining telephone communications during the diel data-collection periods.

DATA COLLECTION

Data requirements for modeling stream quality include traveltimes, reaeration-rate coefficients, stream discharges, BOD, and various chemical constituent concentrations.

Channel and streamflow characteristics, atmospheric reaeration rates, and chemical-quality measurements were made on the Du Page River for low-flow periods from July to September 1983. Traveltimes and reaeration-rate coefficients were determined at various flow rates throughout the study period. Two diel studies at different low-flow conditions were done on July 18-19 and on August 8-9. Chlorophyll-a concentrations, BOD, and the chemical constituent concentrations were determined from samples collected at 79 sites during the diel studies. These sites included 21 WWTF outfalls, 21 tributary sites, and 37 river sites (fig. 2). Field measurements of pH, specific conductance, DO, stage, and air and water temperatures were also made at these sites.

There are 25 WWTFs that discharge to the Du Page River or its tributaries, serving a population of approximately 379,300 (U.S. Census Bureau, 1980). Four of the 25 WWTFs were not monitored (Glen Ellen Heights, Bolingbrook No. 2, Farmingdale, and Shorewood) because the plant outfall was outside the study area or because it discharged an insignificant volume compared to the volume of streamflow at the point of discharge. Most of the WWTFs that were monitored use some form of advanced treatment (table 3).

Streamflow and Channel Characteristics

Streamflow was measured at 103 sites several times from June to September 1983. Reference points were established and stage-discharge relations were developed for the low-flow range of discharge at 31 of the 37 river sites using the methods described by Rantz and others (1982). Discharge at the time of sampling was estimated by measuring the stream stage and using the low-flow stage-discharge relations. Discharges from WWTFs were furnished from flow charts maintained by the WWTF; for those WWTFs without daily discharge records, monthly averages, as provided to the IEPA, were used.

Table 3.--Wastewater treatment facility characteristics

[All wastewater treatment facility design information from R. Schacht, Illinois Environmental Protection Agency, written commun., 1983]

Map symbols[1]	Wastewater treatment facility name	Secondary treatment[2]	Tertiary treatment[2]	Nitrification[2]	Treatment-plant discharge, (cubic feet per second): Design discharge	Average discharge during diel study: July	Average discharge during diel study: August	Location of outfall[3]
A	Bloomingdale wastewater treatment facility	AS	HRF	Single-stage AS	5.34	1.99	1.85	EB / 23.7
B	Glendale Heights wastewater treatment facility	AS	HRF	Second-stage AS	6.19	4.84	4.42	Armitage ditch to EB / 21.5
C	Glenbard wastewater treatment facility	AS	HRF	None	22.16	15.9	13.2	EB /15.9
D	Downers Grove wastewater treatment facility	AS	MS	None	14.85	12.6	11.8	EB / 11.8
E	Du Page County temporary wastewater treatment facility	AS	None	None	1.04	.94	.96	EB / 10.7
F	Lisle wastewater treatment facility	AS	HRF	None	4.30	3.42	2.80	EB / 10.5
G	Woodridge wastewater treatment facility	AS	HRF	None	6.19	8.11	6.47	Crabtree Creek to EB / 7.4
H	Bolingbrook wastewater treatment facility	AS	MS	None	2.32	1.62	1.62	EB / 5.5
I	Citizen's Utility wastewater treatment facility No. 2	AS	None	None	4.64	2.57	2.23	EB / 2.4
J	Metropolitan Sanitary District of Greater Chicago, Hanover Park wastewater treatment facility	AS	HRF	Single-stage AS	18.57	10.3	9.97	WB / 58.6
K	Roselle-Botterman wastewater treatment facility	AS	MS	None	1.24	.50	.47	WB / 57.3
L	Hanover Park wastewater treatment facility No. 1	AS	HRF	None	1.86	.66	.69	WB / 56.5

Table 3.--Wastewater treatment facility characteristics--Continued

Map symbols[1]	Wastewater treatment facility name	Secondary treatment[2]	Tertiary treatment[2]	Nitrification[2]	Treatment-plant discharge, (cubic feet per second): Design discharge	Average discharge during diel study: July	Average discharge during diel study: August	Location of outfall[3]
M	Bartlett wastewater treatment facility	AS	MS	None	3.51	1.61	1.09	WB / 54.6
N	Hanover Park wastewater treatment facility No. 2	AS	HRF	Second-stage AS	1.86	.51	.49	WB / 51.7
O	Carol Stream wastewater treatment facility	AS	HRF	None	3.87	3.04	2.83	Klein Creek to WB / 47.1
P	Winfield wastewater treatment facility	AS	None	None	2.32	2.70	2.70	Wetlands Lake to WB / 44.1
Q	West Chicago wastewater treatment facility	AS	Polishing pond	None	3.71	3.37	3.08	WB / 43.1
R	Wheaton wastewater treatment facility	TF	Polishing pond	Second-stage AS	13.77	10.1	10.3	Spring Brook to WB / 39.8
S	Naperville Springbrook wastewater treatment facility	AS	HRF	None	15.47	16.8	13.9	DR / 27.0
T	Plainfield wastewater treatment facility	AS	Polishing pond	None	1.55	1.92	1.23	DR / 19.0
U	Citizen's Utility wastewater treatment facility No. 1	AS	Polishing pond	None	1.98	1.92	1.76	Lily Cache Creek to DR / 14.6

1 Map symbols correspond to those in figure 2 of this report.

2 Explanation of symbols used to define treatment processes (explanations of treatment processes are discussed by Clark and others, 1977)

- AS Activated Sludge
- TF Trickling filters
- HRF High rate sand filters
- MS Micro screens

3 The format for this column is: stream name or symbol / river mile

River miles for tributaries are the location of the mouth of the tributary.

River miles are from the mouth of the Du Page River for West Branch and Main Stem locations and from the mouth of the East Branch Du Page River for all the East Branch locations.

The explanations for the stream symbols are

- EB East Branch Du Page River
- WB West Branch Du Page River
- DR Main Stem Du Page River

Channel cross-sectional area and width were measured directly using the methods described by Rantz and others (1982). These measurements were made as part of the discharge measurements. The locations of the measuring sites were chosen to provide the best measurement of discharge. Average channel depth was calculated by assuming the stream channel was rectangular and dividing cross-sectional area by width.

Traveltime and Reaeration-Rate Coefficients

Traveltime refers to the period of time it takes for water or waterborne materials to move from one point to another in a stream (Hubbard and others, 1982). Reaeration rate refers to the rate at which oxygen is absorbed from the atmosphere by the stream (Rathbun and Grant, 1978). The 70.3-mile study reach of the river was divided into 64 subreaches based on estimates of traveltimes and reaeration rates, and on accessibility. Selection of river subreaches used in the traveltime - reaeration-rate studies was based on the criterion that the product of the propane desorption rate and traveltime equal one. This minimizes the errors introduced in the gas tracer technique described by Yotsukura and others (1983). Traveltimes and reaeration-rate coefficients were measured simultaneously using a steady-state version of the gas tracer technique (Yotsukura and others, 1983). Traveltimes and reaeration rates were measured once for 55 subreaches and twice for 5 subreaches. Several attempts were made to measure the traveltimes and reaeration rates for the four uppermost subreaches of the East Branch, but all of these attempts were interrupted by heavy rains, and subsequently, these four subreaches, totaling 5.2 river miles, were not modeled.

The gas-tracer technique for determining reaeration-rate coefficients is based on the constant relation between the rate at which a tracer gas desorbs from water and the rate at which oxygen is absorbed from or desorbed to the atmosphere by the water. This relation has been studied by using laboratory tank tests, and the technique has been used to measure rates of gas loss over stream reaches (Rathbun and Grant, 1978). The steady-state version of this method uses a steady gas-injection rate to produce a concentration of gas which remains constant over time at a given downstream location, but which decreases with distance downstream from the injection site. The reaeration rates of the Du Page River were determined using propane gas that was steadily injected through porous diffuser plates for approximately the total traveltime of the subreach being measured.

The propane-gas injection was accompanied by a slug injection of Rhodamine WT, a fluorescent red dye. The dye was injected using a 6- to 8-foot section of 4-inch diameter polyvinyl chloride pipe that had both ends plugged and large holes along one side of its entire length. The pipe was filled with a mixture of dye and water and then dumped as quickly and evenly as possible across the center of flow of the river to approximate an instantaneous line injection. The stream was then sampled for gas and dye at two or three sites downstream from the injection site. These sample sites were far enough downstream from the injection site to assume complete lateral and vertical mixing of both gas and dye based on the equations discussed by Hubbard and others (1982). The quantities of gas and dye injected were determined using the methods described by Rathbun (1979).

Fluorometers were used in the field to detect the arrival of the dye cloud, the peak dye concentration, and the passing of the dye cloud. As many as 65 samples were collected to define the dye-concentration curves for each site. These samples were later reanalyzed in the laboratory to provide a more stable and controlled environment for operation of the fluorometers, thereby providing for more accurate results.

Four to eight water samples were collected at 20-minute intervals for propane analysis. The samples were collected relative to the dye cloud to insure that concentrations of propane in the samples were at or near their plateau and that nearly the same parcel of water was sampled at each site. Each sample was preserved with formalin and sent to the Survey laboratory in Doraville, Georgia, for analysis. Gas chromatography was used to determine the propane concentrations (Wershaw and others, 1983). Figure 3 shows an example of the gas and dye results plotted for two consecutive sampling sites.

Accurate traveltimes for each subreach of the river are important in modeling the water quality. The traveltime for each subreach of the river was calculated as the time it took for the centroid of the dye cloud to pass through a subreach. Traveltime was used to determine the average stream velocity and the reaeration-rate coefficient for each subreach. The average velocity was determined by dividing the subreach length by its traveltime.

Reaeration from the atmosphere is one of the primary mechanisms by which the dissolved oxygen, consumed by the biological processes in the river, is replenished. The reaeration-rate coefficient, calculated from the propane- and dye-concentration data collected for each subreach, describes how quickly this process occurs.

To calculate the reaeration-rate coefficient[1], the propane desorption-rate coefficient, K_p, is first calculated based on the mass of propane lost from the subreach and the traveltime in that subreach. The equation used is (Yotsukura and others, 1983)

$$K_p = \frac{\ln\left(\frac{C_u Q_u}{C_d Q_d}\right)}{ToT} \qquad (1)$$

where K_p is the propane desorption-rate coefficient, in reciprocal days;
ToT is the traveltime for the subreach, in days;
C is the propane concentration at the given location;
Q is the stream discharge; and
u,d indicate location at upstream and downstream ends of the subreach, respectively.

[1] All rate coefficients in this report are calculated using natural logarithms (base e).

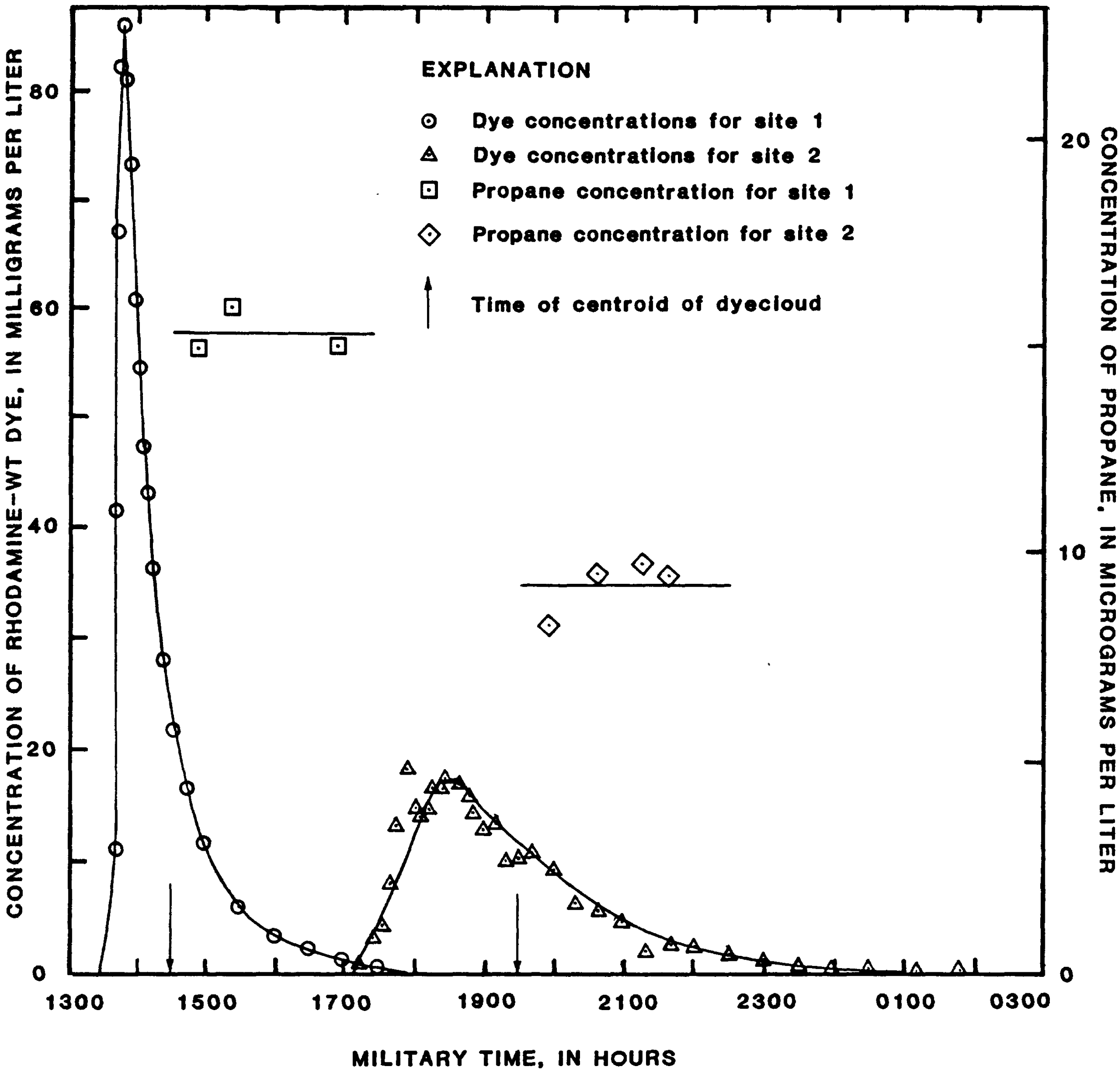


Figure 3.--Gas and dye concentrations as a function of time for two consecutive sites, 0.6 and 1.7 river miles from the injection point.

The reaeration-rate coefficient (K_2) is related to the propane desorption-rate coefficient by the following equation (Rathbun, 1979):

$$K_2 = 1.39\ K_p. \qquad (2)$$

The reaeration-rate coefficient was standardized to 20°C using the following equation (Rathbun, 1979; Yotsukura and others, 1983):

$$K_2^{20} = K_2^T\ (1.0241)^{(20-T)} \qquad (3)$$

where K_2^{20} is the reaeration-rate coefficient at 20°C, in reciprocal days;

K_2^T is the reaeration-rate coefficient at T°C, in reciprocal days; and

T is the water temperature, in degrees Celsius.

Water-Quality Characteristics

A 24-hour composite sample of effluent from each WWTF was collected daily for 4 to 8 days before each diel study; the number depending on the estimated traveltime from the WWTF outfall to the downstream end of the study reach. These samples were used to identify any variations in effluent quality that might affect the water quality of the river during the diel studies. An additional 24-hour composite sample was collected from each WWTF during the diel studies, and four discrete samples of effluent (each 6 hours apart) were collected at six of the larger WWTFs.

During the diel studies, water samples were collected every 4 hours from 37 sites on the Du Page River and from 5 sites on the tributaries that received treated wastewater. Tributaries that did not receive treated wastewater (15 sites) and the outfall from Wetlands Lake which did contain treated wastewater, were assumed to have a fairly constant water quality during low-flow periods (fig. 2). These sites were sampled twice during each diel study; once in the early morning (0300-0600 hours) and again in the late afternoon (1500-1800 hours) in order to measure chemical constituent concentrations and to estimate the range of daily variations in the DO concentration. Water-quality field measurements of specific conductance, DO concentration, pH, and temperature were made using hand-held four-parameter monitors. These measurements, along with air temperature, were made every 2 to 4 hours at all river sites and at sites in the tributaries that received treated wastewater. Field measurements were also made during the two visits to the other tributary sites and on each visit to the WWTF outfalls.

Water and effluent samples were chilled with ice, transported to the IEPA laboratory within 8 hours of being collected, and analyzed using IEPA laboratory methods (1986). Each water sample was analyzed to determine the concentrations of total organic plus ammonia nitrogen (total kjeldahl nitrogen), dissolved ammonia nitrogen, dissolved nitrite plus nitrate nitrogen, and dissolved and total phosphorus. Ultimate carbonaceous BOD and the decay rate were determined for each of these samples, and total (nitrogenous plus carbonaceous) BOD was also determined for selected samples. Ultimate carbonaceous BOD refers to the total amount of DO used by heterotrophic microbes in oxidizing all of the biologically oxidizable carbonaceous material in a specified volume. It is expressed as milligrams DO consumed per liter of sample. The decay rate is the rate at which the oxygen is consumed. Ultimate carbonaceous BOD and its decay rate were determined using methods described by Stamer and others (1983). This method involves incubating the samples in the dark at 20°C and periodically determining the amount of DO consumed. The ultimate carbonaceous BOD and the decay rate are then calculated from this time-series data by using a nonlinear least squares method. A small amount of nitrapyrin was added to most of the BOD samples to inhibit nitrification. One sample from each site was analyzed without nitrapyrin to measure the total (carbonaceous plus nitrogenous) BOD. Total BOD simply refers to the DO depletion due to oxidation of all of the biologically oxidizable material. Residual chlorine concentrations were measured in all BOD samples, and appropriate amounts of sodium sulfite were added to neutralize the chlorine residual. All BOD samples were then seeded using 1 milliliter of raw sewage obtained from the Champaign, Illinois, Sewage Treatment Works, in order to introduce microbe populations that may have been killed by the chlorine. The contribution of BOD from the seed was negligible.

Two samples that were collected in the early morning and late afternoon from each site, except at the WWTF sites, were analyzed for chlorophyll-a concentration. One sample from each site, including the WWTF sites, was analyzed for 54 other constituents: turbidity; chemical oxygen demand; total alkalinity; total acidity; total suspended solids; volatile suspended solids; total ammonia nitrogen; total nitrite plus nitrate nitrogen; cyanide; hardness; chloride; sulfate; fluoride; arsenic; fecal coliform; phenol; total dissolved solids; mercury; and total and dissolved calcium, magnesium, sodium, potassium, lead, manganese, nickel, silver, barium, boron, beryllium, cadmium, strontium, vanadium, zinc, chromium, copper, and iron.

Results of the water-quality analyses are available for inspection at the Survey's Illinois District Office.

ASSESSMENT OF LOW-FLOW WATER QUALITY

Diel Water Quality

The Illinois Pollution Control Board establishes the water-quality standards for the State of Illinois. The general-use water-quality standards, which apply to the Du Page River and its tributaries, are intended to "protect the State's water for aquatic life, agricultural use, primary and secondary contact use, and most industrial uses and to ensure the aesthetic quality of the State's aquatic environment" (Pollution Control Board, 1984). The results of the water-quality analyses on the samples collected at the 37 stream sites on July 18-19 and on August 8-9, 1983, are presented in part in tables 12 and 13, at the end of this report. These results and their relation to applicable water-quality standards are discussed here.

The State standard for DO declares that during at least 16 hours of any 24-hour period the DO concentration must be 6.0 milligrams per liter (mg/L) or greater, and the concentration may never be less than 5.0 mg/L (Pollution Control Board, 1984). DO concentrations can be affected by factors such as BOD, SOD, reaeration, algal growth and respiration, and others. There is probably no place in the river where DO is not affected by one or more of these factors. The QUAL-II water-quality model was used to determine which of these factors had the largest impact on the DO concentrations in several subreaches of the river. A second method was used to identify those sites where algae caused DO concentrations to fall below the State standard. This method required the assumption that the diel fluctuation in DO concentration was caused by plant photosynthesis and respiration. In this method, the magnitude of the change in DO concentration between the time-weighted average concentration and minimum concentration measured at a site was compared to the magnitude of the change between the DO saturation concentration and the State minimum standard of 5.0 mg/L (S. C. McCutcheon, U.S. Geological Survey, written commun., 1984). The DO saturation concentration for each site was determined from the average water temperature at that site using the following equation (Thomann, 1972):

$$C_s = 14.652 - 0.41022\ T + 0.007991\ T^2 - 0.000077774\ T^3 \qquad (4)$$

where C_s is the oxygen saturation concentration at standard pressure (29.92 inches of mercury), in milligrams per liter, and

T is the water temperature, in degrees Celsius.

If the magnitude of the measured DO change was larger than the magnitude of the change calculated from the saturation concentration, then plant activity was a major factor and the State minimum standard would probably have been violated regardless of the effects of other factors such as BOD and SOD.

The DO concentrations in the East Branch Du Page River ranged from 1.5 to 12.2 mg/L during the July diel study and from 0.9 to 14.2 mg/L during the August diel study. Site 6 was the only site in the East Branch where plant activity was the primary cause of the DO standard being violated. Algal activity was the dominant factor at the site during both the July and August diel studies.

Site 2 was in a short riverine section within a small wetlands area of the East Branch, and site 4 was downstream of the wetlands area. Both of these sites had DO concentrations consistently below 6.0 mg/L and, except for one measurement in August at site 2, concentrations were all below 5.0 mg/L. Algal activity did not appear to be an important factor at these sites. The DO concentrations between sites 6 and 13 in the East Branch fluctuated around 6.0 mg/L, and during the July diel study, minimum concentrations in this subreach often fell below 5.0 mg/L. The data-collection sites downstream of site 13 in the East Branch had DO concentrations that were always below 6.0 mg/L and almost always below 5.0 mg/L during both diel studies. This subreach of the East Branch from about RM 8.0 (site 13) to the mouth was, in terms of DO, the most critical subreach of the Du Page River system.

DO concentrations in the West Branch and Main Stem Du Page River ranged from 3.3 to 14.3 mg/L during the July diel study and from 2.1 to 29.3 mg/L during the August diel study. DO concentrations were generally greater than 5.0 mg/L throughout the West Branch and Main Stem, and, in most cases, concentrations were above 6.0 mg/L for a long enough period of each diel study to comply with the State DO standard. During the July diel study, DO concentrations fell below 5.0 mg/L at sites 22, 23, 24, 28, 31, 37, and 38. Site 38 was the only one of these sites where algal activity was the primary cause of the State standard violation.

During the August diel study, DO concentrations in the West Branch and Main Stem fell below 5.0 mg/L at sites 22, 26, 28, 31, 35, 36, 37, 38, and 39. Of these, all sites except 22 and 26 showed algae to be the dominant factor indicating that DO concentrations would have fallen below 5.0 mg/L regardless of the impact of other factors such as BOD and SOD. Site 37 is just downstream from the confluence of the East and West Branches of the Du Page River. In addition to the effects of algae, low DO concentrations at this site were caused in part by the inflow of water with low DO from the East Branch. Although there are several sites where the State DO standard is not met, the water quality in terms of DO, in the West Branch and Main Stem is much better than that of the East Branch.

The State general-use water-quality standard for pH specifies that it should be between 6.5 and 9.0 except for natural causes (Pollution Control Board, 1984). The pH in the East Branch Du Page River ranged from 6.4 to 8.6 during the July diel study and from 6.2 to 8.4 during the August diel study. The pH dropped below the State standard at site 6 during the July diel study and at site 2 during the August diel study. The pH in the West Branch and Main Stem ranged from 6.5 to 8.2 in July and from 7.1 to 8.6 during the August diel study. These values were in compliance with the State standard.

The State general-use water-quality standard for total ammonia nitrogen and un-ionized ammonia nitrogen specifies that the total ammonia-nitrogen concentration must be less than or equal to 15.0 mg/L. If the total ammonia-nitrogen concentration is between 1.5 and 15.0 mg/L, the un-ionized ammonia-nitrogen concentration must be less than or equal to 0.04 mg/L. Total ammonia-nitrogen concentrations less than 1.5 mg/L are considered lawful regardless of the corresponding un-ionized ammonia-nitrogen concentrations (Pollution Control Board, 1984). Total (unfiltered) ammonia-nitrogen concentrations were determined from one sample at each site. Total ammonia-nitrogen concentrations in the West Branch and Main Stem were never greater than 1.5 mg/L. The total ammonia-nitrogen concentrations in the East Branch ranged from 0.10 to 8.0 mg/L and from 0.29 to 5.1 mg/L during the July and August diel studies, respectively. The un-ionized ammonia-nitrogen concentrations were calculated using measured pH and water temperatures with this equation (Pollution Control Board, 1984):

$$u = \frac{N}{(0.94412(1 + 10^{x}) + 0.0559)} \qquad (5)$$

$$x = 0.09018 + \frac{2729.92}{(T + 273.16)} - pH \qquad (6)$$

where u is the concentration of un-ionized ammonia nitrogen, in milligrams per liter;

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

T is the water temperature, in degrees Celsius.

The results of these calculations indicated that sites 1, 2, and 4 were not in compliance with the State standard for un-ionized ammonia during the July diel study and that sites 1, 4, and 16 were not in compliance during the August diel study.

Dissolved phosphorus and dissolved nitrite- plus nitrate-nitrogen concentrations were measured in the Du Page River although there are no State standards that apply to these constituents. However, these constituents are of concern as nutrients for algal growth. The concentrations of inorganic phosphorus and inorganic nitrogen needed to promote algal growth are 0.01 and 0.3 mg/L, respectively (Sawyer, 1952; Muller, 1953). These constituents are present in large enough concentrations to propogate algal growth in the Du Page River with the exception of site 2 during the August diel study and sites 5 and 6 during both diel studies. At these sites, nitrite- plus nitrate-nitrogen concentrations fell below 0.3 mg/L. Although phosphorus concentrations at site 6 were above 0.01 mg/L, they were low enough to reduce the algal growth rate. Site 2 is located in a wetlands area of the East Branch where large macrophyte populations reduced nutrient concentrations. Sites 5 and 6 are downstream of a small reservoir where chlorophyll-a concentrations were high and detention times long enough for algal growth to reduce the nutrient concentrations to growth-limiting levels.

Site 6 (RM 16.92) was previously discussed as being the only site on the East Branch where algal activity was the dominant factor causing DO concentrations to fall below 5.0 mg/L. DO concentrations were high enough to indicate that nutrient concentrations large enough to promote algal growth were present. The supposition is that nutrients contributed by a small unmeasured outflow from a construction site around RM 18.5 were enough to promote algal growth. This algal growth then reduced nutrient concentrations to growth-limiting levels farther downstream. Concentrations of chlorophyll-a from the upstream reservoir were high enough that a small increase in nutrient concentration could cause a surge in algal growth.

The State general-use water-quality standard for total dissolved solids specifies that concentrations shall not be greater than 1,000 mg/L (Pollution Control Board, 1984). Total dissolved solids in the East Branch ranged from 784 to 1,440 mg/L during the July diel study and from 940 to 1,440 mg/L during the August diel study. Concentrations exceeded the State standard throughout most of the East Branch except at sites 1, 2, 4, and 5 during the July diel study and at sites 1 and 2 during the August diel study.

Total dissolved solids in the West Branch and Main Stem Du Page River ranged from 744 to 1,190 mg/L and from 932 to 1,180 mg/L during the July and August diel studies, respectively. The State standard was exceeded at sites 31, 32, 33, 34, 35, 36, and 38 during the July diel study and at all sites except 19, 22, 24, and 27 during the August diel study.

The concentrations of total dissolved solids from the measured inflows were used in conjunction with the discharge measured at these point sources to determine dilution factors and calculate corresponding stream concentrations. These calculated concentrations assumed that the headwaters and point sources were the only contributing factors to stream concentrations and that total dissolved solids was a conservative constituent. Calculated concentrations were compared with measured stream concentrations to determine if the point sources could account for the total dissolved solids present.

Figures 4 and 5 show that the measured concentrations were somewhat variable and that the levels and trends of the measured and calculated total dissolved solids were somewhat comparable. This indicates that point sources are probably a major factor in the total dissolved-solids concentrations and that other factors such as sediment interactions may also play an important role.

Total iron concentrations measured in the East Branch ranged from 80 to 2,400 micrograms per liter (μg/L) during the July diel study and from 61 to 4,100 μg/L during the August diel study. Total iron concentrations measured in the West Branch and Main Stem ranged from 64 to 1,800 μg/L and from 16 to 1,700 μg/L during the July and August diel studies, respectively. These concentrations exceeded the State standard of 1,000 μg/L throughout much of the river. Iron concentrations were calculated from the contributions of the headwaters and point sources and were then compared to the measured iron concentrations (figs. 6 and 7). Measured concentrations were fairly consistently higher than the calculated concentrations in the East Branch and West Branch Du Page River, but the concentrations were comparable in the Main Stem. These results indicate that point sources are not the major cause of high iron concentrations in the river. Sediment interactions, chemical release, and nonpoint sources may help to account for the iron in the river.

Fluoride concentrations in the East Branch and Main Stem Du Page River were well below the State standard of 1.4 mg/L during both diel studies. Fluoride concentrations exceeded the State standard in the West Branch at sites 19, 20, and 21 during the July diel study and at sites 27 and 28 during the August diel study. Figures 8 and 9 show comparisons of the measured fluoride concentrations and the concentrations calculated from the headwaters and point-source contributions for the East Branch and the West Branch and Main Stem, respectively. The concentrations were generally comparable indicating that the point sources were the primary factor controlling fluoride concentrations. There was an exception at sites 19 and 20 in the West Branch during the July diel study. Measured concentrations at these sites were much higher than the calculated concentrations indicating that some factor such as an unmeasured point or nonpoint source was controlling the concentrations.

All other constituents that were measured during the two diel studies were within the limits specified by the applicable State general-use water-quality standards.

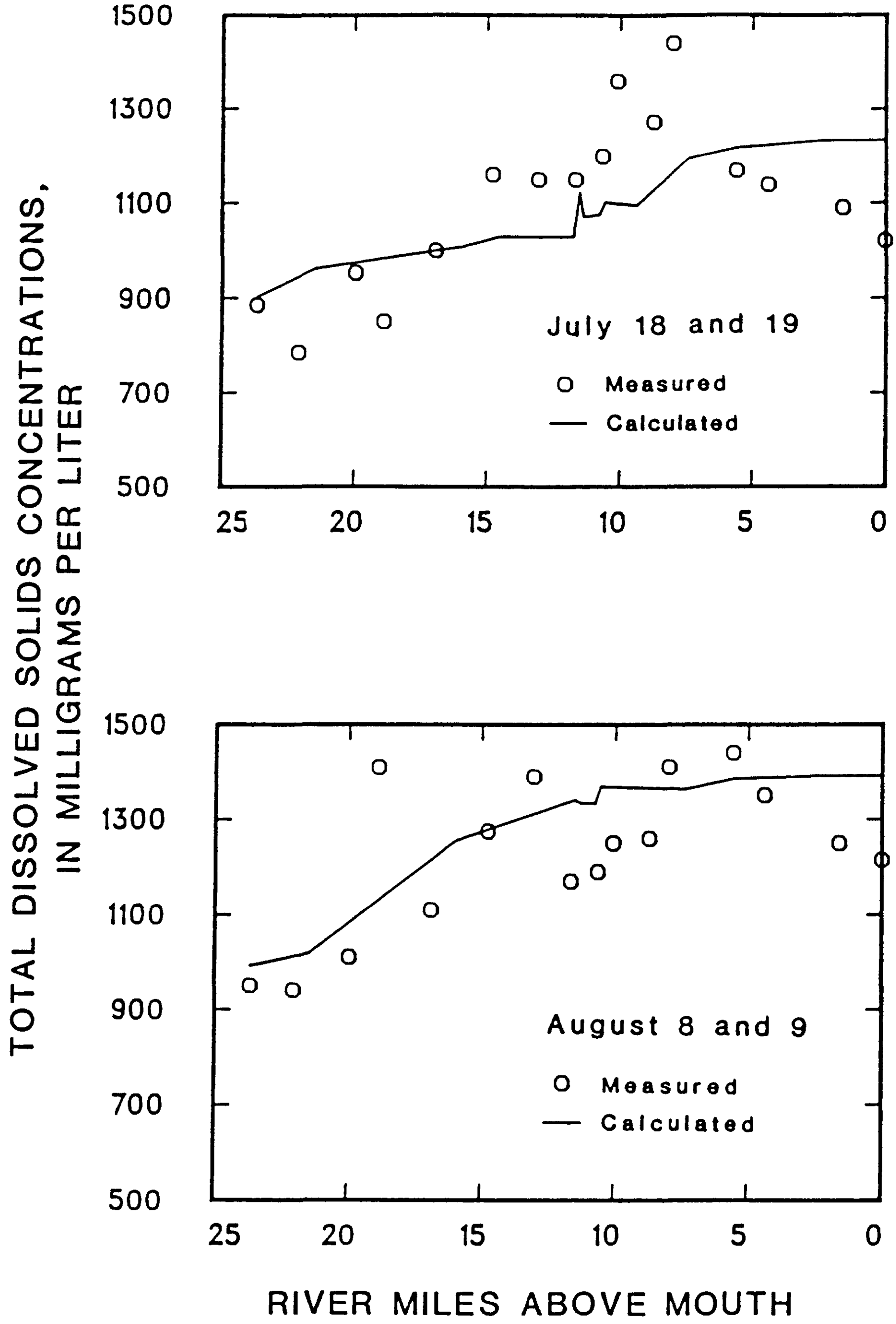


Figure 4.--Profiles of measured and calculated total dissolved-solids concentrations in the East Branch Du Page River for the July and August diel studies.

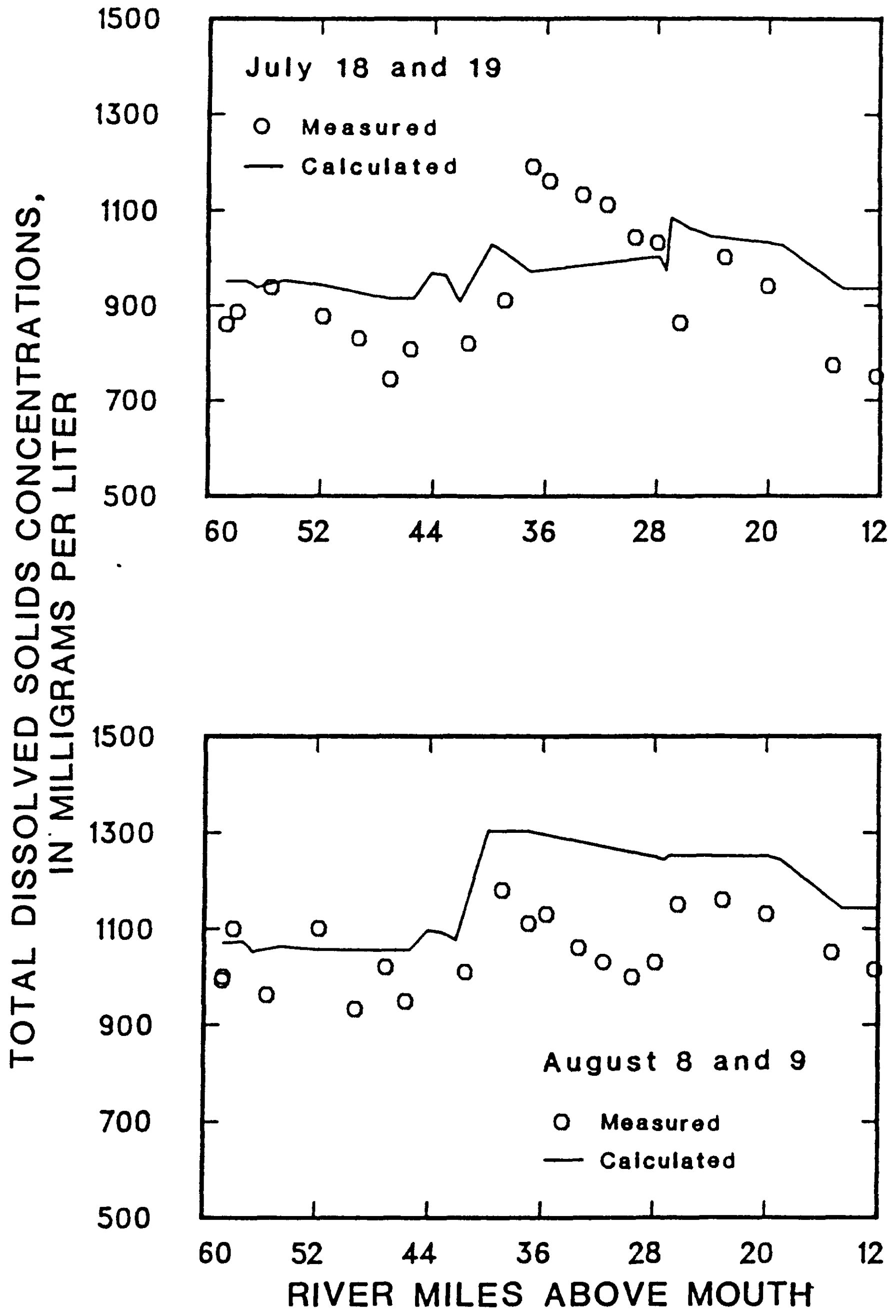


Figure 5.--Profiles of measured and calculated total dissolved-solids concentrations in the West Branch and Main Stem Du Page River for the July and August diel studies.

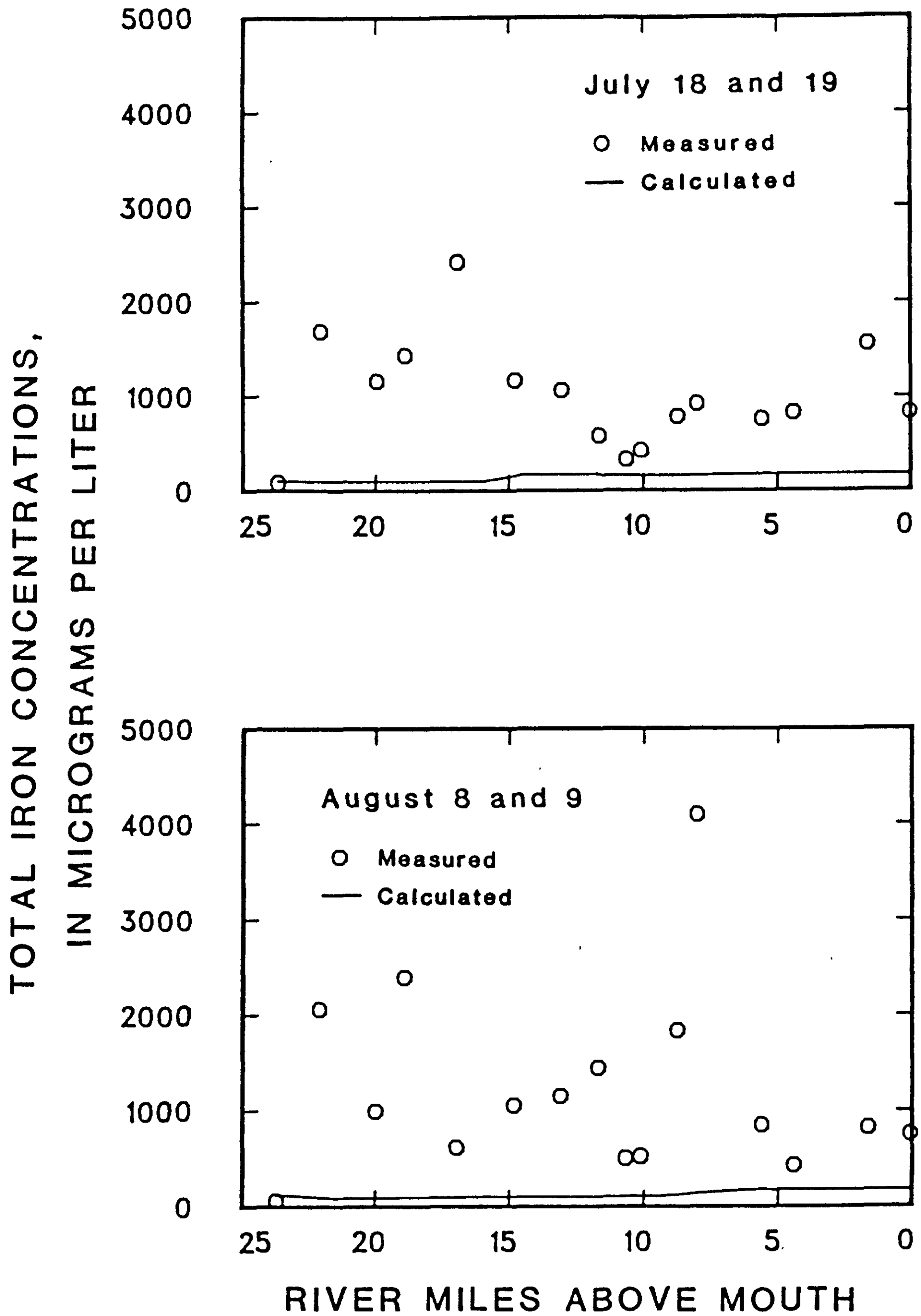


Figure 6.--Profiles of measured and calculated total iron concentrations in the East Branch Du Page River for the July and August diel studies.

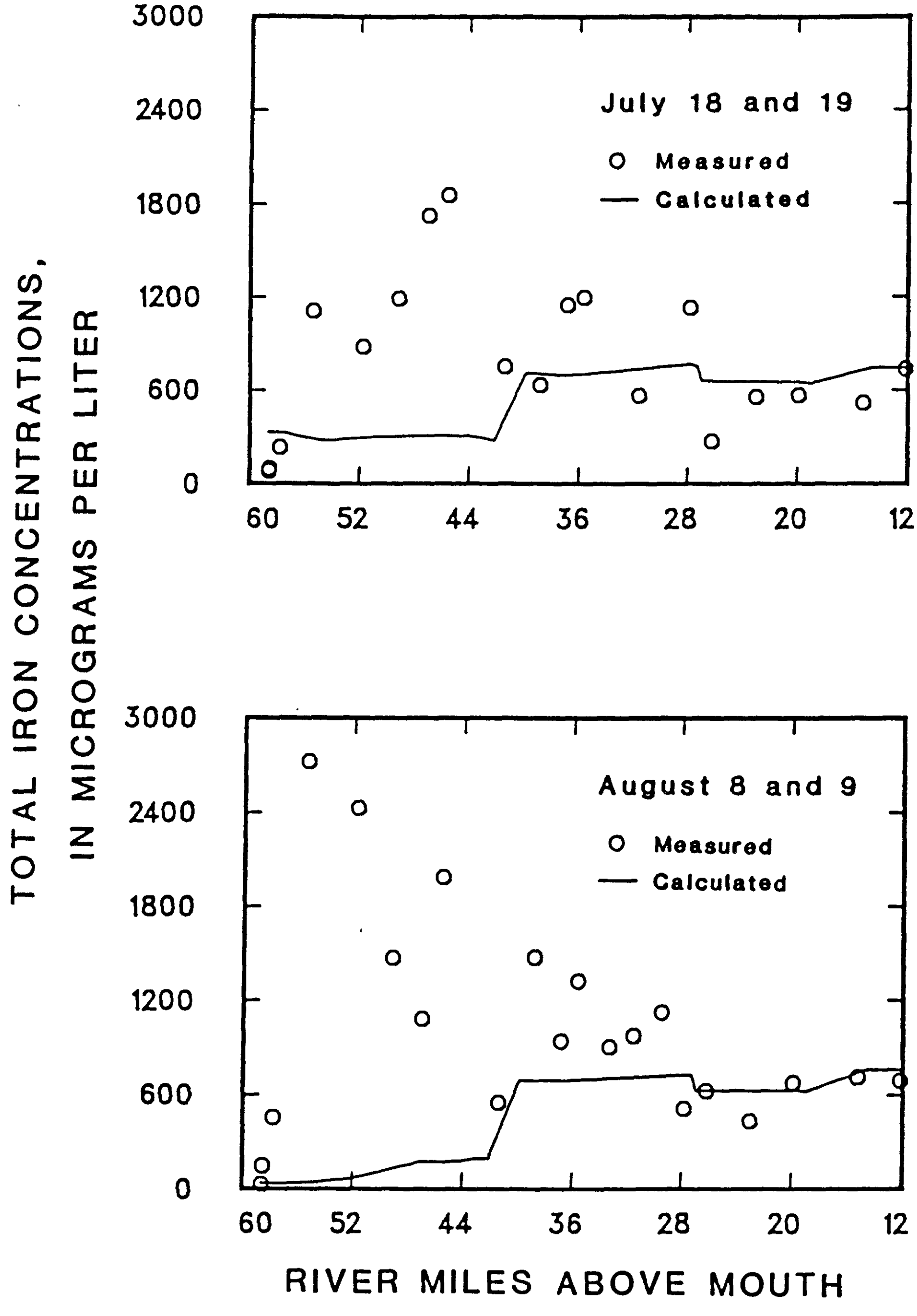


Figure 7.--Profiles of measured and calculated total iron concentrations in the West Branch and Main Stem Du Page River for the July and August diel studies.

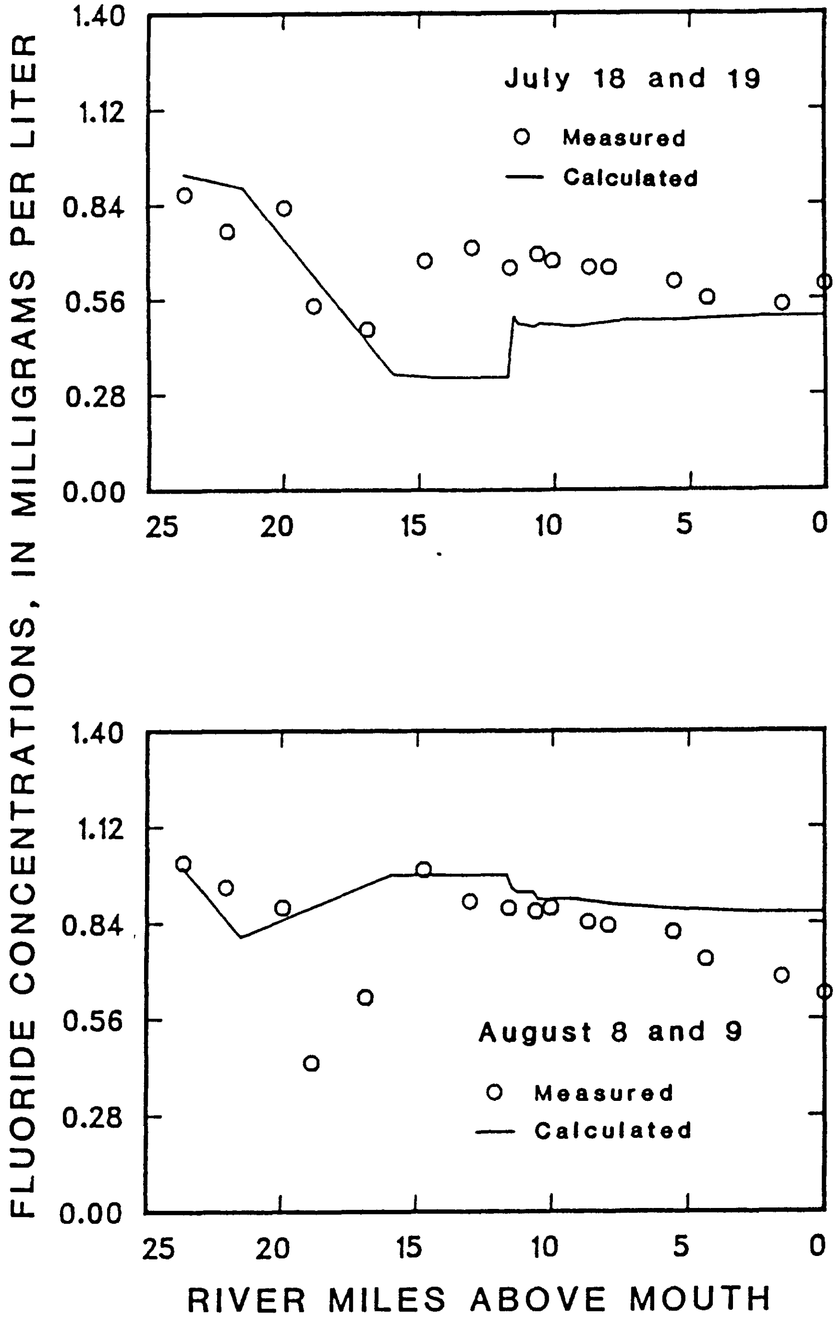


Figure 8.--Profiles of measured and calculated fluoride concentrations in the East Branch Du Page River for the July and August diel studies.

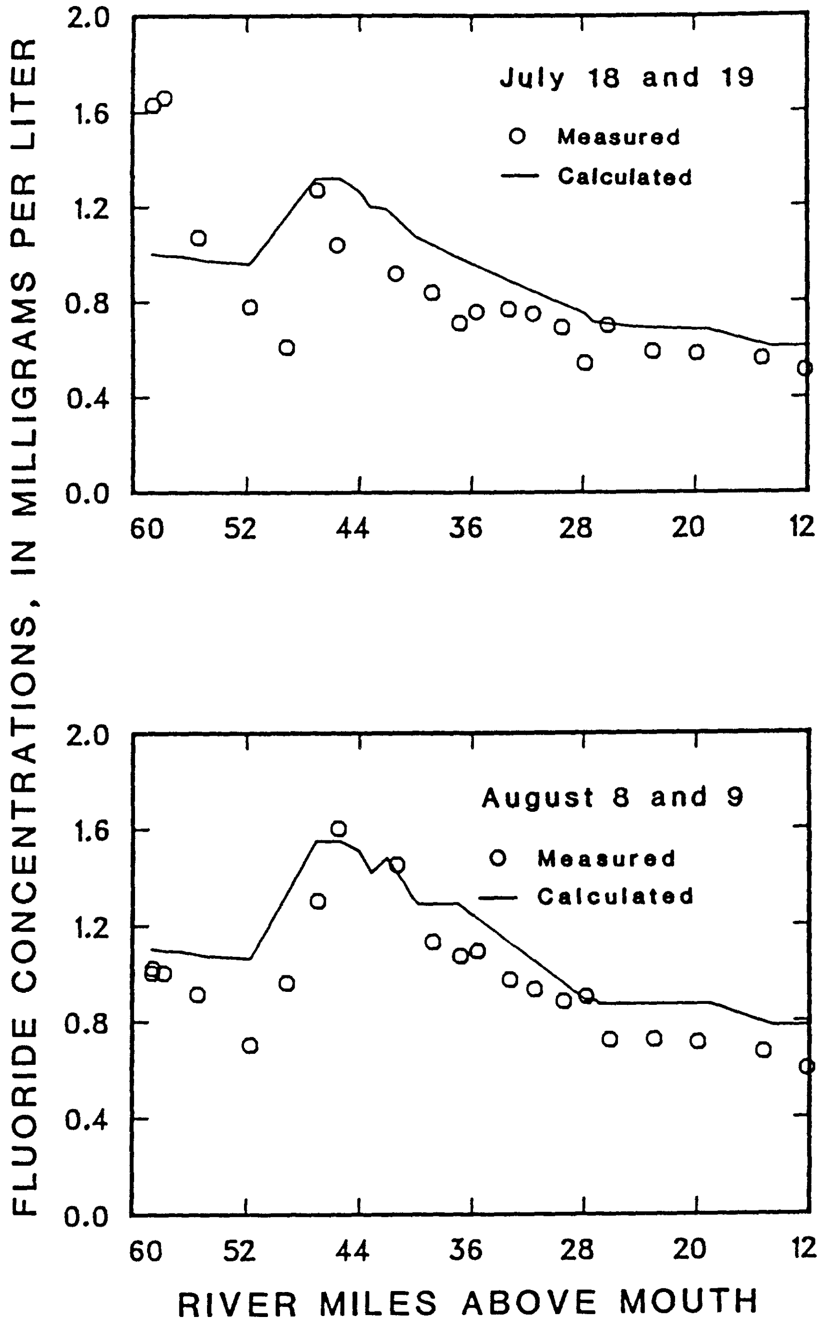


Figure 9.--Profiles of measured and calculated fluoride concentrations in the West Branch and Main Stem Du Page River for the July and August diel studies.

Water-Quality Modeling

The QUAL-II, one-dimensional, steady-state, water-quality model (National Council of the Paper Industry for Air and Stream Improvement, 1982) was used because it is capable of modeling up to 13 water-quality constituents, including algae (modeled as chlorophyll-a). For this study, the QUAL-II model was used to evaluate nine water-quality characteristics: DO, ultimate carbonaceous BOD, SOD, algae as chlorophyll-a, ammonia, nitrite, nitrate, phosphorus, and specific conductance. Figure 10 shows the constituents and their interactions in the QUAL-II model. Water samples were analyzed for nitrite plus nitrate nitrogen to avoid the problem of possible concentration changes due to oxidation during transport to the laboratory. To compensate for this in the model, a high nitrite oxidation rate was used so that nitrite plus nitrate nitrogen was simulated rather than the separate constituents.

The QUAL-II model assumes stream discharge at any point approximates steady-state flow conditions. However, during low-flow periods in the Du Page River, a large part of the streamflow is comprised of wastewater discharges, which vary within a day. Nevertheless, average flow variations during the July and August diel studies were 12 and 8 percent, respectively. This variability was considered small enough to satisfy the QUAL-II model's assumption of steady-state flow.

The QUAL-II model represents the 65.1-mile reach of the river that was modeled as a series of subreaches. These subreaches are referred to as model subreaches in this report. Model subreaches were further subdivided into computational elements which define the shortest river length that the QUAL-II model considers for its calculations. The mathematical basis for QUAL-II is given in the model user's guide (National Council of the Paper Industry for Air and Stream Improvement, 1982).

The 65.1-mile reach of the Du Page River that was modeled was divided into two sections. A schematic of the two sections as they were modeled is shown in figure 11. The West Branch and Main Stem model represents the entire West Branch and the Main Stem Du Page River from Rm 58.7 down to RM 12.1. Thirty model subreaches with 19 point sources (including the East Branch) and one point withdrawal (labeled Golf Course Withdrawal on fig. 11) were specified. The computational element length was specified at 0.2 mile.

The East Branch model represents the East Branch Du Page River from RM 18.9 to RM 0.0. The upper 5.2-mile subreach was not modeled because data were not available to accurately simulate water quality through the reservoir and wetlands area within that subreach. Seventeen model subreaches with 11 point sources were specified. The computational element length was specified at 0.1 mile.

Computing Model Requirements from Field Data

Data from the August diel study were used to calibrate the QUAL-II model because flow conditions were much lower than during the July diel study. Data from the July diel study were used to verify the model by validating the choice of calibration coefficients under different hydrologic and waste-load conditions.

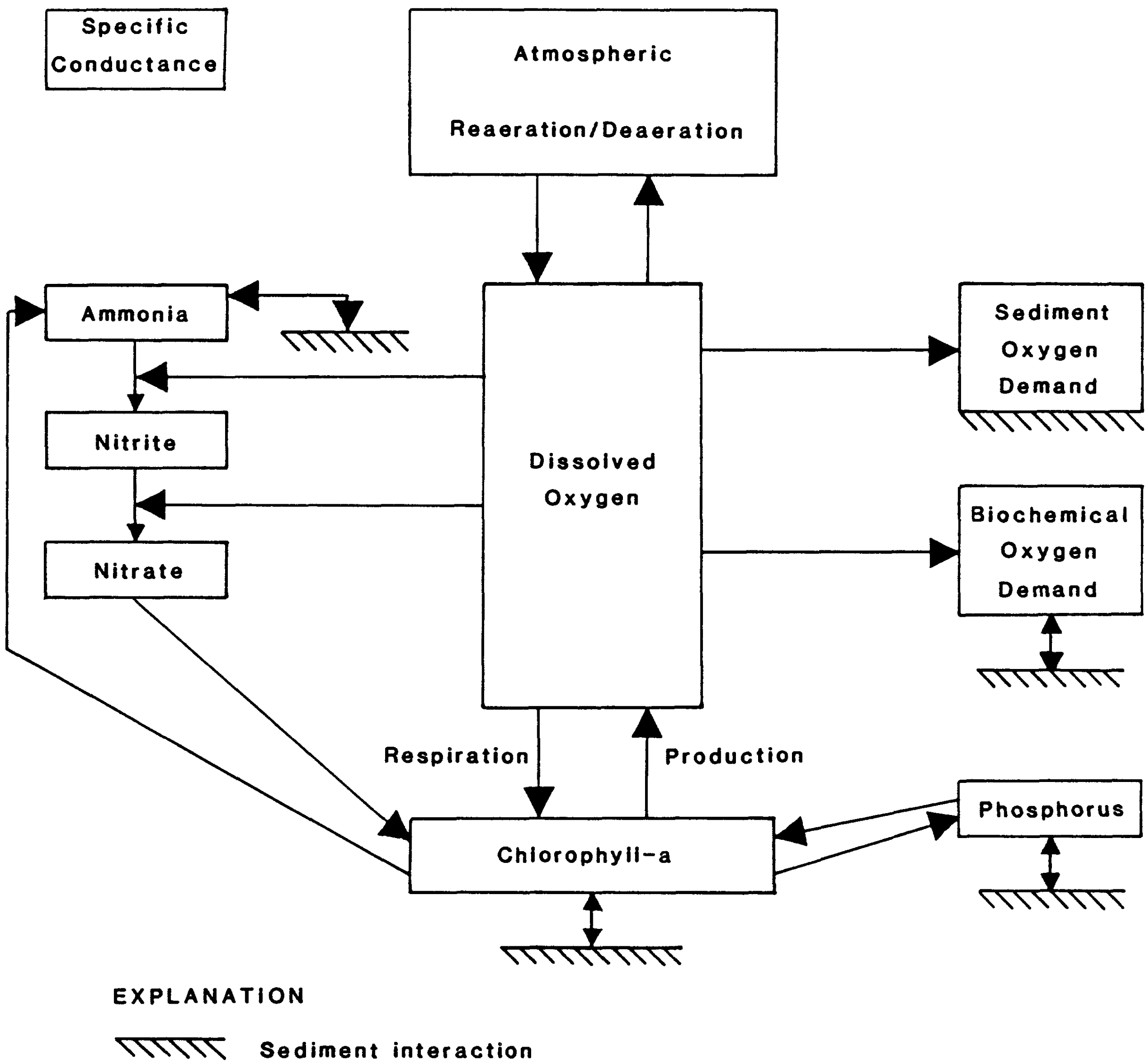


Figure 10.--Constituents and interactions evaluated with the QUAL-II model.

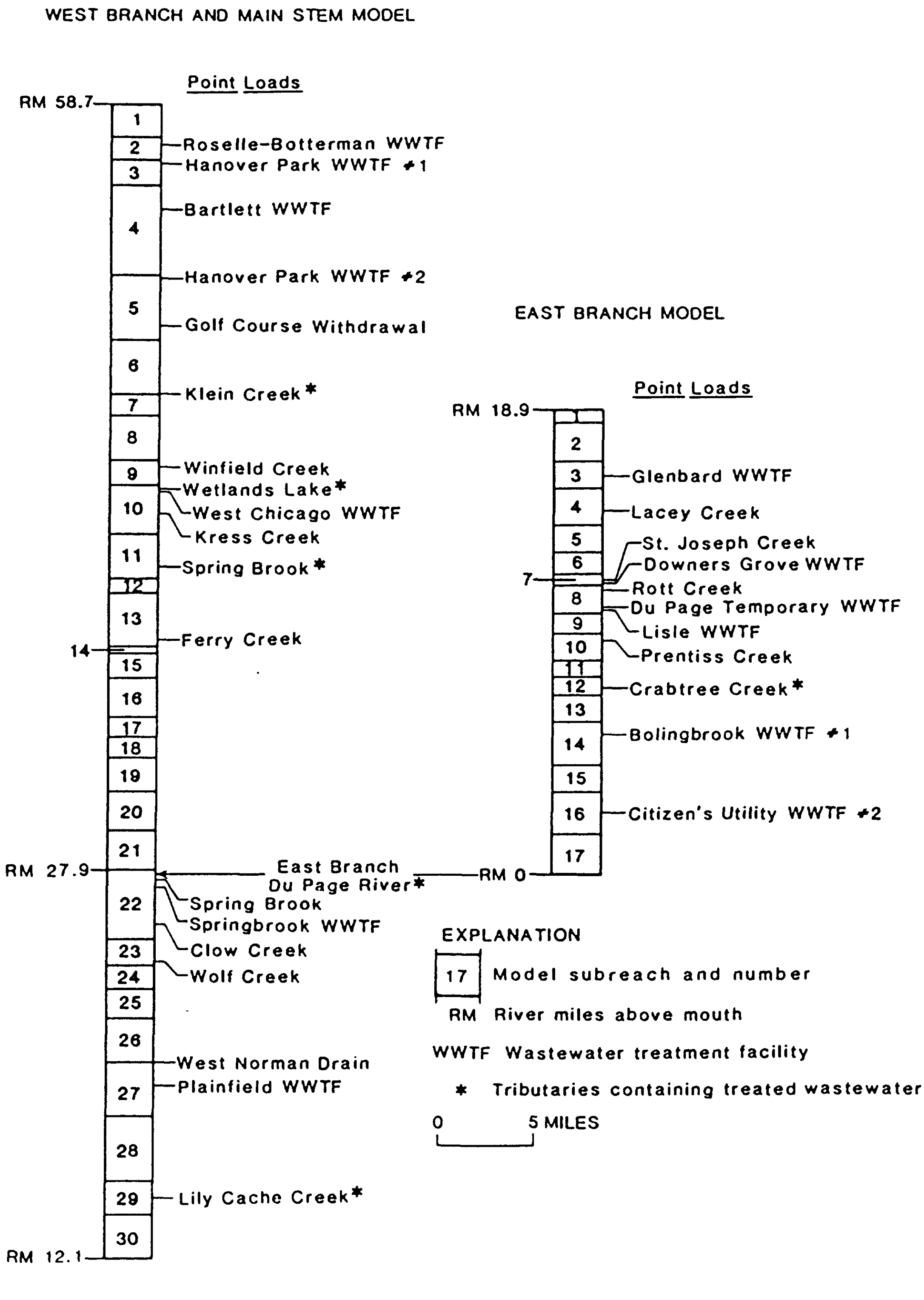


Figure 11.--Modeled river system.

Traveltimes and reaeration-rate coefficients for the two diel periods were determined by using multivariate regression on measurements made at different discharges. Traveltime and reaeration-rate measurements were made for mean daily stream discharges at the Survey gaging station at Shorewood (05540500), ranging from 104 to 411 ft^3/s. These discharges encompass those measured during the July and August diel studies of 229 and 124 ft^3/s, respectively.

Two equations which relate traveltime to flow characteristics were developed to predict traveltimes for the diel-study conditions. The best equation incorporating data from all subreaches of the river was

$$TOT = (61.04) \frac{A^{0.27} L^{0.69}}{Q^{0.55}} \qquad (7)$$

where TOT is the traveltime in the subreach, in seconds;

A is the average cross-sectional area of the subreach, in square feet;

L is the subreach length, in feet; and

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

The multiple correlation coefficient of the equation-estimated traveltimes, when compared with the observed traveltimes, is 0.70. The relation has an associated standard error of either +43.3 or -30.2 percent.

The best equation developed using data from only those reaches which did not contain any inflows, dams, or lakes is

$$TOT = 3{,}325 + 1.67\, L + 65.06\, Q \qquad (8)$$

where all the variables are as defined in equation 7. This equation has an associated multiple correlation coefficient for estimated versus observed traveltimes of 0.76, and a standard error of 3,283 seconds. Traveltime in each river subreach was predicted from these equations.

The reaeration-rate coefficients were measured during periods of flow that were different from those of the diel studies. Several of the subreaches have inflows, lakes, or dams that can affect DO and reaeration without affecting the channel and flow characteristics. Measured reaeration-rate coefficients were used in the model for three model subreaches containing low-head dams. An equation was developed to estimate the reaeration-rate coefficients for the remaining subreaches of the river, based on known discharge and channel characteristics for each subreach. The parameters considered for inclusion in this equation were average discharge, average cross-sectional area, average surface width, channel slope, and reach length. These parameters were selected because they were known for both the traveltime and reaeration-rate studies, as well as the diel studies. A review of the literature shows the parameters are used in many existing reaeration-rate equations. The best equation was developed from data from all but nine of the subreaches measured. The nine subreaches omitted had suspected measurement errors, or physical features such as dams, which could affect the reaeration-rate coefficient. The best fit equation was

$$K_2 = 282.0 \times W^{0.55} S^{0.86} \qquad (9)$$

where K_2 is the reaeration-rate coefficient at 20°C, in reciprocal days;

W is the average surface width, in feet; and

S is the bed slope for the subreach.

To test the validity of equation 9, measured coefficients (K_2) were compared with coefficients estimated by 17 other reaeration-rate coefficient equations (O'Connor and Dobbins, 1958; Churchill and others, 1962 (2 equations); Krenkel and Orlob, 1963; Owens and others, 1964; Langbein and Durum, 1967; Cadwallader and McDonnell, 1969; Thackston and Krenkel, 1969; Velz, 1970; Padden and Gloyna, 1971; Bennett and Rathbun, 1972 (2 equations); Lau, 1972; Parkhurst and Pomeroy, 1972; Tsivoglou and Wallace, 1972; Bansal, 1973; and Tsivoglou and Neal, 1976). The estimated values using the equation developed for the Du Page River (eq. 9) had the best agreement with the measured values, based on a multiple correlation coefficient of 0.70 and a standard error of 64 and 39 percent. Multiple correlation coefficients ranged from 0.39 to 0.60 when the 17 other equations were used to estimate K_2.

Average cross-sectional area, surface width, depth, and discharge for each subreach were determined from an average of the values measured at the two sites that define the subreach boundaries. As discussed previously, the surface width and cross-sectional area were measured at each site, and average depths were calculated from the width and cross-sectional area measurements assuming a rectangular channel.

Coefficients and rate constants used in the model must be defined for each of the model subreaches. The subreaches defined by the sites sampled during the traveltime and reaeration-rate studies did not always correspond to the model subreaches, and it was necessary to adjust some of the data to fit these model subreaches.

Traveltimes corresponding to the flow conditions observed during the diel studies were estimated using equations 7 and 8. Equation 7 was used for those subreaches containing inflows, lakes, and dams, and equation 8 was used for all other subreaches. Reaeration-rate coefficients were estimated using equation 9. The field data and reaeration-rate coefficients were used directly if the model subreach was entirely within a single diel subreach. If not, then the field data often had to be averaged so that the data would correspond to the model subreaches. A weighted average of the diel subreach coefficients was used when a model subreach contained portions of, or more than, one diel subreach. The weights used in calculating these averages were the percent of the model subreach included in each diel subreach.

Calibration, Verification and Sensitivity

The QUAL-II model was used to simulate environmental processes and water quality of the Du Page River. The processes and their interactions (fig. 10) are defined in the model by several rate constants and coefficients. These constants and coefficients were specified to best describe the processes in the Du Page River. Model calibration was accomplished by using calculated and measured values for the coefficients when available, and adjusting the other coefficients within ranges described by Zison and others (1978) and by the QUAL-II user's manual (National Council of the Paper Industry for Air and Stream Improvement, 1982) until the model-simulated constituent concentrations approximated the measured concentrations. The August diel study conditions and data were used to calibrate the model.

The rate constants and coefficients determined from the model calibration were then used in conjunction with the July diel-study conditions and data to validate that choice of coefficients. This model verification showed how well the calibration coefficients defined the processes in the Du Page River by identifying the model's ability to simulate the water quality under different hydrologic and waste-load conditions. Conditions of the July diel study were significantly different from those of the August diel study, thus providing for good model verification. Tables 4 and 5 list several of the rate constants and coefficients used to verify the East Branch and the West Branch and Main Stem models.

The stream discharge measured during both the July and August diel studies very nearly matched that determined by summing the discharge measured from the headwaters and each of the point sources during the respective studies. Because of this, the measured discharge of the headwaters and point sources were used directly in the model. As discussed previously, the East Branch model does not include the upper 5.2 river miles of the East Branch Du Page River. Therefore, the average discharge measured at site 5 was specified as the headwaters in the model.

Some additional inflow to the model-simulated stream discharge was necessary to account for unmeasured point or nonpoint sources. This forced the simulated discharge to match that measured in the river during the respective diel studies. In the East Branch model, a total of 1.12 ft^3/s was equally divided and added to the streamflow over the subreaches from RM 18.9 to RM 14.2 to match the August diel study conditions. This constituted only 5 percent of the flow measured at RM 14.2. For the July diel study conditions, 12.0 ft^3/s was divided equally among the model subreaches from RM 9.8 to the mouth, constituting 18 percent of the total flow. Incremental inflow in the West Branch and Main Stem model for the August diel study conditions was added over two sections of the modeled river; 1.94 ft^3/s was added over the subreaches from RM 58.7 to RM 55.5 and 4.56 ft^3/s was added over the subreaches from RM 36.9 to RM 31.1. These constituted 15 and 12 percent, respectively, of the flow. For the July diel study conditions, a total of 27.72 ft^3/s was added over the model subreaches from RM 58.7 to RM 27.9 constituting 20 percent of the flow.

Table 4.--Selected rates and coefficients for the East Branch model

Model subreach	Length (mile)	Rate of sediment oxygen demand (milligrams per day per foot)	Decay rate of carbonaceous biochemical oxygen demand (reciprocal days)		Source/sink rate for carbonaceous biochemical oxygen demand (reciprocal days	Source/sink rate for ammonia (milligrams nitrogen per day per foot)	Source/sink rate for phosphorus (milligrams phosphorus per day per foot)	Rate of algal settling (foot per day)	Light extinction coefficient (reciprocal feet)
			July	August					
1	0.5	1,500	0.12	0.13	1.96	0	0	0.50	0.10
2	1.5	1,500	.13	.13	.96	0	0	.50	.10
3	1.1	3,000	.12	.12	-.36	0	0	.50	.10
4	1.6	7,209	.10	.11	-.36	0	0	.50	.10
5	1.1	8,500	.10	.11	.00	0	0	.50	.10
6	.9	7,209	.10	.12	.00	0	0	.50	.10
7	.5	7,209	.10	.12	.00	0	0	.50	.10
8	1.1	7,209	.10	.12	.00	0	0	.50	.10
9	.8	7,209	.12	.09	.00	0	0	-6.00	.10
10	1.1	22,000	.12	.10	.00	0	0	-6.00	.90
11	.7	40,000	.12	.10	.00	0	0	-6.00	.90
12	.7	60,000	.11	.10	.00	0	0	-6.00	.50
13	1.1	44,000	.10	.10	.00	0	-2,000	-3.00	.10
14	1.8	43,000	.09	.09	.66	0	-2,000	-2.00	.10
15	1.1	75,000	.13	.10	.96	-1,400	-2,000	-2.20	.10
16	1.7	105,000	.11	.11	.96	-4,000	-2,000	1.00	.10
17	1.6	92,000	.08	.11	.96	-10,000	-2,000	1.00	.10

Table 5.--Selected rates and coefficients for the West Branch and Main Stem model

Model subreach	Length (mile)	Rate of sediment oxygen demand (milligrams per day per foot)	Decay rate of carbonaceous biochemical oxygen demand (reciprocal days) July	Decay rate of carbonaceous biochemical oxygen demand (reciprocal days) August	Source/sink rate for carbonaceous biochemical oxygen demand (reciprocal days	Source/sink rate for ammonia (milligrams nitrogen per day per foot)	Source/sink rate for phosphorus (milligrams phosphorus per day per foot)	Rate of algal settling (foot per day)	Light extinction coefficient (reciprocal feet)
1	1.4	12,000	0.13	0.10	-0.36	50	0	-12.0	.10
2	.8	10,000	.13	.11	- .36	-150	0	-6.0	.10
3	1.0	40,000	.09	.13	- .36	-450	-2,000	.1	.30
4	3.6	30,690	.09	.14	- .36	-650	-750	1.0	.30
5	2.6	40,000	.11	.16	- .36	-950	-500	1.0	.90
6	2.2	45,000	.11	.15	- .36	-950	-500	1.0	.90
7	.8	20,000	.10	.13	- .36	-550	-500	2.5	.90
8	1.8	55,000	.10	.12	- .36	-1,500	-500	2.0	.90
9	1.0	20,000	.11	.14	- .16	-1,500	-1,000	2.0	.90
10	2.0	40,000	.12	.15	- .16	-550	-900	2.0	.40
11	1.8	30,000	.14	.16	- .36	-550	-500	1.5	.40
12	.6	10,000	.16	.16	- .36	-1,500	-500	1.5	.70
13	2.2	18,000	.15	.16	- .36	-1,200	0	1.5	.40
14	.2	20,000	.14	.15	- .36	-1,200	0	.9	.40
15	1.0	20,000	.14	.15	- .36	-1,200	-500	.1	.40
16	1.6	35,000	.13	.15	- .36	-1,200	-1,500	.5	.90
17	.8	10,000	.12	.16	- .36	-1,200	-1,000	2.5	.90
18	.8	10,000	.12	.15	- .36	-1,200	-800	2.5	.80
19	1.4	0	.12	.14	- .36	-1,200	-700	4.5	.35
20	1.6	8,000	.14	.15	- .36	-1,200	-700	.1	.90
21	1.6	0	.14	.14	- .36	-1,200	-700	.1	.90
22	2.8	0	.11	.11	- .36	-8,500	-800	.1	.10
23	1.0	0	.11	.12	- .66	-8,500	-700	.1	.07
24	1.0	0	.10	.13	- .66	-7,500	-600	.1	.10
25	1.2	0	.10	.13	- .46	-5,000	-600	- .1	.10
26	1.8	0	.12	.13	- .56	-3,000	-600	- .1	.15
27	2.2	0	.14	.12	- .66	-450	-600	.5	.25
28	2.6	0	.13	.12	- .96	-450	-600	1.0	.35
29	1.4	0	.12	.12	- .96	-450	-600	1.8	.75
30	1.8	0	.12	.13	- .96	-450	-600	- .5	.90

The water-quality characteristics for these incremental inflows were specified in the model using an average of the water quality measured in all of the tributaries that did not contain treated wastewater. The water-quality characteristics for the headwaters and point sources were specified as an average of the values measured for each. Tables 6, 7, 8, and 9 show lists of the water-quality characteristics for the headwaters, point sources, and incremental inflows used in the East Branch and the West Branch and Main Stem models for both diel studies.

The QUAL-II model determines stream depth and velocity for each model subreach by multiplying the stream discharge by a coefficient for depth and a coefficient for velocity. The velocities determined from subreach length and traveltime and the stream depths determined from cross-sectional area and width measurements were used in the model by choosing coefficients of discharge that forced the model to simulate measured values.

The capability of the model to simulate a conservative constituent is helpful in identifying the accuracy of the model-simulated streamflow and how well the point sources are accounted for. Conservative constituents are not affected by biological decay or most other interactions in the river. Simulation of a conservative constituent will identify incorrect stream discharge in the model by showing too much or too little dilution of the point sources. These inaccuracies would show up as calculated concentrations that are lower or higher than the measured concentrations. A jump in the measured concentration that is not shown by the simulated concentrations can also indicate an unmeasured point or nonpoint source.

Specific conductance is a relatively conservative constituent and was modeled as such for this study. Figures 12 and 13 show profiles of the simulated and measured specific conductance in the East Branch model and the West Branch and Main Stem model, respectively. Simulated specific conductance in the East Branch very closely approximated the measured values; thus, the streamflow and point sources were accurately simulated in the East Branch model. The measured specific conductances at RM 16.9 during the July diel study were higher than those simulated. This was very likely due to an unmeasured point or nonpoint source, but the values were close enough to consider this as being insignificant.

The simulated specific conductance in the West Branch and Main Stem approximated the measured conductances fairly well. The conductance values measured between RM 49.2 and RM 41.4 were consistently higher than the simulated values, and the measured specific conductance values from RM 23.1 to the end of the study reach (RM 12.0) were consistently lower than the simulated values. This could indicate that streamflow was inaccurately simulated. However, the simulated flow almost exactly matches the average measured flow. The variations between measured and simulated conductances could also be attributable to unmeasured point or nonpoint sources. Since the Du Page River system contains so many point sources of highly variable water quality, the difference between simulated and measured specific conductance can be considered of minor significance. Assuming this would indicate that the streamflow and point sources for the West Branch and Main Stem were fairly accurately simulated.

Table 6.--Characteristics and constituent concentrations for the headwaters and point sources in the East Branch model for the July diel-study period

[°C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter]

Point source name	Outfall location (river miles)	Temperature (°C)	Dissolved oxygen (mg/L)	Biochemical oxygen demand (mg/L)	Chlorophyll-a (µg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Phosphorus (mg/L)
Headwaters-- site 5 East Branch at Hill Avenue at Lombard, Ill.	18.5	25.1	7.7	27	140	0.58	0.38	0.17
Incremental Inflow	--	27.4	8.2	9.6	.0	.15	2.4	.13
Glenbard wastewater treatment facility	15.9	21.4	8.2	4.1	.0	.08	7.7	2.6
Lacey Creek	14.6	24.2	10.4	16	40	.13	.52	.05
St. Joseph Creek	11.9	30.4	4.6	7.7	85	.08	.00	.02
Downers Grove waste-water treatment facility	11.8	21.1	8.3	9.1	.0	2.2	3.7	2.3
Rott Creek	11.3	28.8	8.9	19	90	.00	.49	.12
Du Page County temporary wastewater treatment facility	10.7	20.4	9.5	6.4	.0	.10	7.5	2.5
Lisle wastewater treatment facility	10.5	20.1	9.0	45	.0	3.6	5.4	2.2
Prentiss Creek	9.4	28.6	8.5	15	.0	.00	.18	.02
Crabtree Creek	7.4	21.4	3.4	46	65	10	2.7	2.8
Bolingbrook #1 waste-water treatment facility	5.5	21.7	7.2	50	.0	14	.11	2.6
Citizen's Utility #2 wastewater treatment facility	2.4	20.6	7.6	24	.0	2.0	13	2.6

Table 7.--Characteristics and constituent concentrations for the headwaters and point sources in the East Branch model for the August diel-study period

[°C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter]

Point source name	Outfall location (river miles)	Temperature (°C)	Dissolved oxygen (mg/L)	Biochemical oxygen demand (mg/L)	Chlorophyll-a (µg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Phosphorus (mg/L)
Headwaters-- site 5 East Branch at Hill Avenue at Lombard, Ill.	18.5	20.8	5.9	17	83	0.48	0.15	0.19
Incremental Inflow	--	24.3	7.3	6.1	.0	.10	.70	.02
Glenbard wastewater treatment facility	15.9	23.2	8.2	4.4	.0	.32	8.9	4.2
Downers Grove waste-water treatment facility	11.8	22.1	6.3	5.6	.0	2.0	5.1	3.5
Rott Creek	11.3	26.5	10.1	7.6	33	.10	.40	.24
Du Page County temporary wastewater treatment facility	10.7	21.5	8.2	6.1	.0	.18	5.6	1.2
Lisle wastewater treatment facility	10.5	21.2	7.8	45	.0	6.7	3.9	2.7
Prentiss Creek	9.4	24.6	4.9	5.0	9.0	.00	.00	.02
Crabtree Creek	7.4	22.0	5.5	31	40	15.0	.20	3.0
Bolingbrook #1 waste-water treatment facility	5.5	22.1	5.3	110	.0	18.0	.00	2.8
Citizen's Utility #2 wastewater treatment facility	2.4	21.9	6.7	25	.0	.49	17.0	3.3

Table 8.--Characteristics and constituent concentrations for the headwaters and point sources in the West Branch and Main Stem model for the July diel-study period

[°C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter]

Point source name	Outfall location (river miles)	Temperature (°C)	Dissolved oxygen (mg/L)	Biochemical oxygen demand (mg/L)	Chlorophyll-a (µg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Phosphorus (mg/L)
Headwaters-- Metropolitan Sanitary District of Greater Chicago's Hanover Park wastewater treatment facility	58.6	26.5	6.5	5.3	5.1	0.21	11	3.4
Incremental Inflow	--	27.4	8.2	9.6	.0	.15	2.4	.13
Roselle-Botterman wastewater treatment facility	57.3	23.2	7.7	16	.0	6.4	4.5	4.2
Hanover Park #1 wastewater treatment facility	56.6	23.9	7.5	6.2	.0	5.8	4.9	3.9
Bartlett wastewater treatment facility	54.6	21.8	8.7	4.1	.0	.10	15	3.8
Hanover Park #2 wastewater treatment facility	51.7	23.8	7.3	7.0	.0	3.5	3.8	4.8
Klein Creek	47.1	24.7	4.9	14	5.6	3.0	4.4	1.7
Wetlands Lake	44.1	29.8	22.4	77	330	1.2	.24	1.1
West Chicago wastewater treatment facility	43.1	22.6	5.9	21	.0	3.1	2.8	.56
Kress Creek	42.1	25.7	7.5	2.9	9.4	.11	4.8	.12
Spring Brook	39.8	24.0	6.2	6.6	8.3	.76	9.2	1.4
Ferry Creek	37.0	27.3	10.2	7.5	15	.00	.96	.09

Table 8.--Characteristics and constituent concentrations for the headwaters and point sources in the West Branch and Main Stem model for the July diel-study period--Continued

Point source name	Outfall location (river miles)	Temperature (°C)	Dissolved oxygen (mg/L)	Biochemical oxygen demand (mg/L)	Chlorophyll-a (μg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Phosphorus (mg/L)
East Branch Du Page River	27.8	25.3	3.2	16	24	.99	3.8	.93
Spring Brook	27.3	26.8	6.5	3.6	16	.00	4.6	.06
Naperville Spring-brook wastewater treatment facility	27.0	18.7	9.4	3.7	.0	.13	7.5	1.6
Clow Creek	25.5	26.7	5.8	6.3	18	.00	2.8	.05
Wolf Creek	23.7	26.8	6.6	5.2	15	.00	5.6	.27
West Norman Drain	19.9	27.0	5.8	5.3	7.3	.00	10	.02
Plainfield waste-water treatment facility	19.0	23.6	11.2	19	.0	2.0	.66	.82
Lily Cache Creek	14.6	25.8	7.2	5.6	16	.00	3.6	.08

Table 9.--Characteristics and constituent concentrations for the headwaters and point sources in the West Branch and Main Stem model for the August diel-study period

[°C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter]

Point source name	Outfall location (river miles)	Temperature (°C)	Dissolved oxygen (mg/L)	Biochemical oxygen demand (mg/L)	Chlorophyll-a (µg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Phosphorus (mg/L)
Headwaters-- Metropolitan Sanitary District of Greater Chicago's Hanover Park wastewater treatment facility	58.6	22.7	8.0	4.8	50	0.11	14	4.2
Incremental Inflow	--	24.3	7.3	6.1	.0	.00	.70	.02
Roselle-Botterman wastewater treatment facility	57.3	22.7	7.7	11	.0	5.3	9.8	4.7
Hanover Park #1 wastewater treatment facility	56.6	23.8	7.6	11	.0	5.4	5.3	3.9
Bartlett wastewater treatment facility	54.6	21.6	8.4	3.9	.0	.08	19	3.8
Hanover Park #2 wastewater treatment facility	51.7	22.9	7.2	4.4	.0	.14	13	4.6
Klein Creek	47.1	24.2	5.2	7.0	.7	.34	15	2.9
Wetlands Lake	44.1	28.9	6.6	78	134	1.4	.15	1.1
West Chicago wastewater treatment facility	43.1	22.2	6.2	21	.0	4.8	1.5	1.5
Kress Creek	42.1	23.8	9.0	11	10	.00	.80	.28
Spring Brook	39.8	23.0	6.5	5.2	7.2	.18	10	2.1
Ferry Creek	37.0	23.9	6.1	5.5	1.4	.00	.52	.08

Table 9.--Characteristics and constituent concentrations for the headwaters and point sources in the West Branch and Main Stem model for the August diel-study period--Continued

Point source name	Outfall location (river miles)	Temperature (°C)	Dissolved oxygen (mg/L)	Biochemical oxygen demand (mg/L)	Chlorophyll-a (µg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Phosphorus (mg/L)
East Branch Du Page River	27.8	25.1	3.0	8.8	.9	2.0	4.4	1.8
Spring Brook	27.3	24.3	7.3	6.1	1.4	.00	.70	.01
Naperville Spring-brook wastewater treatment facility	27.0	20.3	7.5	4.6	.0	.07	8.6	2.8
Clow Creek	25.5	24.7	5.6	3.4	.6	.15	.30	.04
West Norman Drain	19.9	23.6	6.4	6.8	7.6	.00	.76	.04
Plainfield waste-water treatment facility	19.0	25.5	12.8	27	.0	.84	2.8	1.4
Lily Cache Creek	14.6	26.0	7.6	6.0	5.0	.00	2.0	.07

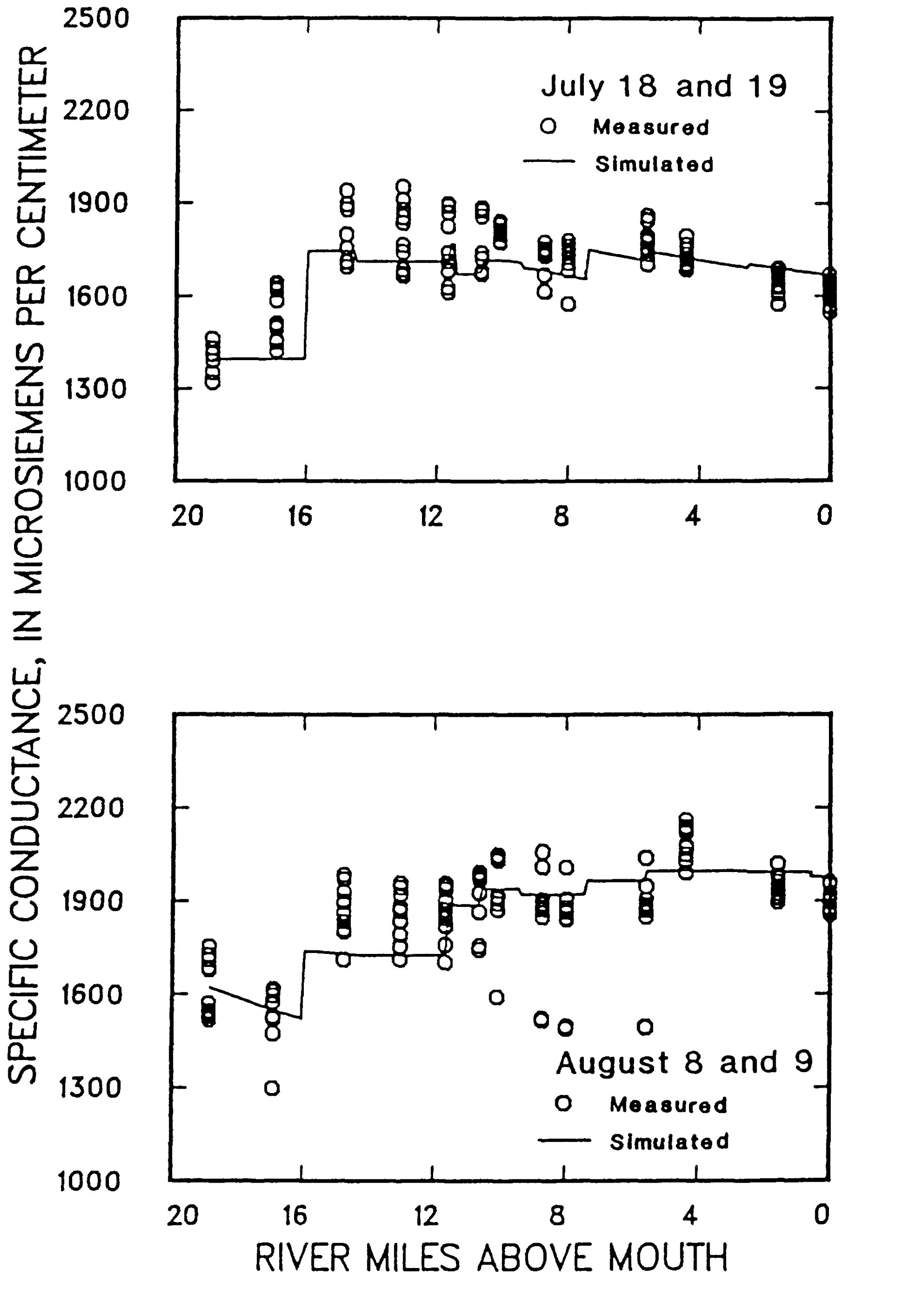


Figure 12.--Profiles of simulated and measured specific conductance in the East Branch Du Page River for the July and August diel studies.

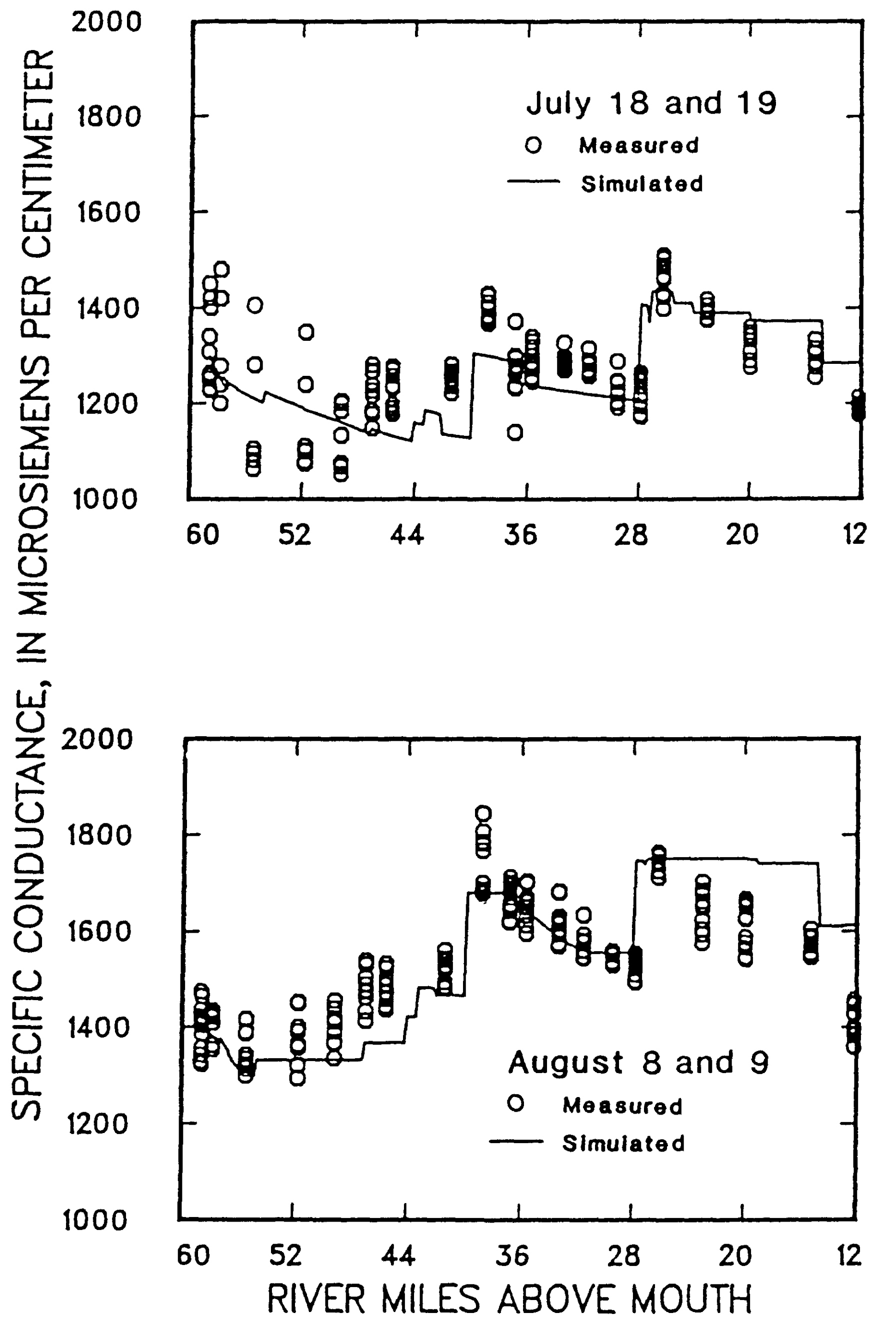


Figure 13.--Profiles of simulated and measured specific conductance in the West Branch and Main Stem Du Page River for the July and August diel studies.

Ultimate carbonaceous BOD was calibrated by varying the settling/scour rate coefficient (a negative rate indicates scour) that caused the model to simulate concentrations of carbonaceous BOD within the ranges measured during the August diel study (figs. 14 and 15). The BOD settling/scour rate coefficients for the East Branch model ranged from -0.36 to 1.96 reciprocal days. These rate coefficients for the East Branch model were validated by the carbonaceous BOD concentrations simulated using the July diel study conditions. The BOD settling/scour rate coefficients for the West Branch and Main Stem model ranged from -0.96 to -0.16 reciprocal days. The results of the model verification using the July diel conditions indicated that the coefficients were fairly well validated from the headwaters down to RM 38.8 but that the coefficients were not valid from RM 38.8 to the end of the study reach (RM 12.0). One possible factor for the inaccuracy is that the river contained more algae (as chlorophyll-a) during the August study. During the BOD analysis, samples were incubated in the dark. Algae will die during these prolonged periods of darkness and the dead algae can contribute significantly to the BOD. It is possible that the measured BOD values, especially in August, were artifically high because of this effect. By calibrating to the artificially high BOD concentrations in August, the model overestimated the BOD in July, when algal concentrations were lower. Simulations were done to determine how sensitive the model was to BOD using a +/-20 percent change in headwaters and point source ultimate carbonaceous BOD concentrations. DO, the constituent of primary interest, showed a maximum change of 0.09 mg/L for both the East Branch and the West Branch and Main Stem models. The results indicated that the model was very insensitive to changes in BOD.

Large diel fluctuations in DO suggest that photosynthesis and respiration were important factors in the water quality of the Du Page River, especially in the West Branch and Main Stem during the August diel study. A limitation of the QUAL-II model is that it simulates only the phytoplankton or free-floating portion of the photosynthetic organisms (simulated as chlorophyll-a). The Du Page River had large populations of macrophytes and periphyton in addition to the phytoplankton population. All of these plants had an effect on the DO and nutrient (nitrite plus nitrate nitrogen and phosphorus) concentrations of the river. Accurate simulation of the water quality of the Du Page River required that the effects of these plants were accounted for. Measurements of the plants or their effects were not made, but the effects of the plants were modeled within the constraints of the model. This was done with available data by adjusting some of the coefficients governing algal concentration in the model. Algal concentrations were adjusted to calibrate the simulated with the measured nitrite- plus nitrate-nitrogen concentrations. The nitrite- plus nitrate-nitrogen concentrations are affected by the oxidation rates of ammonia to nitrite, and nitrite to nitrate, as well as by algal growth (fig. 10).

Due to the fact that the model was calibrated for the plant community by using nitrite- plus nitrate-nitrogen concentrations, this calibration depended somewhat on the oxidation rates of ammonia and nitrite. Sensitivity analyses were performed on these oxidation rates by comparing simulations that used the extremes of the ranges suggested by Zison and others (1978). Results of these and other model sensitivity analyses are summarized in tables 10 and 11. The suggested range for the oxidation rate of ammonia is 0.1 to 0.5 reciprocal days, and the sensitivity results with this range showed a maximum change in

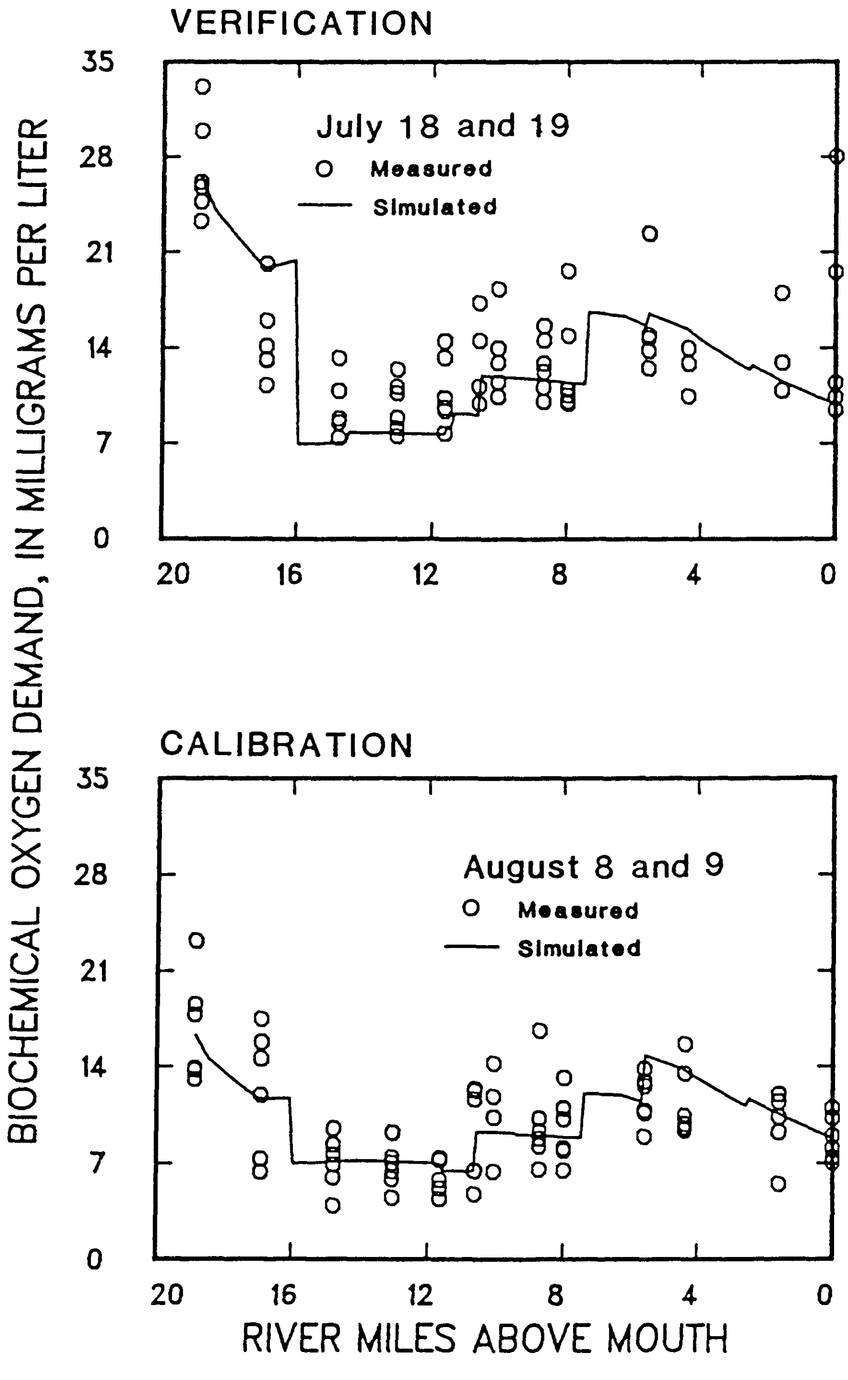


Figure 14.--Profiles of simulated and measured ultimate carbonaceous biochemical oxygen demand in the East Branch Du Page River for the July and August diel studies.

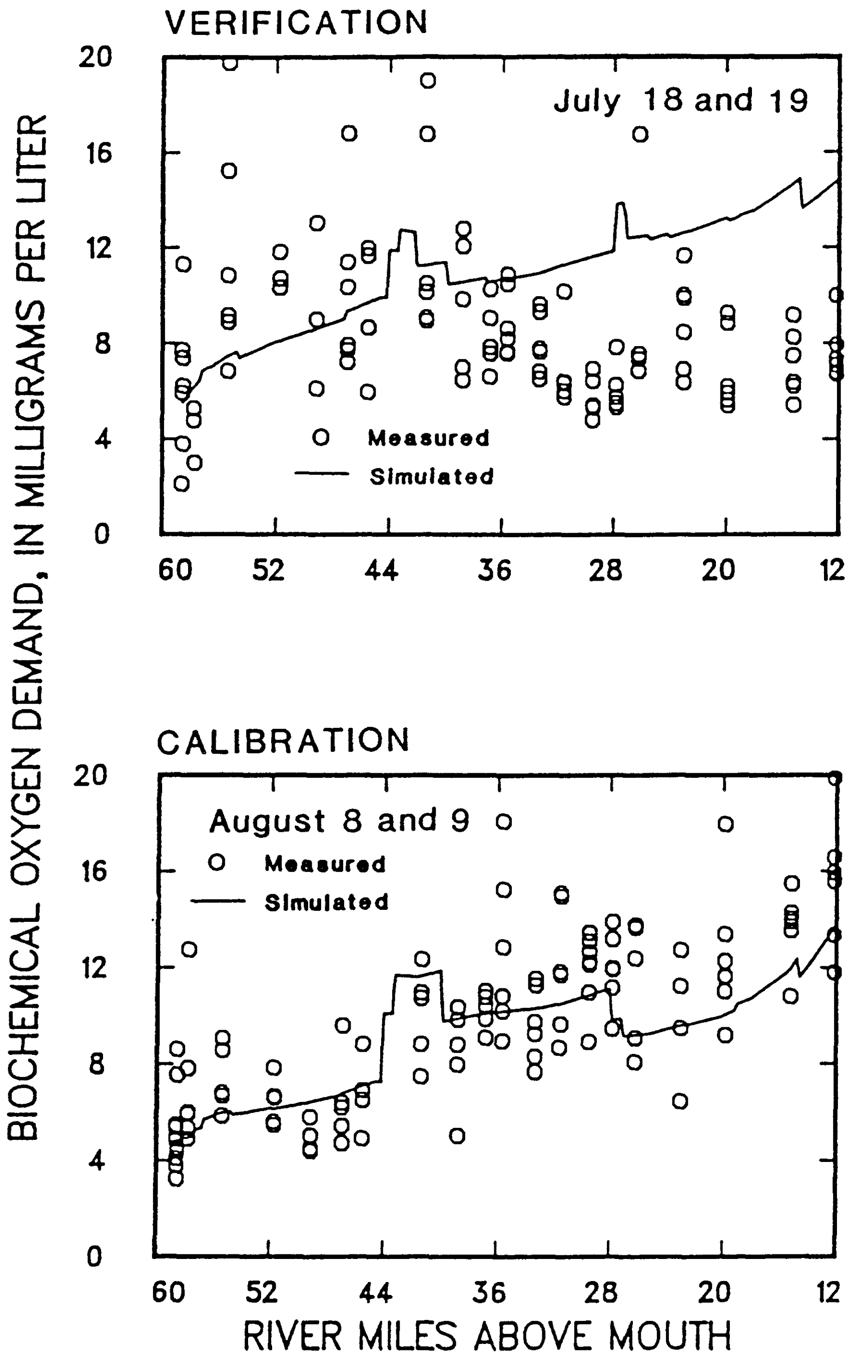


Figure 15.--Profiles of simulated and measured ultimate carbonaceous biochemical oxygen demand in the West Branch and Main Stem Du Page River for the July and August diel studies.

Table 10.--Sensitivity analyses showing maximum changes in constituent concentrations in the East Branch model from simulations using ranges in values of model coefficients

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Change in coefficients	Dissolved oxygen (mg/L)	Chlorophyll-a (µg/L)	Nitrite plus nitrate nitrogen (mg/L)	Ammonia nitrogen (mg/L)	Phosphorus (mg/L)
Reaeration-rate coefficients decreased 39 percent from the calculated values.	2.76	0.00	0.00	0.00	0.00
increased 64 percent from the calculated values.	2.23	.00	.00	.00	.00
Traveltimes decreased 30.2 percent or 3,283 seconds from the calculated values. *	21.04	719.01	4.33	1.06	.57
increased 43.3 percent or 3,283 seconds from the calculated values. *	3.38	512.40	.83	.11	.14
Ammonia oxidation rate range from 0.1 to 0.5 reciprocal days.	1.54	24.60	.95	1.06	.01
Nitrite oxidation rate range from 0.2 to 10 reciprocal days.	.19	19.62	.73	.01	.01
Chloraphyll-a to algae ratio range from 50 to 100 micrograms chlorophyll-a per milligram algae.	3.38	13.51	.68	.16	.09
Nitrogen content of algae range from 0.08 to 0.09 milligram nitrogen per milligram algae.	.06	2.95	.15	.04	.01
Phosphorus content of algae range from 0.012 to 0.015 milligram phosphorus per milligram algae.	.01	.24	.01	.01	.04
Oxygen production and uptake per unit of algae photosynthesis and respiration range from uptake of 1.6 and production of 1.8 to an uptake of 2.3 and production of 1.4 milligrams oxygen.	4.28	.00	.00	.00	.00

* Model subreaches without dams, lakes, or inflows were changed by +/-3,283 seconds.

Table 11.--Sensitivity analyses showing maximum changes in constituent concentrations in the West Branch and Main Stem model from simulations using ranges in values of model coefficients

[milligrams per liter; µg/L, micrograms per liter]

Change in coefficients	Dissolved oxygen (mg/L)	Chlorophyll-a (µg/L)	Nitrite plus nitrate nitrogen (mg/L)	Ammonia nitrogen (mg/L)	Phosphorus (mg/L)
Reaeration-rate coefficients decreased 39 percent from the calculated values.	1.78	0.00	0.00	0.00	0.00
increased 64 percent from the calculated values.	1.40	.00	.00	.00	.00
Traveltimes decreased 30.2 percent or 3283 seconds from the calculated values. *	22.88	853.20	8.41	2.02	1.10
increased 43.3 percent or 3283 seconds from the calculated values. *	8.85	660.20	3.46	.61	.45
Ammonia oxidation rate range from 0.1 to 0.5 reciprocal days.	.22	9.22	.21	.24	.01
Nitrite oxidation rate range from 0.2 to 10 reciprocal days.	.04	4.73	.15	.01	.01
Chloraphyll-a to algae ratio range from 50 to 100 micrograms chlorophyll-a per milligram algae.	5.74	986.40	2.33	.41	.30
Nitrogen content of algae range from 0.08 to 0.09 milligram nitrogen per milligram algae.	.00	.00	.00	.00	.00
Phosphorus content of algae range from 0.012 to 0.015 milligram phosphorus per milligram algae.	.10	13.73	.04	.01	.13
Oxygen production and uptake per unit of algae photosynthesis and respiration range from uptake of 1.6 and production of 1.8 to an uptake of 2.3 and production of 1.4 milligrams oxygen.	6.32	.00	.00	.00	.00

* Model subreaches without dams, lakes, or inflows were changed by +/-3,283 seconds.

nitrite plus nitrate nitrogen of 0.95 mg/L for the East Branch model and 0.21 mg/L for the West Branch and Main Stem model. The results of this sensitivity analysis also showed a maximum change in DO of 1.54 mg/L for the East Branch and 0.22 mg/L for the West Branch and Main Stem models. The results indicated that the West Branch and Main Stem model was very insensitive to changes in the ammonia oxidation rate, due to the fact that ammonia concentrations in the West Branch and Main Stem were very low. The East Branch model was much more sensitive to changes in this rate because of the higher ammonia concentrations that were present. Because measurements of the ammonia oxidation rate were not made, and the East Branch model was somewhat sensitive to this rate constant, the oxidation rate of ammonia to nitrite was specified as 0.3 reciprocal day, the median of the range suggested by Zison and others (1978).

Sensitivity analyses were also performed for the oxidation rate of nitrite to nitrate using the extremes of the range (0.2 to 10 reciprocal days) suggested by Zison and others (1978). These results showed a maximum change in nitrate nitrogen of 0.73 mg/L for the East Branch model and 0.15 mg/L for the West Branch and Main Stem model. The effect of changes in the nitrite oxidation rate on DO was negligible. These results indicate that the model was insensitive to changes in this rate constant. The nitrite-oxidation rate was specified as 10.0 reciprocal days because nitrite-oxidation rates are typically high and nitrite-nitrogen concentrations are typically low (Zison and others, 1978). The model, with a nitrite-oxidation rate of 10.0 reciprocal days, essentially simulated nitrite plus nitrate nitrogen, and the model results could be compared with the measured concentrations of nitrite plus nitrate nitrogen.

Assuming these oxidation rates were accurate, the next phase in calibrating the model for the plant community was to specify the coefficients that govern algal growth rates and concentrations. The QUAL-II model simulates algal activity using the following equations (National Council of the Paper Industry for Air and Stream Improvement, 1982):

$$Chla = \alpha_o A \qquad (10)$$

where Chla is the chlorophyll-a concentration, in micrograms per liter;

α_o is the ratio of chlorophyll-a, in micrograms, to algal biomass, in milligrams; and

A is the algal biomass concentration, in milligrams per liter.

$$\frac{dA}{dt} = \mu A - \rho A - \frac{\sigma_1}{H} A \qquad (11)$$

where t is time, in days;

μ is the local algal specific growth rate, in reciprocal days;

ρ is the local algal respiration rate, in reciprocal days;

σ_1 is the local algal settling rate, in feet per day; and

H is the average depth, in feet.

$$\mu = \mu \max \frac{N_3}{N_3 + K_n} \frac{P}{P + K_p} \frac{1}{\lambda H} \ln \frac{K_L + L'}{K_L + L'e} - \lambda H \qquad (12)$$

where μ max is the maximum algal specific growth rate, in reciprocal days;

N_3 is the local concentration of nitrate nitrogen, in milligrams per liter;

P is the local concentration of phosphorus, in milligrams per liter;

K_n and K_p are empirical half saturation constants for nitrogen (n) and phosphorus (p), in milligrams per liter;

λ is the light extinction coefficient, in reciprocal feet;

L' is the local intensity of light, in langleys per minute; and

K_L is the empirical half saturation constant for light, in langleys per minute.

The ratio of chlorophyll-a to algal biomass (α_0) is important in determining the contribution of algae from the measured point sources. The suggested range for this ratio is 50 to 100 micrograms per milligram (National Council of the Paper Industry for Air and Stream Improvement, 1982). Model simulations using the extremes of this range showed significant changes in all the modeled constituent concentrations. Attempts were made to measure this ratio, but the reliability of these measurements is questionable because of interferences from suspended sediments and zooplankton. The measurements indicated ratios were in the range of 2 to 10 micrograms of chlorophyll-a per milligram of biomass. The ratio used in the model was specified at 50 micrograms per milligram, which is about the median between the maximum suggested value and the measured values, yet still within the suggested range. No attempt was made to calibrate the model to approximate the measured chlorophyll-a concentrations; rather, the model was calibrated to represent the entire plant community in the Du Page River. In doing so, simulated chlorophyll-a concentrations were often higher than the concentrations measured for only the phytoplankton portion of the community.

Plants utilize nitrogen and phosphorus as nutrients for growth and release these nutrients upon death through decomposition. Figure 10 indicates these interactions as they were modeled with the QUAL-II model. The nitrogen content of algae can range from 0.08 to 0.09 milligrams (mg) nitrogen per milligram algae. The range for the phosphorus content of algae is 0.012 to 0.015 mg phosphorus per milligram algae (National Council of the Paper Industry for Air and Stream Improvement, 1982). Simulations using the extremes of these ranges showed that the model was insensitive to these coefficients. Subsequently, the coefficients were specified as 0.09 mg nitrogen per milligram algae and 0.015 mg phosphorus per milligram algae. The emperical half-saturation constants for nitrogen, phosphorus, and light (K_n, K_p, and K_L) were specified as 0.3 mg/L, 0.04 mg/L, and 0.03 langleys per minute, respectively, which were the medians of the suggested ranges (National Council of the Paper Industry for Air and Stream Improvement, 1982).

Algal respiration rates (ρ) can range from 0.05 to 0.50 reciprocal day (National Council of the Paper Industry for Air and Stream Improvement, 1982), and algal maximum specific growth rates (μ max) can range from 0.2 to 8.0 reciprocal days (Zison and others, 1978). A limitation of the QUAL-II model is that these rates are specified for the entire model rather than the model subreaches and thus cannot be varied relative to the varieties of plants present in each subreach. The algal respiration rate was specified as 0.5 reciprocal day for both the East Branch model and the West Branch and Main Stem model. The algal maximum specific growth rate was specified as 4.5 reciprocal days for the East Branch model and as 5.0 reciprocal days for the West Branch and Main Stem model. These values were chosen from preliminary model simulations of DO and nutrient concentrations. The values were maintained throughout the remaining model calibration.

Zison and others (1978) describe algal settling rates as being highly variable, and they suggest that the rate coefficients (σ_1) can range from negative values, indicating a source of algae, to a maximum of about 6.6 feet per day (ft/d), indicating algal sink or loss. The algal settling-rate coefficients were specified for each model subreach and used as the primary means of calibrating the model to simulate the plant communities in the Du Page River. The specified algal settling rate coefficients ranged from -6.0 to 1.0 ft/d for the East Branch model and from -12.0 to 4.5 ft/d for the West Branch and Main Stem model.

The light extinction coefficient (λ) can range from 0.03 reciprocal foot in very clear water, to 0.9 reciprocal foot in very turbid water (Zison and others, 1978). Values were specified for each model subreach and ranged from 0.10 to 0.90 reciprocal foot in the East Branch model and from 0.07 to 0.90 reciprocal foot in the West Branch and Main Stem model. The light extinction coefficients were chosen in conjunction with the algal settling rate coefficients to best account for the growth rates and algal concentrations needed to simulate the plant communities. These coefficients were varied until the model-simulated nitrite- plus nitrate-nitrogen concentrations approximated the concentrations measured during the August diel study.

Figures 16 and 17 show profiles of the simulated and measured nitrite- plus nitrate-nitrogen concentrations in the East Branch model and the West Branch and Main Stem model, respectively. As discussed previously, the nitrite- plus nitrate-nitrogen concentrations were used as an indicator of how well the model accounts for the plant community in the river. The results of the simulations with the July diel-study data and conditions indicate that the coefficients chosen in calibrating the model to the August diel conditions were valid since the model accurately simulated nitrite- plus nitrate-nitrogen concentrations in the Du Page River under differing hydrologic and waste-loading conditions. Because nitrite plus nitrate concentrations are primarily affected by algal growth, the verification also indicates that the plant community is accurately simulated.

Ammonia-nitrogen and phosphorus concentrations were calibrated by adjusting their respective source/sink rates until the simulated concentrations approximated the concentrations measured in August (a negative rate indicates a sink). The source/sink coefficients used in the models (tables 4 and 5) are fairly well validated by the July simulations (figs. 18, 19, 20, and 21).

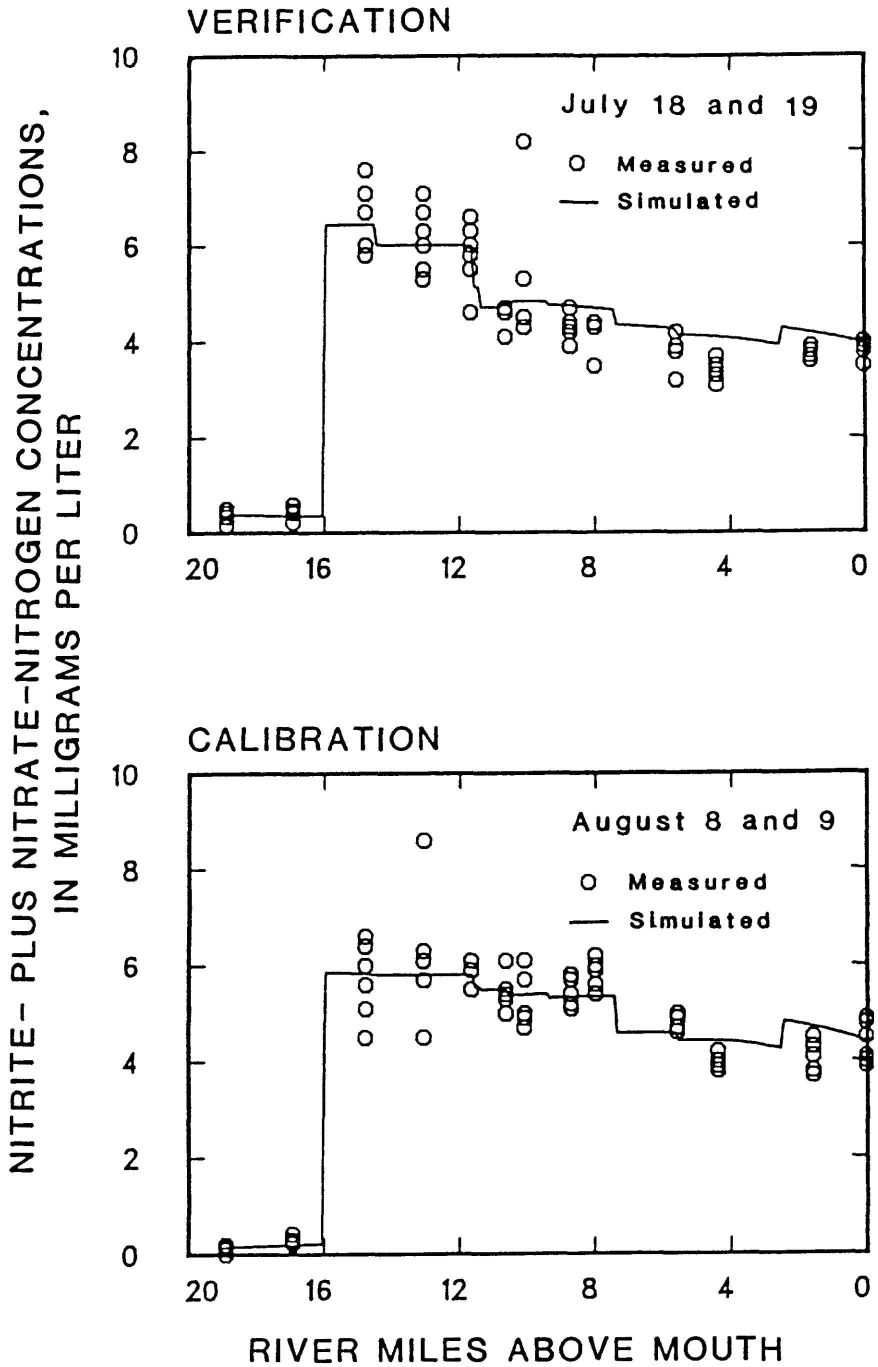


Figure 16.--Profiles of simulated and measured nitrite- plus nitrate-nitrogen concentrations in the East Branch Du Page River for the July and August diel studies.

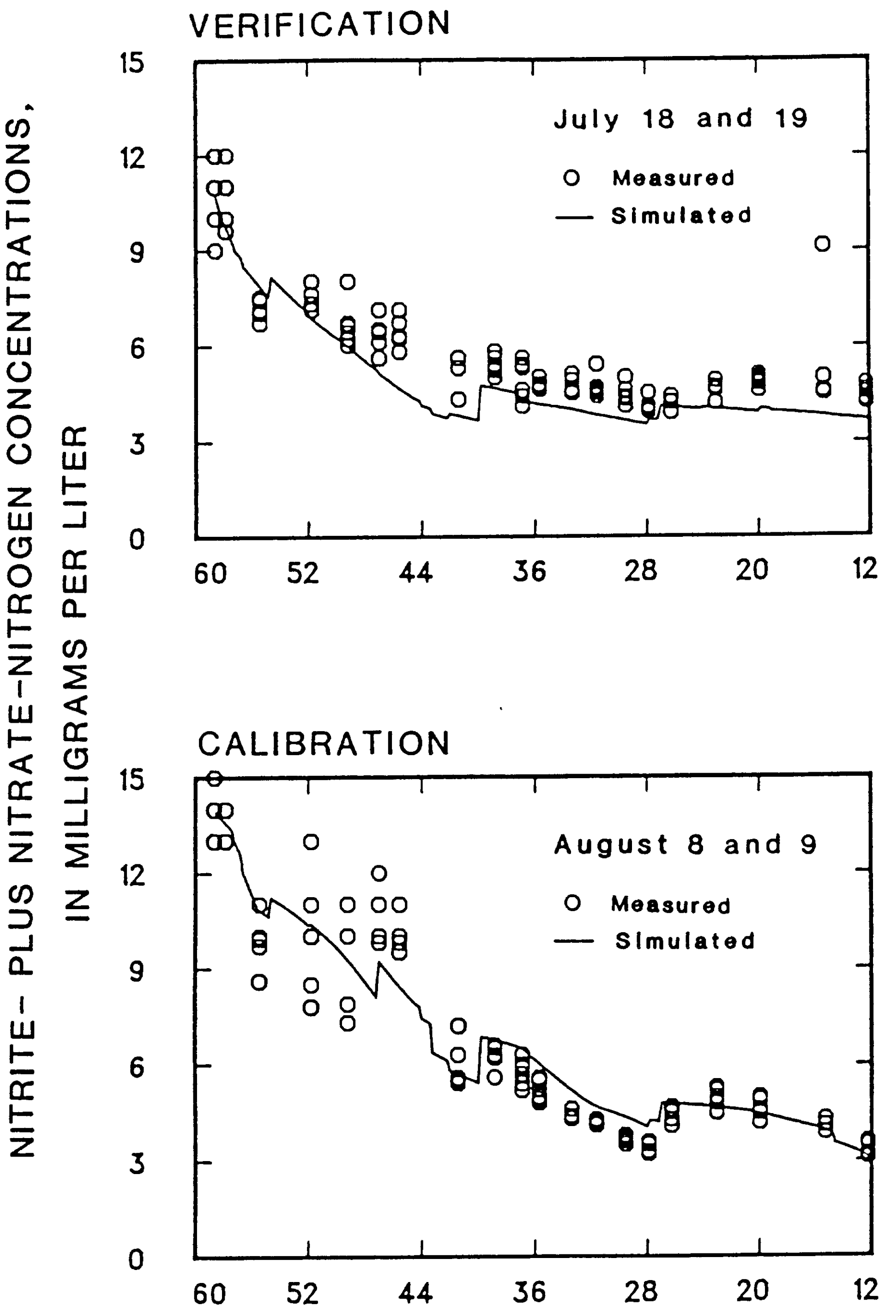


Figure 17.--Profiles of simulated and measured nitrite- plus nitrate-nitrogen concentrations in the West Branch and Main Stem Du Page River for the July and August diel studies.

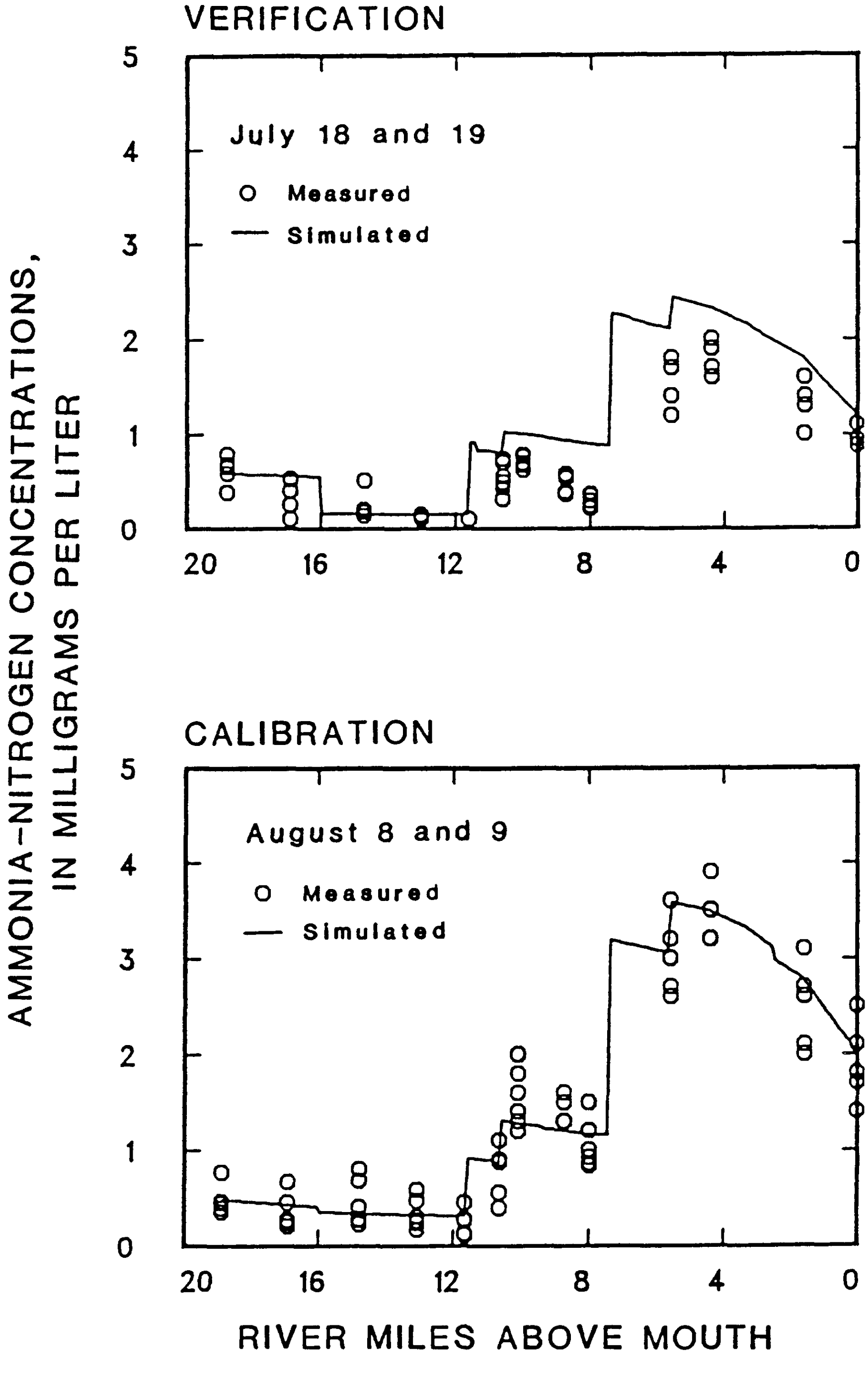


Figure 18.--Profiles of simulated and measured ammonia-nitrogen concentrations in the East Branch Du Page River for the July and August diel studies.

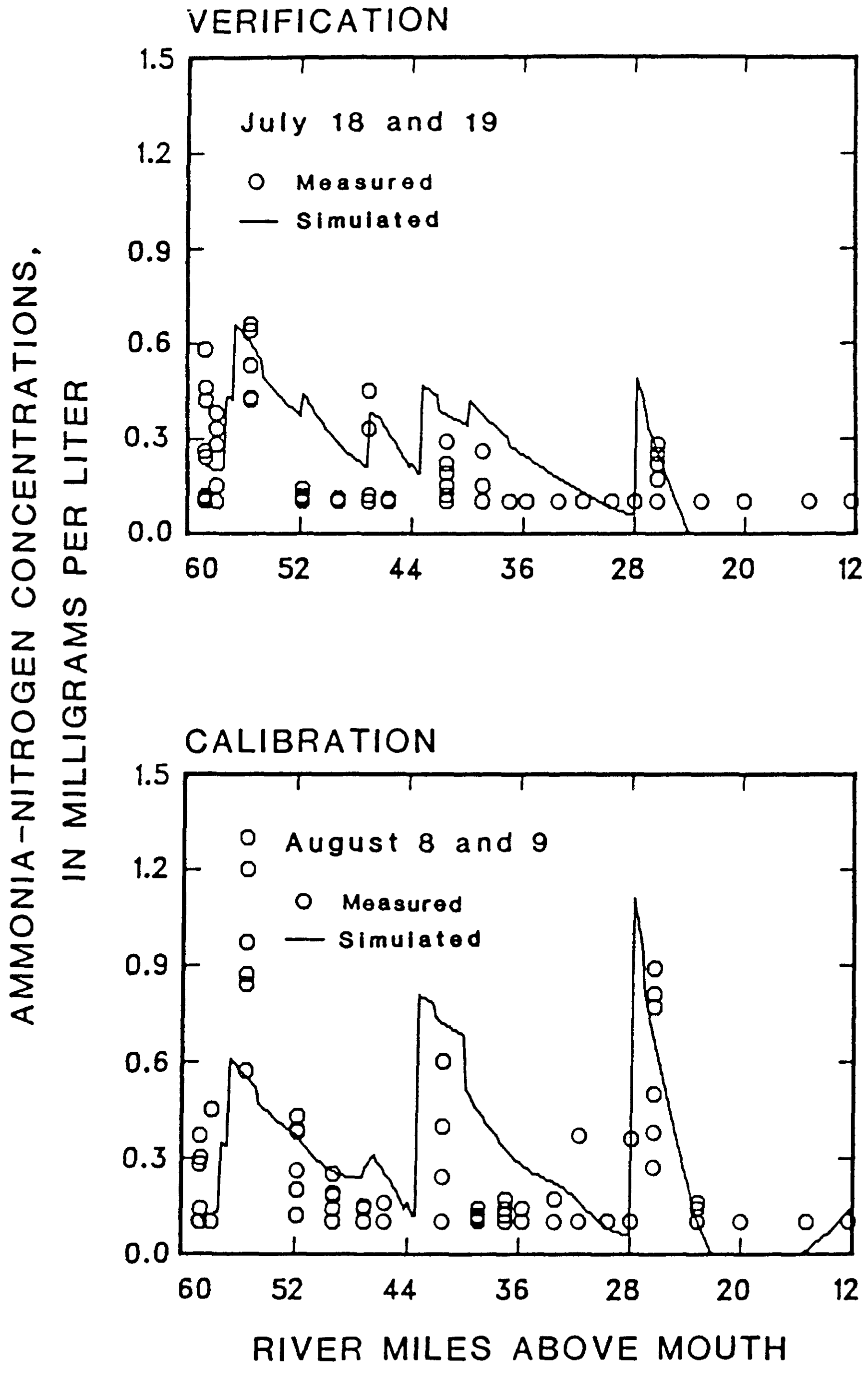


Figure 19.--Profiles of simulated and measured ammonia-nitrogen concentrations in the West Branch and Main Stem Du Page River for the July and August diel studies.

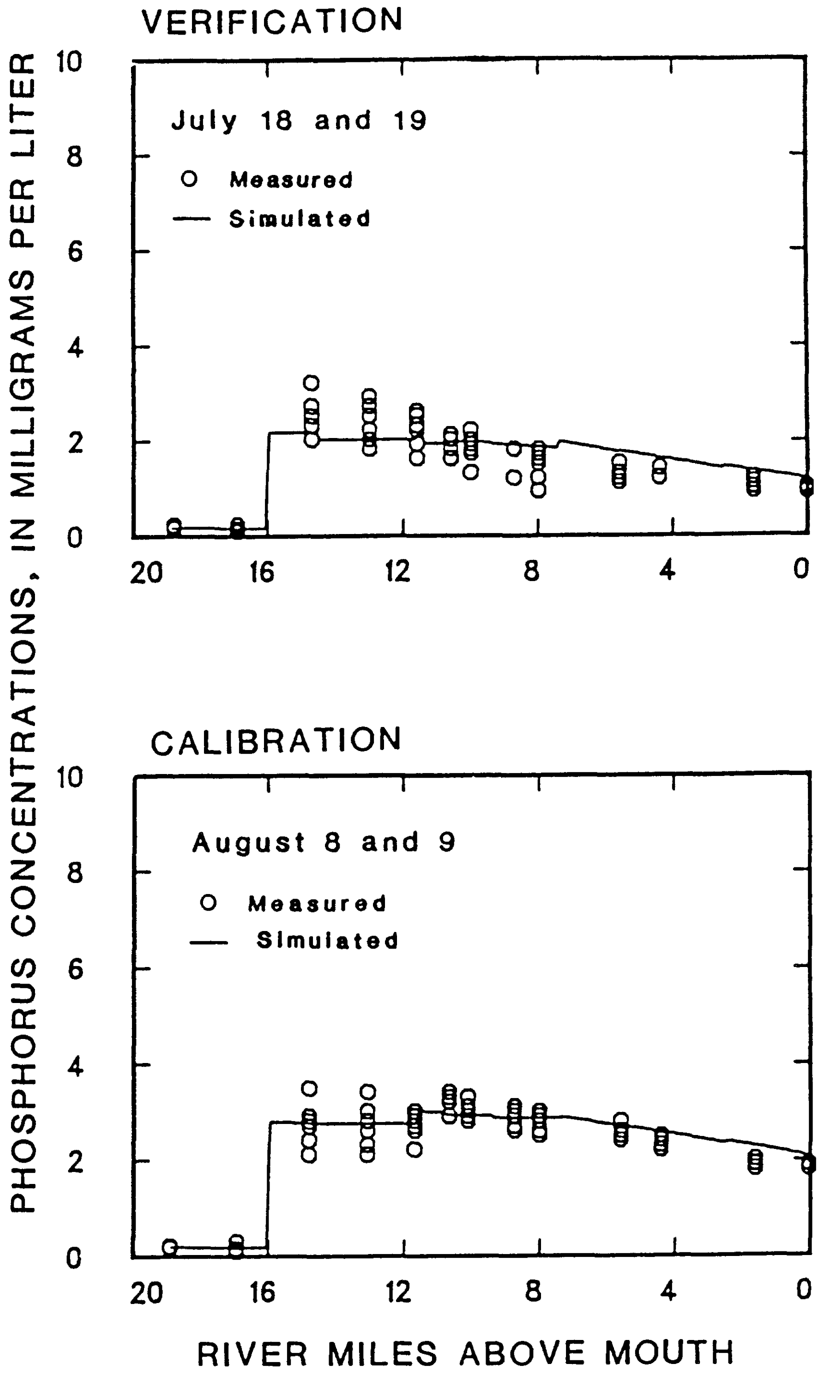


Figure 20.--Profiles of simulated and measured phosphorus concentrations in the East Branch Du Page River for the July and August diel studies.

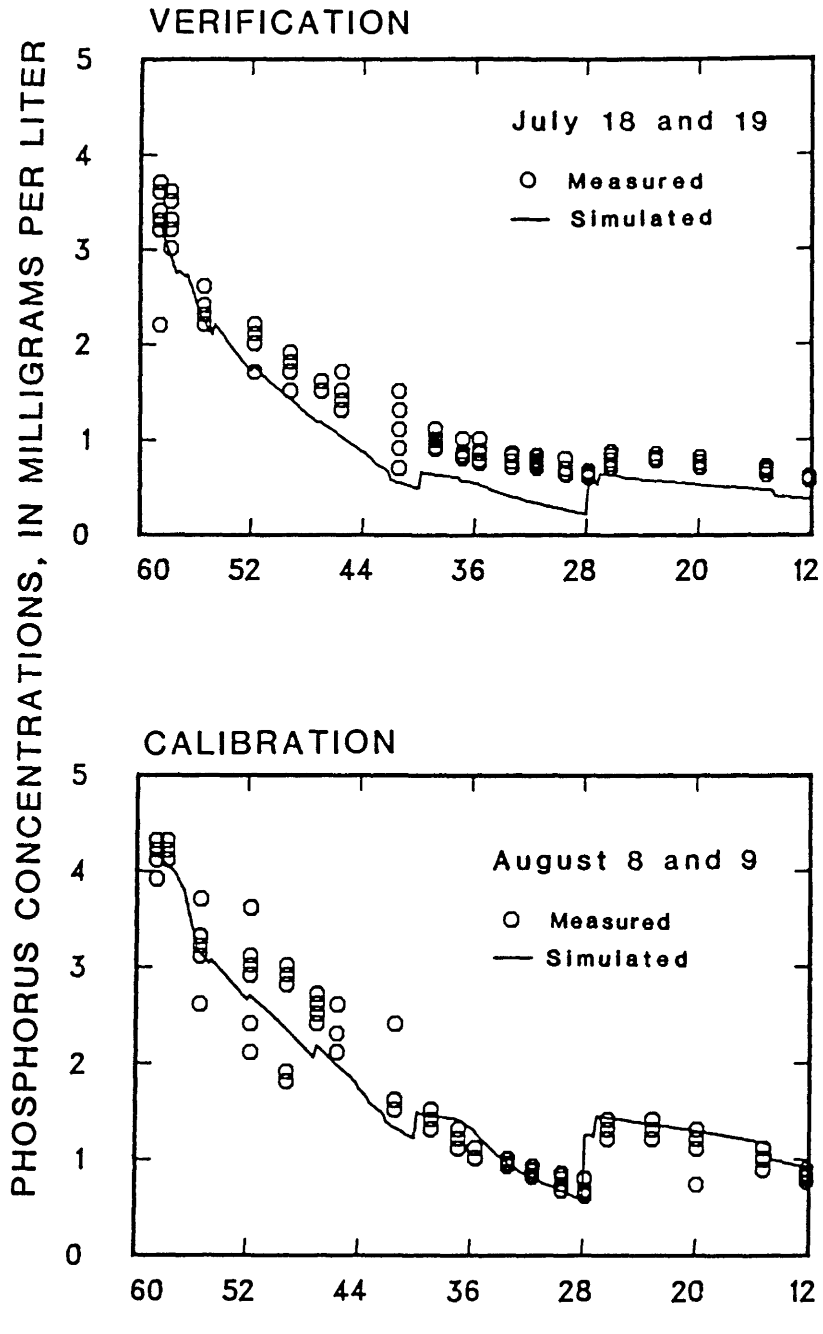


Figure 21.--Profiles of simulated and measured phosphorus concentrations in the West Branch and Main Stem Du Page River for the July and August diel studies.

Ammonia concentrations in the West Branch and Main Stem were so low that accurate simulations were not possible without increasing the number of subreaches modeled, thereby reducing the subreach length over which the source/sink rates are specified. Since the analytical detection limit for ammonia is 0.1 mg/L, concentrations below the detection limit indicate measured concentrations of less than 0.1 mg/L. To account for these concentrations in the model, they have been assigned a value of 0.1 mg/L.

The most important and complex constituent modeled was DO. Figure 10 shows which factors can affect the DO concentration in the QUAL-II model. The model simulates DO using the following equation (National Council of the Paper Industry for Air and Stream Improvement, 1982):

$$\frac{dO}{dt} = K_2(O^*-O) + A(\alpha_3\mu-\alpha_4\rho)-(K_1L)-(K_4/A_x)-(\alpha_5\beta_1N_1)-(\alpha_6\beta_2N_2) \qquad (13)$$

where O is the concentration of DO, in milligrams per liter;

O^* is the saturation concentration of dissolved oxygen at the local temperature and pressure, in milligrams per liter;

K_1 is the carbonaceous BOD decay rate, in reciprocal days;

K_2 is the reaeration-rate coefficient, in reciprocal days;

K_4 is the sediment oxygen demand rate, in milligrams per foot per day;

α_3 is the rate of oxygen production per unit of algal growth, in milligram oxygen per milligram algae;

α_4 is the rate of oxygen uptake per unit of algal respiration, in milligram oxygen per milligram algae;

α_5 is the rate of oxygen uptake per unit of ammonia oxidation, in milligram oxygen per milligram of ammonia nitrogen;

α_6 is the rate of oxygen uptake per unit of nitrite oxidation, in milligram oxygen per milligram nitrite nitrogen;

β_1 is the ammonia oxidation rate constant, in reciprocal days;

β_2 is the nitrite oxidation rate constant, in reciprocal days;

A is the algae concentration, in milligrams per liter;

A_x is the average cross-sectional area, in feet squared;

μ is the local specific growth rate of algae, in reciprocal days;

ρ is the local respiration rate of algae, in reciprocal days;

L is the ultimate carbonaceous BOD, in milligrams per liter;

N_1 is the concentration of ammonia nitrogen, in milligrams per liter; and

N_2 is the concentration of nitrite nitrogen, in milligrams per liter.

Measured values of the carbonaceous BOD decay rate coefficient (K_1) were specified for each model subreach. The reaeration-rate coefficients (K_2) were determined from equation 9 except for West Branch and Main Stem model subreaches 12, 14, and 15 where measured values were used because these subreaches contained low-head dams.

The rate of oxygen uptake for both the ammonia (α_5) and nitrite (α_6) oxidation reactions were specified as the stoichiometric equivalent amounts necessary to balance the chemical reactions. The oxygen uptake rates were specified as 3.43 mg oxygen per milligram ammonia nitrogen oxidized to nitrite, and 1.14 mg oxygen per milligram nitrite nitrogen oxidized to nitrate (Zison and others, 1978).

Oxygen production per unit of algal growth (α_3) can range from 1.4 to 1.8 mg oxygen per milligram algae. Oxygen uptake per unit of algal respiration (α_4) can range from 1.6 to 2.3 mg oxygen per milligram algae (National Council for the Paper Industry on Air and Stream Improvement, 1982). The sensitivity of the model to these coefficient ranges was tested by comparing a simulation using the maximum of the oxygen production and the minimum of the uptake with a simulation using the minimum production and the maximum uptake rates. Comparison of these simulations showed a significant impact on the DO concentrations for both the East Branch and the West Branch and Main Stem models. Because of the models' sensitivity to these rates, the median values of 1.6 mg oxygen per milligram algae for the oxygen production rate and 1.95 mg oxygen per milligram algae for the oxygen uptake rate were specified in the model.

The SOD rate (K_4) was used for calibrating the DO in the model. SOD rate coefficients can be highly variable depending on the amounts of biologically oxidizable material in the sediments. Often these rates are very site specific and can differ even in a cross section of the stream. The SOD rate coefficients were specified such that the model simulated DO concentrations approximated the measured DO concentrations. SOD coefficients specified for the East Branch model ranged from 1,500 to 105,000 mg oxygen per foot per day. The SOD coefficients for the West Branch and Main Stem model ranged from 0 to 55,000 mg oxygen per foot per day. These coefficients are dependent on the average width of the subreach, and to obtain comparable values, the coefficients were divided by the average width of their respective model subreach. The resulting ranges then became 66 to 2,625 mg oxygen per square foot per day and 0 to 2,040 mg oxygen per square foot per day for the East Branch and the West Branch and Main Stem models, respectively. Simulated SOD rates are high in several subreaches of the river, including the critical subreaches of the East Branch (from RM 8.0 down to its mouth). To observe the effects of SOD on DO, a simulation with SOD rates reduced by 20 percent was performed (fig. 22). It is apparent from this simulation that SOD is a major factor in the DO depletion in the model and that the model is sensitive to SOD changes.

Figures 23 and 24 show profiles of simulated and measured dissolved oxygen for the East Branch model and the West Branch and Main Stem model, respectively. The August calibration coefficients are well validated by the July simulations. The East Branch July simulated concentrations are slightly high, around RM 10.0 to RM 14.0, but simulated and measured concentrations nearly match through the critical subreaches of the river (RM 8.0 to RM 0.0). As

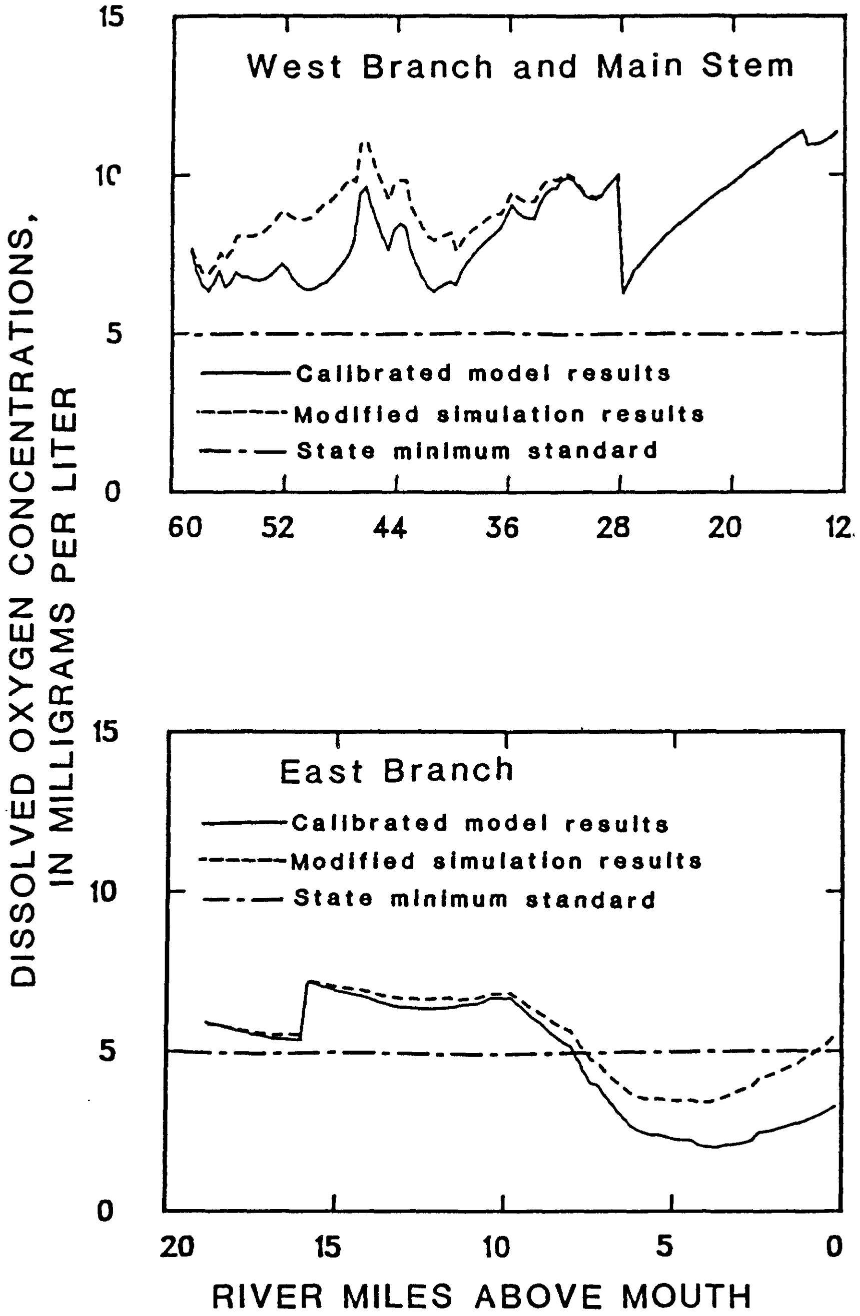


Figure 22.--Profiles of predicted dissolved-oxygen concentrations for the calibrated model and a simulation with SOD rates reduced 20 percent in the East Branch and the West Branch and Main Stem models.

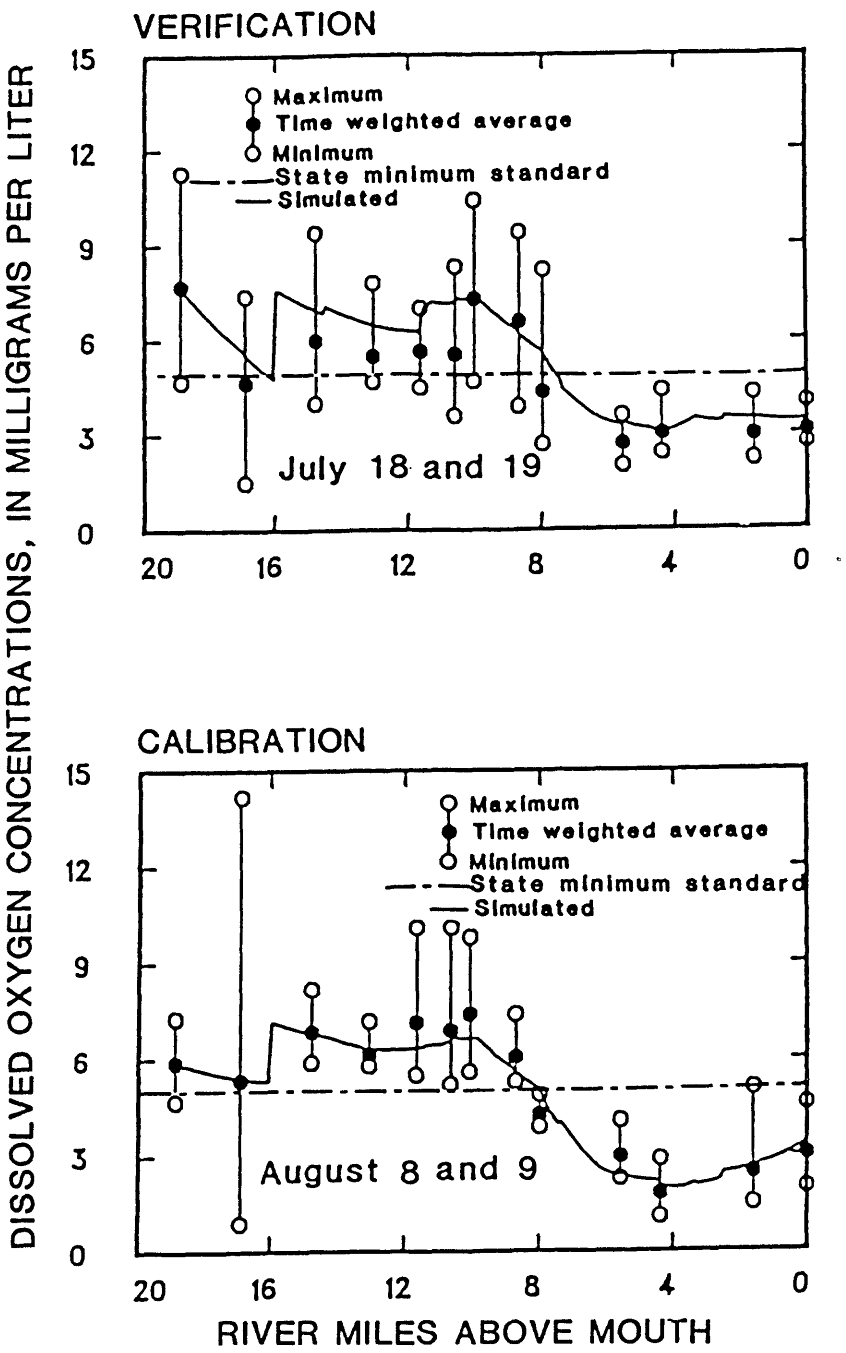


Figure 23.--Profiles of simulated and measured dissolved-oxygen concentrations in the East Branch Du Page River for the July and August diel studies.

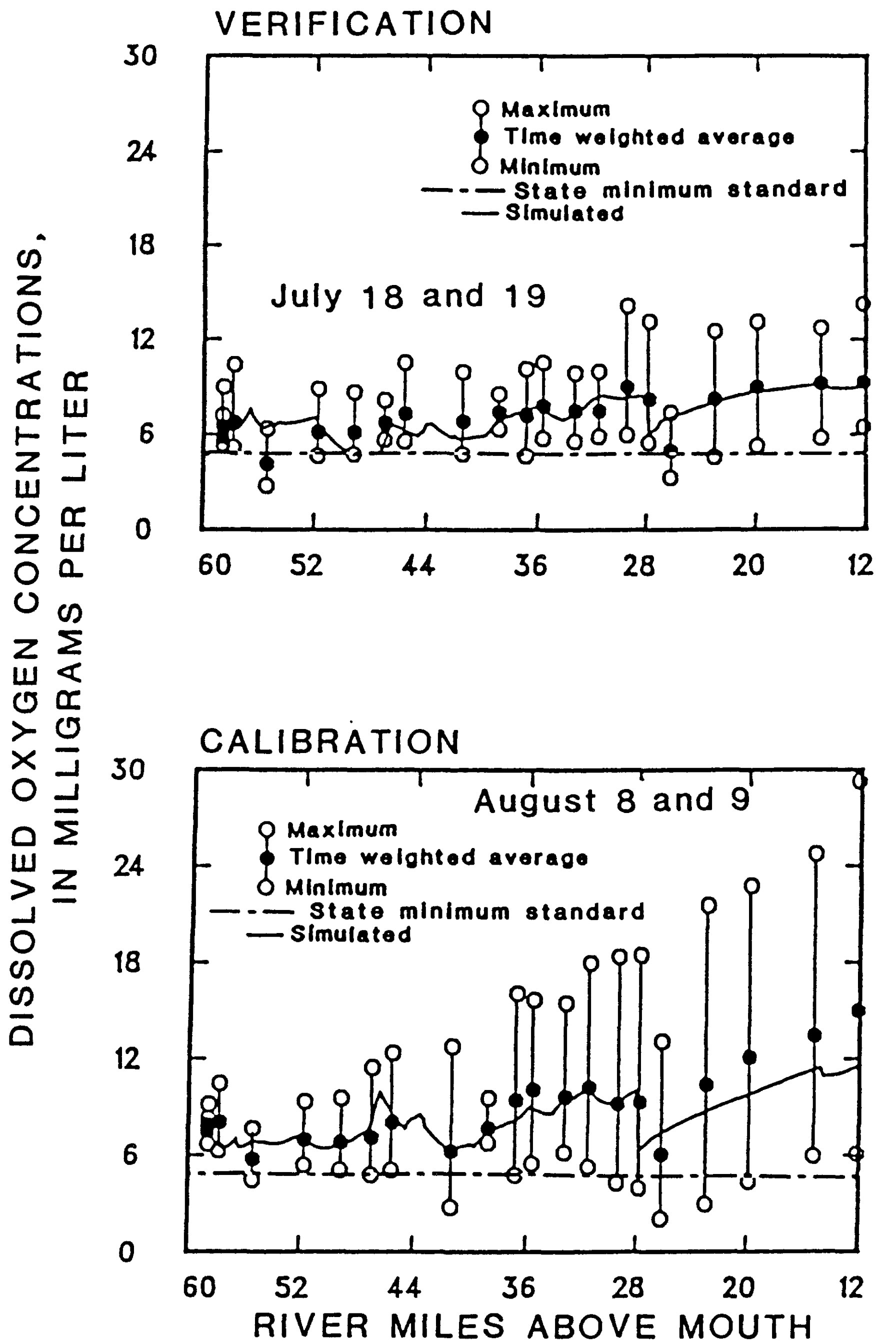


Figure 24.--Profiles of simulated and measured dissolved-oxygen concentrations in the West Branch and Main Stem Du Page River for the July and August diel studies.

discussed previously, the section of the East Branch from around RM 8.0 to its mouth has the most severe water-quality problems, especially in terms of DO, of the entire Du Page River study reach.

The July simulations with the West Branch and Main Stem model also closely match the measured DO concentrations. The simulated and measured concentrations for the July verification almost match from RM 24.0 to RM 12.0 while the calibrated concentrations in August do not. This is because SOD throughout these subreaches is zero, and the August simulated DO concentrations are as high as they will go without requiring changes in some other model parameter.

As discussed previously, equations were developed to predict the traveltimes (eqs. 7 and 8) and the reaeration-rate coefficients (eq. 9) for the model. Model simulations using plus and minus the standard error of these equations were performed for both of these parameters. The resulting constituent concentrations were then compared with the simulation concentrations determined from the equation-predicted coefficient values (tables 10 and 11). Although the model is somewhat sensitive to the reaeration-rate coefficients, a change of one standard error did not significantly improve DO concentrations in the critical subreaches of the East Branch. The model is very sensitive to changes in traveltimes, especially decreases. A decrease of one standard error caused an increase in DO concentration of more than 20 mg/L in both the East Branch and the West Branch and Main Stem models. This large change in DO was caused by an increase in the model-generated chlorophyll-a concentration. It is apparent then, that incorrect traveltimes could have a significant impact on the modeled water quality. The traveltimes used in these models are our best estimates using equations 7 and 8 based on field measurements made from June through September 1983.

Every attempt was made to use the most reasonable and accurate coefficients for model calibration. It is important to note, however, that due to the many interrelated factors affecting constituent concentrations in the model, some coefficients may be in error, with that error compensated by other related coefficients. Nevertheless, July verification results indicate that the combination of model coefficients used are valid, and the model can simulate low-flow water quality in the Du Page River for different hydrologic and waste-loading conditions.

Simulations Using Alternative Conditions

Alternative waste-load conditions were imposed on the model to demonstrate the model's use as a tool to predict the effect of different management strategies. The output from the simulation was compared with that from the calibrated model to evaluate the impact of changing waste loads.

One simulated condition was to restrict all WWTF effluents to a maximum ammonia concentration of 1.5 mg/L. Most of the WWTF effluents were already near or below this concentration of ammonia so this simulation resulted in little change in the DO concentrations. It did, however, reduce ammonia concentrations below the State standard in subreaches where the standards were not being met (figs. 25 and 26).

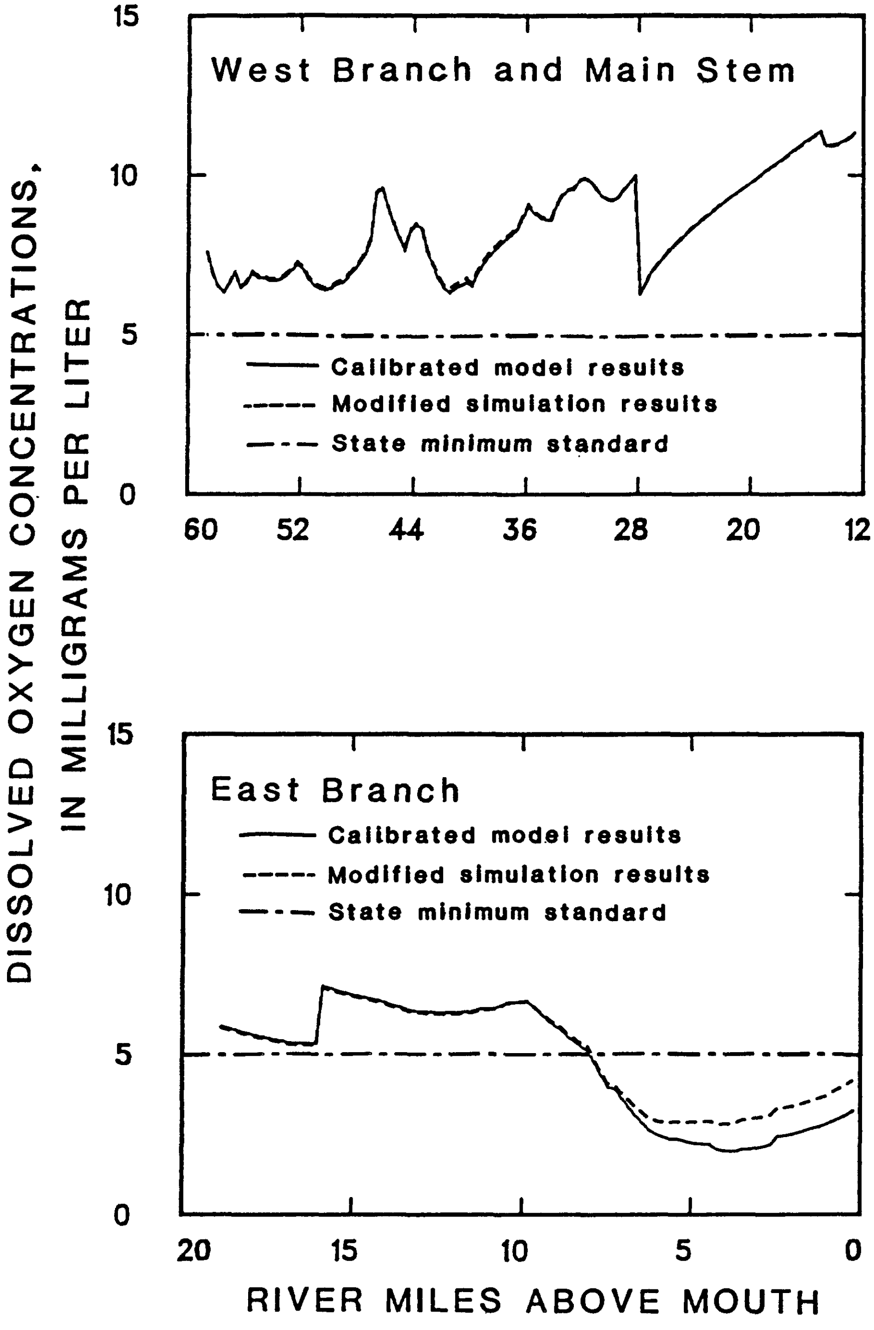


Figure 25.--Profiles of predicted dissolved-oxygen concentrations for the calibrated model and a simulation with the wastewater treatment facility effluent ammonia concentrations reduced to 1.5 milligrams per liter in the East Branch and the West Branch and Main Stem models.

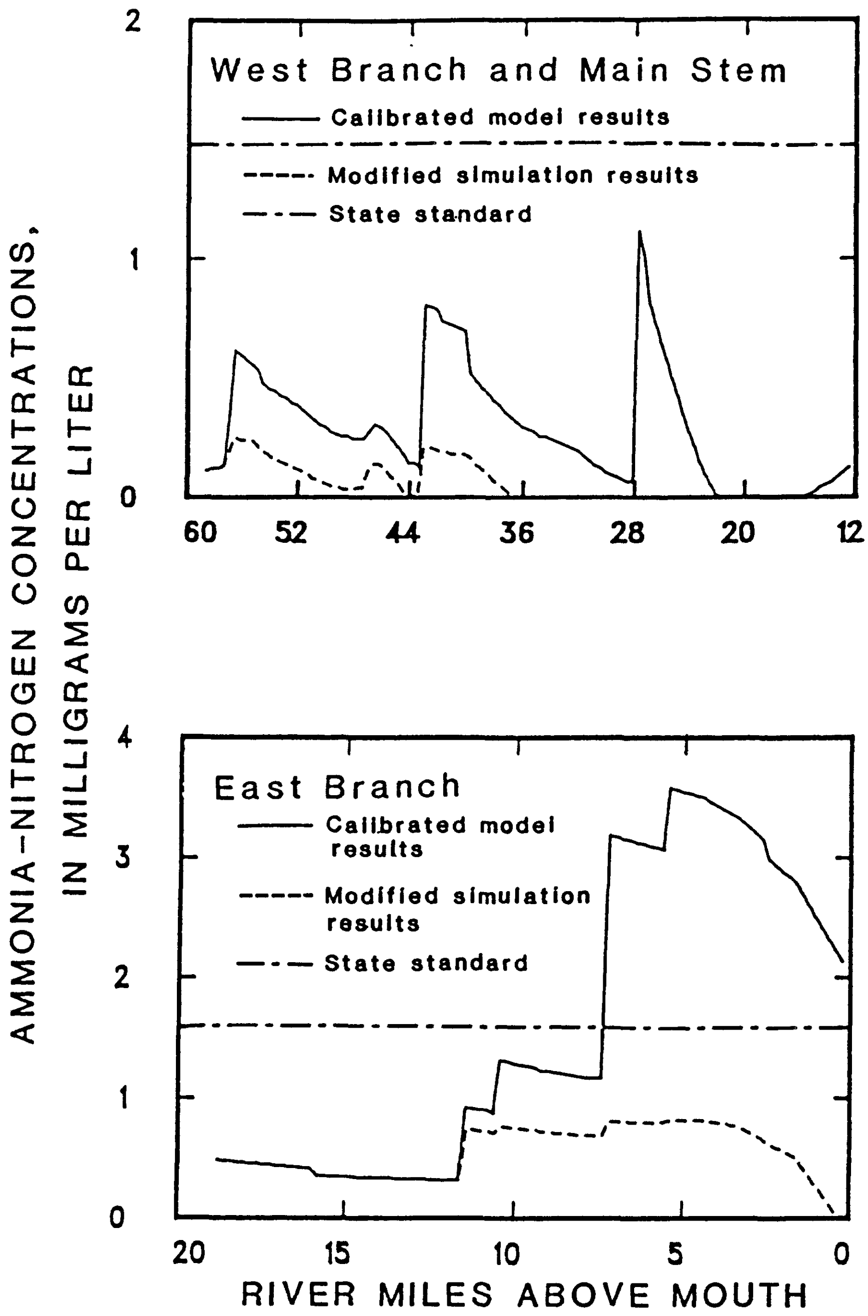


Figure 26.--Profiles of predicted ammonia-nitrogen concentrations for the calibrated model and a simulation with the wastewater treatment facility effluent ammonia concentrations reduced to 1.5 milligrams per liter in the East Branch and the West Branch and Main Stem models.

BOD is often considered a major cause of low DO concentrations in a stream. A second simulated condition restricted the ultimate carbonaceous BOD in the WWTF effluents to 8.5 mg/L, a value at or below best practical treatment levels. Limiting the carbonaceous BOD discharges had little or no effect on the DO in either the East Branch or the West Branch and Main Stem models (fig. 27).

The effects of carbonaceous BOD and ammonia oxidation on the DO concentration were small compared to the effects of SOD in the East Branch model and algal activity in the West Branch and Main Stem model. These simulated conditions indicated that carbonaceous BOD and ammonia oxidation are not major causes of low DO concentrations in the Du Page River. This is probably because many of the WWTFs use treatment processes which significantly reduce the effluent ammonia and carbonaceous BOD concentrations. Only in the critical subreaches of the East Branch did ammonia oxidation have some effect on DO concentrations.

The last set of simulated conditions used an average of the ammonia-nitrogen and 5-day BOD effluent concentrations on record with the IEPA for the years 1974 and 1975. There has been some consolidation of small WWTFs and some improvements in their effluent quality over the years, so this is not an accurate simulation of the water quality. This simulation indicates what the water quality might have been if current (1983) volumes of effluent were discharged with the 5-day BOD and ammonia-nitrogen concentrations discharged in 1974 and 1975. Five-day BOD values were converted to ultimate BODs using the decay coefficients measured during the August diel study.

Figure 28 shows the DO results for this simulation. The results show very little change in the water quality of the West Branch and Main Stem. The results for the East Branch indicate that improvements in effluent quality since 1974-75 have resulted in improved river water quality.

SUMMARY AND CONCLUSIONS

Several subreaches of the Du Page River where the water quality exceeded the State general-use water-quality standards were identified. The East Branch had more severe water-quality problems than the West Branch or Main Stem, especially in terms of DO concentrations. The lowest DO concentrations were in the East Branch. Most of these low DO concentrations were in the subreaches from RM 8.0 to the mouth of the East Branch. In these subreaches, DO concentrations were all below 6.0 mg/L and most were below 5.0 mg/L during both diel studies. Model simulations indicate that depletion of DO in these subreaches is caused primarily by high SOD rates and also by the oxidation of ammonia.

DO concentrations in the West Branch and Main Stem were in compliance with the standard for a large portion of both diel-study periods, but at several downstream sites concentrations at the minimum of the diel cycle fell below the State minimum standard of 5.0 mg/L. The DO depletion at these sites appeared to be caused by the combination of low DO downstream of the East Branch and by oxygen consumption from algal respiration at night.

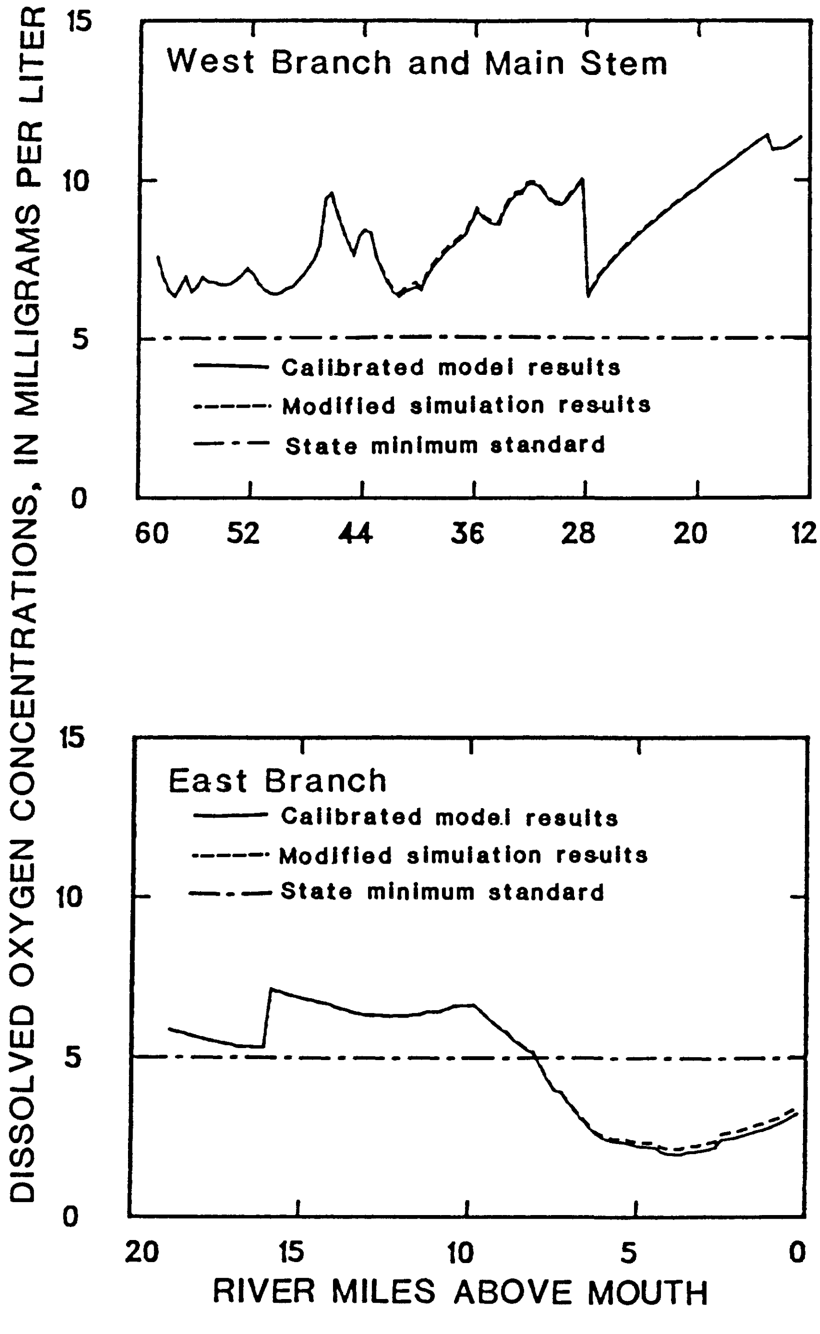


Figure 27.--Profiles of predicted dissolved-oxygen concentrations for the calibrated model and a simulation with the wastewater treatment facility effluent ultimate carbonaceous biochemical oxygen demands reduced to 8.5 milligrams per liter in the East Branch and the West Branch and Main Stem models.

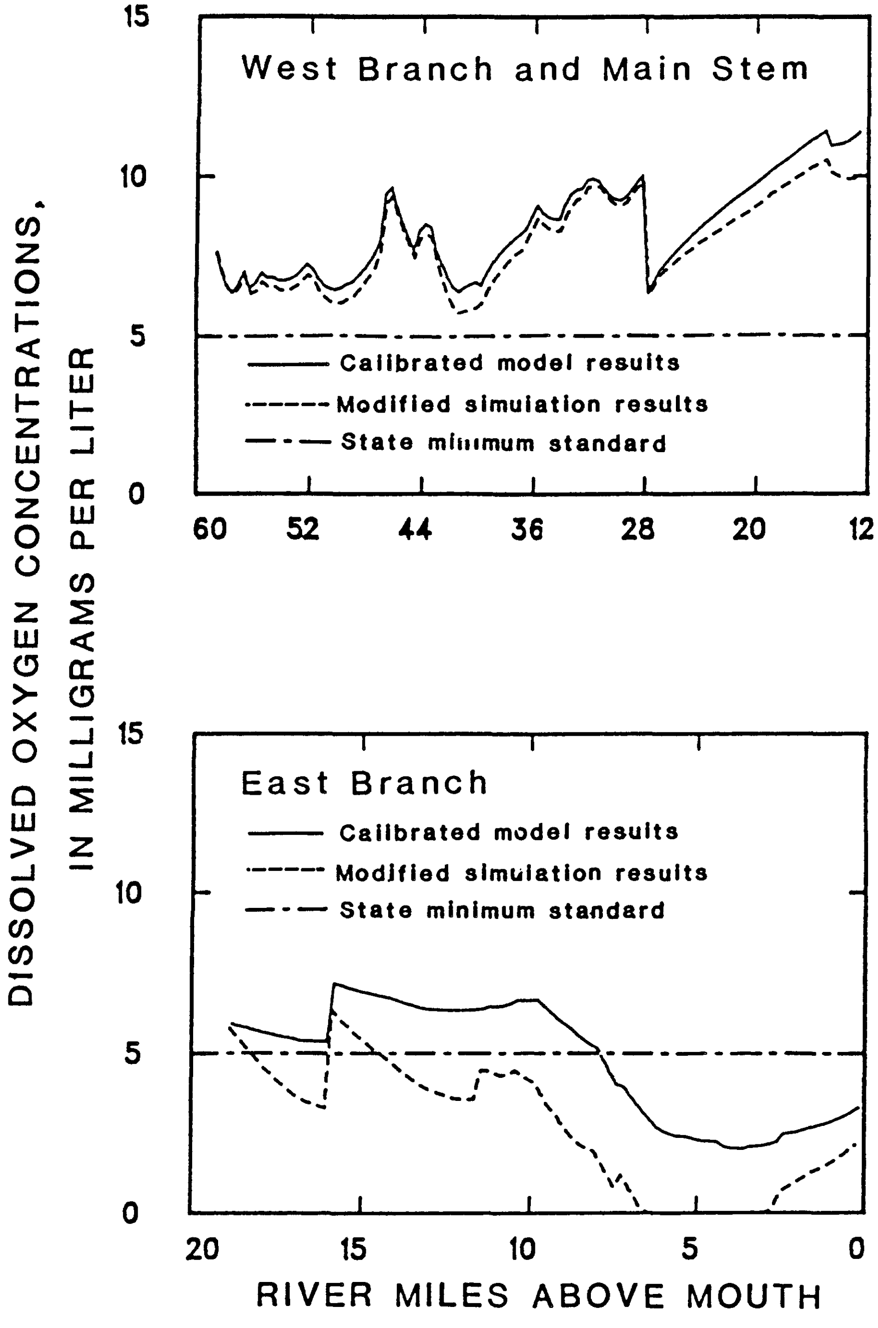


Figure 28.--Profiles of predicted dissolved-oxygen concentrations for the calibrated model and a simulation using waste-water treatment facility effluent ammonia and biochemical oxygen demand concentrations from 1974 and 1975 in the East Branch and the West Branch and Main Stem models.

Ammonia-nitrogen concentrations exceeded the standard at three sites in the East Branch during both diel studies but were in compliance throughout the rest of the river. WWTF effluents were the major source of these high ammonia concentrations.

Total dissolved-solids concentrations exceeded the State standard of 1,000 mg/L throughout most of the East Branch and at many sites in the West Branch and Main Stem during both diel studies. Mass balance calculations indicated that the point sources were a major contributing factor to these high concentrations.

Total iron concentrations during both diel studies exceeded the State standard of 1,000 µg/L throughout most of the East and West Branches but did not exceed the standard in the Main Stem. Mass balance calculations indicated that point sources did not contribute signifiantly to these iron concentrations.

The only other measured chemical constituent that exceeded the State standards was fluoride. Fluoride concentrations exceeded the State standard of 1.4 mg/L at only a few locations in the West Branch and were in compliance throughout the remainder of the Du Page River during both diel studies. Mass balance calculations indicated that point sources were an important factor contributing to these fluoride concentrations.

The QUAL-II one-dimensional, steady-state, water-quality model was calibrated for both the East Branch and the West Branch and Main Stem of the Du Page River using water-quality measurements made during a low-flow period in August 1983. The model coefficients chosen by this calibration were then verified by accurately simulating the water quality under different hydrologic and wasteload conditions. This verification used water-quality measurements made during a low-flow period in July 1983.

Simulated WWTF effluent quality conditions were imposed on the model to predict the impact of different conditions on the water quality of the Du Page River. The predicted water quality indicated that effluent quality improvements since 1974 have had a beneficial impact in the East Branch and little impact in the West Branch and Main Stem. These simulations also indicated that further reduction in the effluent BOD concentrations will have neglible impact on the DO concentrations of the Du Page River but that reduction of the effluent ammonia concentrations in the East Branch could bring ammonia concentrations into compliance with the State water-quality standards and improve DO concentrations in the downstream subreaches.

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TABLES 12 and 13

Table 12.--Selected constituent concentrations measured in the East Branch Du Page River on July 18-19 and August 8-9, 1983

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25° Celsius; µg/L, micrograms per liter; <, less than; dashes indicate no data]

Site number	Date (month/day)	Time (hours)	Oxygen, dissolved (mg/L)	pH (units)	Phosphorus, dissolved (mg/L)	Nitrogen, ammonia dissolved (mg/L)	Nitrogen, NO2+NO3 dissolved (mg/L)	Nitrogen, ammonia total (mg/L)	Specific conductance (µS/cm)	Oxygen demand, biochemical ultimate (mg/L)	Solids, residue at 180 deg. C dissolved (mg/L)	Iron, total recoverable (µg/L)	Fluoride, total (mg/L)
1	07/18	2000	7.0	7.0	2.7	7.9	1.2	--	1,750	9.7	--	--	--
	07/19	0015	6.7	7.3	2.9	7.7	.99	--	1,550	--	--	--	--
		0315	6.9	7.3	3.1	7.2	.66	--	1,480	--	--	--	--
		0630	12.2	8.6	3.6	7.8	.78	--	1,500	--	--	--	--
		1000	9.3	7.3	2.8	6.1	.65	--	1,350	--	--	--	--
		1230	8.0	7.4	--	--	--	--	1,570	--	--	--	--
		1430	10.1	7.4	2.6	8.1	.58	8.0	1,610	7.8	884	80	0.9
	08/08	1837	8.0	7.1	1.2	6.4	1.5	--	1,640	9.4	--	--	--
		2031	8.2	7.4	--	--	--	--	1,640	--	--	--	--
		2230	8.3	7.4	1.5	5.9	1.5	--	1,630	6.5	--	--	--
	08/09	0012	8.1	7.4	--	--	--	--	1,620	--	--	--	--
		0310	7.8	7.3	1.6	4.8	1.4	5.1	1,580	8.6	950	60	1.0
		0630	7.6	7.2	1.6	4.6	1.5	--	1,570	--	--	--	--
		0915	9.2	7.2	--	--	--	--	1,450	--	--	--	--
		1000	9.1	7.2	1.6	4.2	1.6	--	1,530	7.1	--	--	--
		1200	9.8	7.2	--	--	--	--	1,560	--	--	--	--
		1400	10.6	7.3	1.5	2.7	3.1	--	1,600	5.4	--	--	--
2	07/18	2045	2.9	7.4	1.2	3.5	1.2	--	1,550	--	--	--	--
	07/19	0045	1.6	7.6	1.3	4.0	1.1	--	1,510	11	--	--	--
		0400	2.1	7.1	1.5	4.1	.71	--	1,480	--	--	--	--
		0730	2.1	7.1	1.7	4.2	.64	--	1,490	--	--	--	--
		1015	4.6	7.1	1.3	4.1	.72	--	1,460	11	--	--	--
		1330	4.3	7.2	--	--	--	--	1,400	--	--	--	--
		1500	4.6	7.2	1.0	3.1	.79	2.9	1,390	8.0	784	1,700	.8
	08/08	1902	5.7	8.4	2.3	1.3	.74	--	1,570	8.5	--	--	--
		2052	4.6	7.4	--	--	--	--	1,560	--	--	--	--
		2247	3.4	7.3	2.7	1.6	.71	--	1,570	7.7	--	--	--
	08/09	0032	2.6	7.3	--	--	--	--	1,570	--	--	--	--
		0340	2.1	6.9	3.5	3.0	.42	3.1	1,560	12	940	2,000	.9
		0715	2.2	6.2	3.8	3.7	.30	--	1,570	--	--	--	--
		1015	2.5	7.5	3.9	4.3	.27	--	1,570	6.7	--	--	--
		1215	3.2	6.9	--	--	--	--	1,570	--	--	--	--
		1415	4.3	7.2	3.7	4.5	.44	--	1,520	11	--	--	--

4	07/18	2230	2.3	7.6	2.2	6.1	1.2	--	1,570	--	--	--	--
	07/19	0200	2.7	7.2	2.2	6.5	1.1	--	1,600	--	--	--	--
		0500	2.6	7.2	2.0	6.1	.97	--	1,600	--	--	--	--
		0815	2.1	7.2	2.3	7.3	.89	--	1,630	16	--	--	--
		1115	2.5	7.2	2.0	7.8	.85	--	1,670	10	--	--	--
		1615	3.7	7.2	2.2	7.4	1.0	7.2	1,660	10	952	1,200	.8
	08/08	1938	3.0	7.3	1.7	4.5	2.7	--	1,680	11	--	--	--
		2121	2.6	7.3	--	--	--	--	1,670	20	--	--	--
		2323	2.4	7.3	1.2	4.1	2.5	--	1,670	11	--	--	--
	08/09	0100	2.4	7.3	--	--	--	--	1,650	--	--	--	--
		0430	2.0	7.3	1.7	4.0	2.6	3.8	1,650	9.4	1,010	990	.9
		0800	2.0	7.1	1.5	3.8	3.0	--	1,660	--	--	--	--
		1100	2.4	7.0	1.6	4.1	3.2	--	1,670	8.7	--	--	--
		1245	2.6	7.1	--	--	--	--	1,670	--	--	--	--
		1445	3.4	7.2	1.7	4.3	3.4	--	1,680	10	--	--	--
5	07/18	2300	6.5	7.2	.10	.58	.34	--	1,320	26	--	--	--
	07/19	0230	5.2	6.9	.20	.65	.42	--	1,410	23	--	--	--
		0530	4.7	6.9	.10	.78	.50	--	1,430	26	--	--	--
		0845	6.7	7.7	.10	.68	.51	--	1,390	33	--	--	--
		1145	8.1	7.8	.10	.38	.34	--	1,460	25	--	--	--
		1700	11.3	7.4	.10	.38	.17	.50	1,350	30	850	1,400	.8
	08/08	2000	7.0	7.0	.10	.46	.14	--	1,730	18	--	--	--
		2135	6.1	6.8	--	--	--	--	1,750	--	--	--	--
		2333	7.3	7.1	.10	.35	.10	--	1,680	23	--	--	--
	08/09	0108	6.6	7.0	--	--	--	--	1,690	--	--	--	--
		0449	5.8	6.9	.20	.77	.00	.78	1,710	14	1,410	2,400	.9
		0815	4.7	7.1	.20	.44	.21	--	1,520	19	--	--	--
		1130	5.4	7.1	.10	.39	.16	--	1,540	13	--	--	--
		1300	5.9	7.3	--	--	--	--	1,530	--	--	--	--
		1500	5.7	7.1	.10	.46	.17	--	1,550	14	--	--	--
		1700	5.5	7.2	--	--	--	--	1,570	--	--	--	--
6	07/18	1809	--	--	.21	.10	.60	--	1,450	11	--	--	--
		2100	3.8	6.4	--	--	--	--	1,640	--	--	--	--
		2130	4.6	6.4	.12	.25	.58	--	1,640	13	--	--	--
		2249	3.3	6.7	--	--	--	--	1,620	--	--	--	--
	07/19	0105	3.3	6.4	--	--	--	--	1,640	--	--	--	--
		0217	1.8	6.4	.12	.53	.41	--	1,630	13	--	--	--
		0424	1.6	6.4	--	--	--	--	1,590	--	--	--	--
		0627	1.5	7.1	.12	.52	.23	--	1,490	14	--	--	--
		0924	4.3	7.2	--	--	--	--	1,500	--	--	--	--
		1035	7.4	7.2	.11	.40	.46	--	1,510	16	--	--	--
		1300	5.0	7.5	--	--	--	--	1,510	--	--	--	--
		1419	5.3	7.3	.07	< .10	.48	.16	1,460	20	1,000	2,400	.5
		1731	7.3	7.7	--	--	--	--	1,420	--	--	--	--

Table 12.--Selected constituent concentrations measured in the East Branch Du Page River on July 18-19 and August 8-9, 1983--Continued

Site number	Date (month/ day)	Time (hours)	Oxygen, dis- solved (mg/L)	pH (units)	Phos- phorus, dis- solved (mg/L)	Nitro- gen, ammonia dis- solved (mg/L)	Nitro- gen, NO2+NO3 dis- solved (mg/L)	Nitro- gen, ammonia total (mg/L)	Spe- cific con- duct- ance (µS/cm)	Oxygen demand, bio- chemi- cal ulti- mate (mg/L)	Solids, residue at 180 deg. C dis- solved (mg/L)	Iron, total recov- erable (µg/L)	Fluo- ride, total (mg/L)
6	08/08	1800	9.5	7.6	0.09	0.20	0.43	--	1,300	6.4	--	--	--
(Cont.)		2100	3.8	7.6	--	--	--	--	1,530	--	--	--	--
		2200	1.8	7.3	.14	.27	.28	--	1,620	7.3	--	--	--
	08/09	0145	0.9	6.8	.29	.45	.23	0.54	1,600	16	1,110	620	0.6
		0420	1.1	7.1	--	--	--	--	1,610	--	--	--	--
		0606	1.2	7.2	.16	.67	.28	--	1,610	15	--	--	--
		0827	3.0	7.2	--	--	--	--	1,580	12	--	--	--
		0945	4.1	7.4	.14	.24	.27	--	1,520	--	--	--	--
		1248	11.3	7.7	--	--	--	--	1,520	18	--	--	--
		1350	13.0	7.7	.11	< .10	.32	--	1,470	--	--	--	--
		1535	14.2	7.7	--	--	--	--					
7	07/18	1844	9.4	7.3	3.2	.13	6.7	--	--	11	--	--	--
		2300	6.2	6.7	2.7	.51	7.1	--	1,940	7.4	--	--	--
	07/19	0120	6.6	6.6	--	--	--	--	1,900	--	--	--	--
		0244	5.4	6.5	2.5	.20	7.6	--	1,900	8.5	--	--	--
		0435	4.6	6.5	--	--	--	--	1,880	--	--	--	--
		0706	5.1	7.1	2.0	.18	6.0	--	1,760	8.5	--	--	--
		0934	5.9	7.1	--	--	--	--	1,710	--	--	--	--
		1052	5.9	6.9	2.3	.17	5.8	--	1,710	8.8	--	--	--
		1311	4.0	7.3	--	--	--	--	1,700	--	--	--	--
		1439	4.6	6.9	2.5	< .10	5.8	.19	1,710	13	1,160	1,200	.7
		1742	7.4	7.3	--	--	--	--	1,800	--	--	--	--
	08/08	1850	7.6	7.4	3.5	.27	6.0	--	1,900	6.9	--	--	--
		2010	7.2	7.5	--	--	--	--	1,970	--	--	--	--
		2245	6.9	7.4	2.9	.80	6.4	--	1,980	8.4	--	--	--
	08/09	0200	6.3	7.1	2.8	.68	6.6	.59	1,930	7.6	1,270	1,000	1.0
		0440	6.0	7.0	--	--	--	--	1,900	--	--	--	--
		0628	5.9	7.1	2.4	.40	5.6	--	1,860	3.9	--	--	--
		0838	6.3	7.1	--	--	--	--	1,830	--	--	--	--
		1000	6.0	7.2	2.1	.28	4.5	--	1,830	9.6	--	--	--
		1256	7.5	7.3	--	--	--	--	1,810	--	--	--	--
		1407	8.2	7.2	2.7	.22	5.1	--	1,800	6.0	--	--	--
		1541	8.1	7.4	--	--	--	--	1,710	--	--	--	--

8	07/18	1926	7.8	6.9	2.9	.12	6.0	--	1,840	8.9	--	--	--
		2330	6.4	6.7	2.7	.10	6.3	--	1,950	11	--	--	--
	07/19	0138	5.8	6.7	--	--	--	--	1,910	--	--	--	--
		0300	5.2	6.7	2.5	< .10	7.1	--	1,880	8.1	--	--	--
		0455	4.7	6.7	--	--	--	--	1,860	--	--	--	--
		0730	5.4	7.2	2.2	.15	6.7	--	1,770	7.5	--	--	--
		0947	6.3	7.6	--	--	--	--	1,740	--	--	--	--
		1104	4.9	7.5	1.8	.11	5.3	--	1,690	12	--	--	--
		1321	5.0	7.5	--	--	--	--	1,670	--	--	--	--
		1525	5.9	6.9	2.0	.13	5.5	.21	1,660	11	1,150	1,000	.7
		1756	6.6	7.1	--	--	--	--	1,690	--	--	--	--
	08/08	1930	6.8	7.5	3.4	.17	6.3	--	1,830	7.5	--	--	--
		2130	6.4	7.5	--	--	--	--	1,870	--	--	--	--
		2305	6.3	7.5	3.0	.26	8.6	--	1,920	6.4	--	--	--
	08/09	0245	5.8	7.1	2.8	.58	6.3	.66	1,960	7.1	1,390	1,200	.9
		0500	5.9	7.1	--	--	--	--	1,940	--	--	--	--
		0649	5.9	7.3	2.6	.47	6.1	--	1,750	4.5	--	--	--
		0830	6.2	7.3	--	--	--	--	1,880	--	--	--	--
		1044	6.4	7.3	2.3	.30	5.7	--	1,840	9.3	--	--	--
		1316	6.8	7.2	--	--	--	--	1,790	--	--	--	--
		1428	6.9	7.2	2.1	.23	4.5	--	1,750	5.9	--	--	--
		1600	7.2	7.2	--	--	--	--	1,710	--	--	--	--
9	07/18	1938	5.5	6.8	2.2	< .10	5.8	--	1,740	9.6	--	--	--
		2340	6.0	6.7	2.6	< .10	5.5	--	1,830	7.7	--	--	--
	07/19	0150	6.0	6.8	--	--	--	--	1,890	--	--	--	--
		0317	5.4	6.8	2.5	< .10	6.3	--	1,900	9.4	--	--	--
		0507	4.5	6.7	--	--	--	--	1,870	--	--	--	--
		0806	6.4	7.3	2.3	< .10	6.6	--	1,740	10	--	--	--
		0957	7.0	7.5	--	--	--	--	1,680	--	--	--	--
		1122	4.8	7.3	1.9	< .10	6.0	--	1,710	13	--	--	--
		1332	5.6	7.5	--	--	--	--	1,680	--	--	--	--
		1630	4.8	7.2	1.6	< .10	4.6	.10	1,630	14	1,150	570	.7
		1808	6.9	7.4	--	--	--	--	1,610	--	--	--	--
	08/08	1950	6.3	7.6	2.8	.11	6.1	--	1,820	7.2	--	--	--
		2140	5.9	7.6	--	--	--	--	1,840	--	--	--	--
		2330	5.7	7.5	3.0	.13	5.9	--	1,850	5.8	--	--	--
	08/09	0315	5.5	7.3	2.9	.28	5.9	.29	1,900	--	--	--	--
		0505	5.6	7.2	--	--	--	--	1,950	--	--	--	--
		0708	5.6	7.3	2.7	.45	5.9	--	1,960	4.4	1,170	1,400	.9
		0901	7.6	7.4	--	--	--	--	1,940	--	--	--	--
		1059	8.3	7.4	2.6	.26	6.1	--	1,870	7.4	--	--	--
		1325	10.1	7.5	--	--	--	--	1,820	--	--	--	--
		1453	9.9	7.4	2.2	.13	5.5	--	1,760	5.2	--	--	--
		1616	9.5	7.4	--	--	--	--	1,700	--	--	--	--

Table 12.--Selected constituent concentrations measured in the East Branch Du Page River on July 18-19 and August 8-9, 1983--Continued

Site number	Date (month/ day)	Time (hours)	Oxygen, dis- solved (mg/L)	pH (units)	Phos- phorus, dis- solved (mg/L)	Nitro- gen, ammonia dis- solved (mg/L)	Nitro- gen, NO2+NO3 dis- solved (mg/L)	Nitro- gen, ammonia total (mg/L)	Spe- cific con- duct- ance (µS/cm)	Oxygen demand, bio- chemi- cal ulti- mate (mg/L)	Solids, residue at 180 deg. C dis- solved (mg/L)	Iron, total recov- erable (µg/L)	Fluo- ride, total (mg/L)
10	07/18	1958	4.9	6.9	1.6	0.49	4.7	--	1,860	11	--	--	--
	07/19	0003	6.0	6.8	2.1	.70	4.6	--	1,890	14	--	--	--
		0200	5.7	6.7	--	--	--	--	1,880	--	--	--	--
		0335	5.5	7.5	2.1	.74	4.6	--	--	17	--	--	--
		0518	3.9	6.8	--	--	--	--	1,880	--	--	--	--
		0822	6.8	7.3	1.8	.43	4.6	--	1,680	10	--	--	--
		1006	6.9	7.3	--	--	--	--	1,670	--	--	--	--
		1138	3.6	7.3	2.0	.55	4.6	--	1,720	--	--	--	--
		1338	5.5	7.5	--	--	--	--	1,740	--	--	--	--
		1651	8.3	7.2	1.6	.31	4.1	0.43	1,680	--	1,200	320	0.7
		1818	7.5	7.6	--	--	--	--	1,680	--	--	--	--
	08/08	2010	6.4	7.7	2.9	.39	6.1	--	1,930	6.5	--	--	--
		2200	5.5	7.6	--	--	--	--	1,970	--	--	--	--
		2350	5.3	7.6	3.2	.87	5.5	--	1,990	12	--	--	--
	08/09	0345	5.2	7.3	3.4	1.1	5.3	1.0	1,970	12	1,190	500	.9
		0515	5.2	7.2	--	--	--	--	1,980	--	--	--	--
		0722	5.3	7.3	3.3	1.1	5.4	--	1,990	4.8	--	--	--
		0910	7.0	7.3	--	--	--	--	1,990	--	--	--	--
		1108	8.3	7.3	3.2	.90	5.0	--	1,930	12	--	--	--
		1332	10.1	7.3	--	--	--	--	1,860	--	--	--	--
		1505	10.1	7.4	2.9	.55	5.3	--	1,760	6.5	--	--	--
		1623	10.0	7.4	--	--	--	--	1,740	--	--	--	--
11	07/18	1845	10.0	7.4	1.3	.77	4.3	--	1,780	14	--	--	--
		2250	5.7	7.2	1.8	.78	5.3	--	1,830	10	--	--	--
	07/19	0300	4.9	7.2	--	--	--	--	1,820	--	--	--	--
		0435	4.7	7.1	2.2	.76	4.5	--	1,840	13	--	--	--
		0635	5.1	7.1	2.0	.62	4.5	--	1,810	18	--	--	--
		0935	7.1	6.8	--	--	--	--	1,780	--	--	--	--
		1025	7.4	7.1	1.9	.67	8.2	--	1,800	--	--	--	--
		1220	8.5	7.3	--	--	--	--	1,830	--	--	--	--
		1400	9.8	7.4	1.7	.70	4.5	.78	1,800	12	1,360	420	.7
		1638	10.4	7.4	--	--	--	--	1,780	--	--	--	--

	08/08	1750	9.6	7.5	2.8	1.2	6.1	--	1,910	10	--	--	--
		2020	7.8	7.3	--	--	--	--	1,900	--	--	--	--
		2222	6.5	7.1	2.9	1.6	5.7	--	1,910	12	--	--	--
	08/09	0106	5.7	7.2	--	--	--	--	1,870	--	--	--	--
		0244	5.6	7.1	3.3	1.8	5.0	1.6	1,590	10	1,250	520	.9
		0645	6.5	7.0	3.3	1.4	5.0	--	1,920	14	--	--	--
		1000	6.9	7.0	3.1	2.0	4.9	--	2,030	--	--	--	--
		1200	8.5	7.3	--	--	--	--	1,910	--	--	--	--
		1400	9.1	7.4	3.0	1.3	4.7	--	2,040	6.4	--	--	--
		1555	9.8	7.4	--	--	--	--	2,050	--	--	--	--
12	07/18	1925	8.9	7.4	1.2	.58	4.3	--	1,780	11	--	--	--
		2310	5.9	7.4	--	--	--	--	1,620	--	--	--	--
		2340	4.9	7.3	1.8	.56	4.4	--	1,620	15	--	--	--
	07/19	0450	3.9	7.1	1.2	.39	3.9	--	1,730	13	--	--	--
		0715	4.4	7.1	1.8	.53	4.2	--	1,760	16	--	--	--
		0945	6.0	7.0	--	--	--	--	1,670	--	--	--	--
		1045	5.8	7.0	1.8	--	4.3	--	1,750	10	--	--	--
		1230	7.3	7.4	--	--	--	--	1,740	--	--	--	--
		1440	8.1	7.3	1.2	.36	4.7	.50	1,740	12	1,270	770	.7
		1650	9.4	7.3	--	--	--	--	1,750	--	--	--	--
	08/08	1808	7.0	7.3	2.7	1.3	5.8	--	1,870	10	--	--	--
		2030	7.4	7.3	--	--	--	--	1,880	--	--	--	--
		2235	6.6	7.2	2.6	1.3	5.7	--	1,850	8.8	--	--	--
	08/09	0117	5.3	7.2	--	--	--	--	1,520	--	--	--	--
		0303	5.3	7.2	2.9	1.5	5.8	1.4	1,520	16	1,260	1,800	.8
		0730	5.3	6.9	3.1	1.6	5.4	--	1,900	9.4	--	--	--
		1020	6.1	7.3	3.1	1.3	5.1	--	1,900	8.2	--	--	--
		1210	6.5	7.0	--	--	--	--	1,890	--	--	--	--
		1425	6.9	7.4	3.0	1.6	5.2	--	2,010	6.6	--	--	--
		1610	7.1	7.4	--	--	--	--	2,060	--	--	--	--
13	07/18	1955	5.5	7.8	1.2	.29	4.4	--	1,780	11	--	--	--
		2325	4.4	7.4	--	--	--	--	1,690	--	--	--	--
		2400	4.0	7.4	.92	.21	3.5	--	1,580	10	--	--	--
	07/19	0325	2.8	7.2	--	--	--	--	1,710	--	--	--	--
		0505	2.7	7.2	1.5	.35	4.4	--	1,740	20	--	--	--
		0735	3.0	7.0	1.8	.36	4.3	--	1,450	15	--	--	--
		0955	4.1	7.0	--	--	--	--	1,760	--	--	--	--
		1105	4.3	7.1	1.7	.36	4.4	--	1,770	10	--	--	--
		1240	8.2	7.3	--	--	--	--	1,750	--	--	--	--
		1525	5.4	7.4	1.6	.24	4.4	.30	1,730	9.9	1,440	910	.7
		1700	6.4	7.3	--	--	--	--	1,740	--	--	--	--

Table 12.--Selected constituent concentrations measured in the East Branch Du Page River on July 18-19 and August 8-9, 1983--Continued

Site number	Date (month/ day)	Time (hours)	Oxygen, dis- solved (mg/L)	pH (units)	Phos- phorus, dis- solved (mg/L)	Nitro- gen, ammonia dis- solved (mg/L)	Nitro- gen, NO2+NO3 dis- solved (mg/L)	Nitro- gen, ammonia total (mg/L)	Spe- cific con- duct- ance (µS/cm)	Oxygen demand, bio- chemi- cal ulti- mate (mg/L)	Solids, residue at 180 deg. C dis- solved (mg/L)	Iron, total recov- erable (µg/L)	Fluo- ride, total (mg/L)
13 (Cont.)	08/08	1820	3.9	7.2	2.8	0.86	6.0	--	1,870	13	--	--	--
		2043	4.1	7.0	--	--	--	--	1,850	--	--	--	--
		2250	4.2	7.0	2.6	.92	6.2	--	1,840	6.5	--	--	--
	08/09	0137	3.9	7.1	--	--	--	--	1,490	--	--	--	--
		0327	4.2	7.1	2.5	1.0	5.9	0.90	1,500	11	1,410	4,100	0.8
		0800	4.1	7.0	3.0	1.5	5.9	--	1,910	10	--	--	--
		1045	4.6	7.1	3.0	1.2	5.6	--	1,910	8.0	--	--	--
		1220	4.4	7.2	--	--	--	--	1,880	--	--	--	--
		1440	4.9	7.3	2.9	.83	5.4	--	1,860	7.9	--	--	--
		1620	4.6	7.2	--	--	--	--	2,010	--	--	--	--
15	07/18	1751	3.6	7.2	1.2	1.2	4.2	--	1,760	13	--	--	--
		2009	3.1	7.0	--	--	--	--	1,780	--	--	--	--
		2139	2.8	6.9	1.3	1.4	4.2	--	1,780	15	--	--	--
	07/19	0010	2.6	6.9	--	--	--	--	1,740	--	--	--	--
		0154	2.6	6.9	1.3	1.4	3.9	--	1,800	15	--	--	--
		0345	2.4	7.1	--	--	--	--	1,800	--	--	--	--
		0600	2.0	7.1	1.1	1.7	3.2	--	1,710	14	--	--	--
		1000	2.4	7.0	1.5	1.8	3.8	--	1,790	22	--	--	--
		1300	2.9	7.2	--	--	--	--	1,850	--	--	--	--
		1400	3.3	7.1	--	--	--	2.1	1,850	--	1,170	750	.6
		1625	3.3	7.1	--	--	--	--	1,860	--	--	--	--
	08/08	1857	2.7	7.3	2.4	3.6	4.9	--	1,950	13	--	--	--
		2106	2.4	7.1	--	--	--	--	1,910	--	--	--	--
		2326	2.3	7.0	2.6	3.0	4.9	--	1,870	10	--	--	--
	08/09	0159	2.5	7.1	--	--	--	--	1,500	--	--	--	--
		0420	2.5	6.9	2.6	3.2	4.6	3.2	1,490	14	1,440	4,100	.8
		0840	3.0	7.3	2.5	2.7	5.0		1,870	11	--	--	--
		1120	3.2	7.3	2.5	2.6	4.9	--	1,850	13	--	--	--
		1240	4.1	7.4	--	--	--	--	1,880	--	--	--	--
		1525	4.1	7.3	2.8	3.0	4.7	--	1,890	8.9	--	--	--
		1645	4.0	7.2	--	--	--	--	2,040	--	--	--	--

16	07/18	1827	3.6	7.0	1.2	1.9	3.5	--	1,690	--	--	--	--
		2025	3.0	7.1	--	--	--	--	1,700	--	--	--	--
		2207	2.7	7.0	1.2	1.6	3.7	--	1,700	10	--	--	--
	07/19	0025	2.6	6.9	--	--	--	--	1,720	--	--	--	--
		0212	2.4	7.1	1.2	1.7	3.4	--	1,690	13	--	--	--
		0400	2.5	7.1	--	--	--	--	1,740	--	--	--	--
		0645	2.8	7.1	1.4	1.7	3.3	--	1,710	14	--	--	--
		1015	2.6	7.0	1.2	2.0	3.1	--	1,690	--	--	--	--
		1315	3.4	7.1	--	--	--	--	1,770	--	--	--	--
		1420	3.4	7.1	--	--	--	2.3	1,800	--	1,140	810	.6
		1640	4.4	7.2	--	--	--	--	1,750	--	--	--	--
	08/08	1745	1.7	7.3	2.2	3.5	3.8	--	2,030	9.4	--	--	--
		1952	1.4	7.1	--	--	--	--	2,070	--	--	--	--
		2150	1.4	7.1	2.2	3.9	3.9	--	2,120	16	--	--	--
		2353	1.3	7.2	--	--	--	--	2,160	--	--	--	--
	08/09	0130	1.3	7.4	2.5	3.5	3.8	3.5	2,130	10	1,350	430	.7
		0436	1.1	7.2	--	--	--	--	2,130	--	--	--	--
		0625	1.6	7.3	2.4	3.2	4.2	--	2,130	14	--	--	--
		0910	2.2	7.2	--	--	--	--	2,140	--	--	--	--
		1050	2.2	7.3	2.3	3.2	4.0	--	2,080	9.9	--	--	--
		1305	2.4	7.3	--	--	--	--	2,050	--	--	--	--
		1440	2.9	7.3	2.3	3.5	3.9	--	2,070	9.6	--	--	--
		1635	2.8	7.3	--	--	--	--	1,990	--	--	--	--
17	07/18	1815	4.3	7.0	.9	1.4	3.6	--	1,580	--	--	--	--
		2037	3.0	7.1	--	--	--	--	1,610	--	--	--	--
		2221	2.8	7.0	1.0	1.4	3.6	--	1,630	--	--	--	--
	07/19	0040	2.5	7.0	--	--	--	--	1,640	--	--	--	--
		0227	2.3	7.2	1.0	1.3	3.7	--	1,680	18	--	--	--
		0415	2.2	7.2	--	--	--	--	1,690	--	--	--	--
		0700	2.2	7.1	1.2	1.6	3.8	--	1,690	13	--	--	--
		1030	3.1	7.1	1.1	1.0	3.9	--	1,670	.9	--	--	--
		1325	3.7	7.1	--	--	--	--	1,690	--	--	--	--
		1445	3.7	7.2	--	--	--	1.9	1,660	--	1,090	1,540	.5
		1650	4.0	7.2	--	--	--	--	1,670	--	--	--	--
	08/08	1840	2.5	7.3	1.9	2.1	4.3	--	1,920	10	--	--	--
		2024	1.9	7.3	--	--	--	--	1,910	--	--	--	--
		2220	1.7	7.3	1.8	2.1	4.1	--	1,900	9.3	--	--	--
	08/09	0017	1.6	7.4	--	--	--	--	1,910	--	--	--	--
		0236	1.5	7.3	1.9	2.7	3.7	2.4	1,920	12	1,250	830	.7
		0502	1.6	7.3	--	--	--	--	1,980	--	--	--	--
		0655	2.0	7.3	1.9	3.1	3.8	--	2,020	11	--	--	--
		0930	2.5	7.3	--	--	--	--	1,980	--	--	--	--
		1100	2.4	7.3	2.0	2.6	4.3	--	1,960	--	--	--	--
		1335	3.9	7.3	--	--	--	--	1,950	--	--	--	--
		1520	4.1	7.4	1.9	2.0	4.5	--	1,940	5.5	--	--	--
		1655	5.1	7.4	--	--	--	--	1.920	--	--	--	--

Table 12.--Selected constituent concentrations measured in the East Branch Du Page River on July 18-19 and August 8-9, 1983--Continued

Site number	Date (month/ day)	Time (hours)	Oxygen, dis- solved (mg/L)	pH (units)	Phos- phorus, dis- solved (mg/L)	Nitro- gen, ammonia dis- solved (mg/L)	Nitro- gen, NO2+NO3 dis- solved (mg/L)	Nitro- gen, ammonia total (mg/L)	Spe- cific con- duct- ance (µS/cm)	Oxygen demand, bio- chemi- cal ulti- mate (mg/L)	Solids, residue at 180 deg. C dis- solved (mg/L)	Iron, total recov- erable (µg/L)	Fluo- ride, total (mg/L)
18	07/18	1857	3.6	7.0	0.90	1.1	3.9	--	1,590	9.4	--	--	--
		2055	3.4	7.0	--	--	--	--	1,550	--	--	--	--
		2235	3.1	7.0	.88	.87	4.0	--	1,570	11	--	--	--
	07/19	0055	2.7	7.0	--	--	--	--	1,600	--	--	--	--
		0250	2.7	7.1	.93	1.1	3.8	--	1,610	10	--	--	--
		0430	2.7	7.2	--	--	--	--	1,640	--	--	--	--
		0730	2.7	7.0	.92	.94	3.5	--	1,650	20	--	--	--
		1100	2.8	7.1	1.0	.94	4.0	--	1,630	28	--	--	--
		1500	3.9	7.2	--	--	--	0.25	1,670	--	1,020	820	0.6
		1700	4.0	7.2	--	--	--	--	1,630	--	--	--	--
	08/08	1905	2.7	7.4	1.8	1.4	4.8	--	1,870	11	--	--	--
		2039	2.2	7.2	--	--	--	--	1,870	--	--	--	--
		2250	2.0	7.3	1.8	1.7	4.5	--	1,870	7.0	--	--	--
	08/09	0035	2.4	7.4	--	--	--	2.0	1,850	--	--	--	--
		0322	2.1	7.3	1.8	2.1	4.0	--	1,860	8.1	1,210	750	.6
		0518	2.3	7.3	--	--	--	--	1,870	--	--	--	--
		0735	2.9	7.3	1.8	2.5	3.9	--	1,920	11	--	--	--
		0940	3.4	7.3	--	--	--	--	1,960	--	--	--	--
		1130	3.5	7.4	--	2.5	4.1	--	1,950	9.0	--	--	--
		1345	4.5	7.3	--	--	--	--	1,920	--	--	--	--
		1550	4.6	7.4	1.9	1.8	4.9	--	1,900	7.4	--	--	--
		1715	4.4	7.4	--	--	--	--	1,900	--	--	--	--

Table 13.--Selected constituent concentrations measured in the West Branch and Main Stem Du Page River on July 18-19 and August 8-9, 1983

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25° Celsius; µg/L, micrograms per liter; <, less than; dashes indicate no data]

Site number	Date (month/day)	Time (hours)	Oxygen, dis-solved (mg/L)	pH (units)	Phos-phorus, dis-solved (mg/L)	Nitro-gen, ammonia dis-solved (mg/L)	Nitro-gen, NO2+NO3 dis-solved (mg/L)	Nitro-gen, ammonia total (mg/L)	Spe-cific con-duct-ance (µS/cm)	Oxygen demand, bio-chemi-cal ulti-mate (mg/L)	Solids, residue at 180 deg. C dis-solved (mg/L)	Iron, total recov-erable (µg/L)	Fluo-ride, total (mg/L)
19	07/18	1900	6.3	7.0	3.2	0.58	11	--	1,260	7.7	--	--	--
		2310	5.8	--	3.3	.26	11	--	1,310	--	--	--	--
	07/19	0254	6.3	6.9	3.4	.12	11	--	1,260	--	--	--	--
		0650	6.4	6.9	3.4	< .10	11	--	1,250	--	--	--	--
		1050	6.9	6.5	3.6	< .10	12	--	1,340	2.1	--	--	--
		1410	7.2	6.9	3.7	< .10	12	0.06	1,450	5.9	860	60	1.6
	08/08	1825	8.2	7.1	4.1	< .10	14	--	1,400	4.9	--	--	--
		2145	8.3	7.1	4.3	.28	15	--	1,480	5.4	--	--	--
	08/09	0125	7.7	7.2	4.3	.37	14	.36	1,420	3.9	992	20	1.0
		0505	7.7	7.4	--	--	--	--	1,420	--	--	--	--
		0745	7.9	7.1	4.2	< .10	13	--	1,340	4.1	--	--	--
		1045	8.2	7.2	4.1	< .10	14	--	1,330	5.5	--	--	--
		1330	7.5	7.2	--	--	--	--	1,420	--	--	--	--
		1440	7.9	7.1	4.1	< .10	14	--	1,410	4.9	--	--	--
		1700	7.5	7.2	--	--	--	--	1,440	--	--	--	--
20	07/18	1925	5.8	7.0	3.2	.46	10	--	1,230	7.4	--	--	--
		2340	5.6	6.8	3.3	.42	11	--	1,260	--	--	--	--
	07/19	0310	5.4	6.9	3.3	.24	11	--	1,260	11	--	--	--
		0725	6.2	7.1	2.2	.11	9.0	--	1,230	6.2	--	--	--
		1105	8.2	6.8	3.6	< .10	12	--	1,400	3.8	--	--	--
		1435	9.0	7.2	3.7	< .10	12	.06	1,420	--	860	80	1.6
	08/08	1845	8.1	7.3	4.3	.14	14	--	1,390	7.6	--	--	--
		2205	7.3	7.3	--	--	--	--	1,470	--	--	--	--
	08/09	0205	7.0	7.3	4.2	.30	15	.25	1,420	8.6	1,000	140	1.0
		0511	6.7	7.3	--	--	--	--	1,420	--	--	--	--
		0810	7.5	7.1	4.3	< .10	14	--	1,360	4.5	--	--	--
		1100	8.9	7.2	4.2	< .10	13	--	1,320	4.4	--	--	--
		1340	9.2	7.3	--	--	--	--	1,410	--	--	--	--
		1500	9.2	7.3	3.9	< .10	14	--	1,420	3.3	--	--	--
		1716	8.6	7.2	--	--	--	--	1,420	--	--	--	--

Table 13.--Selected constituent concentrations measured in the West Branch and Main Stem Du Page River on July 18-19 and August 8-9, 1983--Continued

Site number	Date (month/ day)	Time (hours)	Oxygen, dis- solved (mg/L)	pH (units)	Phos- phorus, dis- solved (mg/L)	Nitro- gen, ammonia dis- solved (mg/L)	Nitro- gen, NO2+NO3 dis- solved (mg/L)	Nitro- gen, ammonia total (mg/L)	Spe- cific con- duct- ance (µS/cm)	Oxygen demand, bio- chemi- cal ulti- mate (mg/L)	Solids, residue at 180 deg. C dis- solved (mg/L)	Iron, total recov- erable (µg/L)	Fluo- ride, total (mg/L)
21	07/18	1955	5.8	7.0	3.0	0.28	9.6	--	1,200	--	--	--	--
	07/19	0025	5.2	6.7	3.2	.38	10	--	1,240	--	--	--	--
		0337	5.6	6.8	3.3	.33	11	--	1,280	5.3	--	--	--
		0800	5.9	7.0	3.3	.15	11	--	1,420	--	--	--	--
		1130	8.8	6.8	3.5	< .10	12	--	1,420	3.1	--	--	--
		1505	10.5	7.4	3.6	< .10	11	0.06	1,480	3.0	886	220	1.7
	08/08	1910	9.6	7.5	4.2	< .10	13	--	1,360	7.8	--	--	--
		2225	6.9	7.4	4.3	< .10	14	--	1,440	13	--	--	--
	08/09	0245	6.4	7.3	4.3	.45	14	.29	1,430	--	1,100	450	1.0
		0845	7.1	7.2	4.1	< .10	13	--	1,360	5.4	--	--	--
		1125	9.1	7.3	4.1	< .10	14	--	1,350	4.9	--	--	--
		1345	10.3	7.3	--	--	--	--	1,430	--	--	--	--
		1530	10.5	7.4	4.1	< .10	14	--	1,420	5.9	--	--	--
		1725	6.3	7.4	--	--	--	--	1,410	--	--	--	--
22	07/18	2035	4.0	7.0	2.3	.43	7.5	--	1,080	8.9	--	--	--
	07/19	0115	3.0	6.7	2.6	.66	7.1	--	1,060	20	--	--	--
		0357	2.8	6.7	2.3	.66	7.4	--	2,000	15	--	--	--
		0845	3.4	7.0	2.2	.42	7.4	--	1,110	11	--	--	--
		1150	5.1	7.1	2.4	.64	7.0	--	1,280	9.2	--	--	--
		1555	6.4	7.3	2.2	.53	6.7	.63	1,410	6.9	938	1,100	1.1
	08/08	1945	5.4	7.4	2.6	.87	8.6	--	1,340	8.6	--	--	--
		2300	4.5	7.5	3.2	1.3	9.9	--	1,390	6.7	--	--	--
	08/09	0325	5.1	7.5	3.7	1.2	9.7	1.0	1,320	5.9	962	2,700	.9
		0525	4.6	7.5	--	--	--	--	1,330	--	--	--	--
		0925	5.5	7.3	3.3	.57	10	--	1,320	9.1	--	--	--
		1145	7.6	7.4	3.3	.97	11	--	1,300	6.8	--	--	--
		1400	7.7	7.3	--	--	--	--	1,390	--	--	--	--
		1550	7.0	7.3	3.1	.84	11	--	1,420	6.7	--	--	--
		1805	6.9	7.5	--	--	--	--	1,420	--	--	--	--

23	07/18	2100	4.8	7.3	1.7	.14	7.3	--	1,110	10	--	--	--
	07/19	0134	4.7	7.0	2.0	< .10	8.0	--	1,100	11	--	--	--
		0415	5.0	7.0	2.0	.11	8.0	--	1,080	12	--	--	--
		0524	4.9	7.0	--	--	--	--	1,070	--	--	--	--
		0910	5.6	7.0	2.2	.12	7.1	--	1,100	--	--	--	--
		1215	8.8	7.0	2.1	< .10	7.1	--	1,240	--	--	--	--
		1630	8.9	7.2	2.0	< .10	7.6	.10	1,350	--	876	870	.8
	08/08	2005	6.5	7.8	3.6	.20	13	--	1,450	7.9	--	--	--
		2320	5.9	7.7	2.4	.39	8.5	--	1,390	6.6	--	--	--
	08/09	0405	5.4	7.7	2.1	.26	7.8	.27	1,360	6.7	1,100	2,400	.7
		0535	6.2	7.7	--	--	--	--	1,390	--	--	--	--
		0945	7.4	7.5	2.9	.43	10	--	1,320	5.6	--	--	--
		1200	9.0	7.6	3.0	.38	10	--	1,300	5.6	--	--	--
		1415	9.4	7.7	--	--	--	--	1,370	--	--	--	--
		1615	8.3	7.8	3.1	.12	11	--	1,400	5.5	--	--	--
		1820	8.1	7.8	--	--	--	--	1,450	--	--	--	--
24	07/18	2126	5.9	7.4	1.9	< .10	8.0	--	1,180	6.1	--	--	--
	07/19	0153	4.8	7.1	1.5	< .10	6.2	--	1,050	--	--	--	--
		0435	4.8	7.1	1.5	.11	6.4	--	1,070	--	--	--	--
		0512	4.9	7.1	--	--	--	--	1,080	--	--	--	--
		0945	5.2	7.3	1.8	< .10	6.7	--	1,130	--	--	--	--
		1240	7.4	7.6	1.7	< .10	6.6	--	1,200	13	--	--	--
		1710	8.7	7.3	1.7	< .10	--	.13	1,200	9.0	830	1,200	.6
	08/08	1900	7.8	7.6	2.9	.14	11	--	1,460	4.5	--	--	--
		2210	6.1	7.7	3.0	.19	10	--	1,420	5.1	--	--	--
	08/09	0230	5.7	7.6	--	--	--	--	1,440	--	--	--	--
		0620	5.1	7.4	2.8	.25	10	.09	1,410	5.8	932	1,500	1.0
		0815	5.6	7.4	--	--	--	--	1,370	--	--	--	--
		1010	6.3	7.4	1.9	< .10	7.3	--	1,370	4.4	--	--	--
		1225	8.6	7.6	--	--	--	--	1,340	--	--	--	--
		1405	9.3	7.6	1.8	.18	7.9	--	1,390	5.0	--	--	--
		1625	9.6	7.6	--	--	--	--	1,420	--	--	--	--
26	07/18	1900	7.4	7.5	1.5	.33	6.5	--	1,270	7.9	--	--	--
		2050	6.6	7.5	--	--	--	--	1,240	--	--	--	--
		2235	6.5	7.5	1.5	< .10	6.5	--	1,230	--	--	--	--
	07/19	0245	6.5	7.5	1.6	< .10	7.1	--	1,280	11	--	--	--
		0510	5.7	7.6	--	--	--	--	1,270	--	--	--	--
		0638	6.0	7.4	1.6	.12	6.1	--	1,190	7.7	--	--	--
		1045	6.3	7.5	1.5	.45	5.6	--	1,220	17	--	--	--
		1440	8.2	7.6	1.5	< .10	6.4	.24	1,180	10	744	1,700	1.3
		1800	8.0	7.7	--	--	--	--	1,150	--	--	--	--

Table 13.--Selected constituent concentrations measured in the West Branch and Main Stem Du Page River on July 18-19 and August 8-9, 1983--Continued

Site number	Date (month/ day)	Time (hours)	Oxygen, dis- solved (mg/L)	pH (units)	Phos- phorus, dis- solved (mg/L)	Nitro- gen, ammonia dis- solved (mg/L)	Nitro- gen, NO2+NO3 dis- solved (mg/L)	Nitro- gen, ammonia total (mg/L)	Spe- cific con- duct- ance (µS/cm)	Oxygen demand, bio- chemi- cal ulti- mate (mg/L)	Solids, residue at 180 deg. C dis- solved (mg/L)	Iron, total recov- erable (µg/L)	Fluo- ride, total (mg/L)
26	08/08	1931	7.1	7.9	2.4	<0.10	11	--	1,510	6.4	--	--	--
(Cont.)		2120	5.9	7.8	--	--	--	--	1,480	--	--	--	--
		2240	5.6	7.8	2.6	< .10	9.8	--	1,480	6.2	--	--	--
	08/09	0040	5.0	7.7	--	--	--	--	1,470	--	--	--	--
		0330	5.3	7.6	--	--	--	0.08	1,540	--	1,020	1,100	1.3
		0525	4.8	7.6	--	--	--	--	1,530	--	--	--	--
		0710	5.3	7.4	2.7	.15	10	--	1,410	9.6	--	--	--
		0850	5.9	7.6	--	--	--	--	1,430	--	--	--	--
		1035	7.6	7.6	2.6	< .10	11	--	1,460	4.7	--	--	--
		1205	9.9	7.8	--	--	--	--	1,490	--	--	--	--
		1435	11.5	7.8	2.5	.14	12	--	1,460	5.4	--	--	--
		1700	9.8	7.8	--	--	--	--	1,480	--	--	--	--
27	07/18	1915	8.4	7.7	1.3	< .10	6.2	--	1,270	12	--	--	--
		2040	7.2	7.7	--	--	--	--	1,280	--	--	--	--
		2255	6.0	7.6	1.5	--	--	--	1,280	6.0	--	--	--
	07/19	0300	5.6	7.5	1.5	< .10	6.3	--	1,230	8.7	--	--	--
		0500	5.9	7.5	--	--	--	--	1,240	--	--	--	--
		0655	5.9	7.5	1.7	.11	6.7	--	1,260	--	--	--	--
		1120	7.6	7.7	--	--	--	--	1,190	--	--	--	--
		1350	9.7	7.9	--	--	--	--	1,180	--	--	--	--
		1510	10.6	7.9	1.4	< .10	5.8	--	1,180	12	808	1,800	1.3
		1810	9.4	7.9	--	--	--	--	1,200	--	--	--	--
	08/08	2000	8.9	8.2	2.1	< .10	9.5	--	1,470	6.9	--	--	--
		2100	7.8	8.1	--	--	--	--	1,490	--	--	--	--
		2300	6.6	8.0	2.3	< .10	10	--	1,520	6.9	--	--	--
	08/09	0030	5.9	7.9	--	--	--	--	1,530	--	--	--	--
		0355	5.3	7.7	--	--	--	.05	1,510	--	948	2,000	1.6
		0505	5.1	7.7	--	--	--	--	1,500	--	--	--	--
		0735	5.4	7.6	2.6	< .10	9.8	--	1,440	8.8	--	--	--
		0840	5.9	7.9	--	--	--	--	1,480	--	--	--	--
		1050	8.0	7.7	2.6	.16	11	--	1,450	4.9	--	--	--
		1150	9.6	7.8	--	--	--	--	1,460	--	--	--	--
		1455	12.4	8.0	2.3	< .10	11	--	1,440	6.5	--	--	--
		1710	12.0	8.1	--	--	--	--	1,460	--	--	--	--

28	07/18	1930	8.6	7.8	.90	.12	4.3	--	1,260	10	--	--	--
		2020	8.0	7.7	--	--	--	--	1,260	--	--	--	--
		2315	5.6	7.6	1.5	.22	4.3	--	1,270	8.9	--	--	--
	07/19	0320	4.8	7.4	.69	.19	4.3	--	1,280	19	--	--	--
		0445	4.8	7.4	--	--	--	--	1,280	--	--	--	--
		0720	4.8	7.4	1.1	.29	5.3	--	1,250	17	--	--	--
		0915	5.6	7.4	--	--	--	--	1,250	--	--	--	--
		1145	7.8	7.7	1.3	.15	5.6	--	1,240	10	--	--	--
		1335	9.5	7.9	--	--	--	--	1,240	--	--	--	--
		1530	10.0	7.9	1.1	< .10	5.6	.11	1,220	9.1	820	740	.9
		1820	8.5	7.8	--	--	--	--	1,260	--	--	--	--
	08/08	2020	5.7	7.9	2.4	.40	5.4	--	1,550	11	--	--	--
		2320	3.6	7.7	1.5	.60	5.5	--	1,540	11	--	--	--
	08/09	0010	3.3	7.7	--	--	--	--	1,540	--	--	--	--
		0420	2.8	7.6	--	--	--	.70	1,560	--	1,010	540	1.5
		0755	2.9	7.5	1.6	--	5.6	--	1,490	12	--	--	--
		0830	3.3	8.3	--	--	--	--	1,480	--	--	--	--
		1105	9.5	7.7	1.6	.24	6.3	--	1,500	7.5	--	--	--
		1135	9.0	7.8	--	--	--	--	1,520	--	--	--	--
		1515	12.8	8.0	1.6	< .10	7.2	--	1,520	8.8	--	--	--
		1720	10.1	8.0	--	--	--	--	1,530	--	--	--	--
30	07/18	2000	8.6	7.7	.92	< .10	5.8	--	1,400	7.0	--	--	--
		2350	7.6	7.7	.98	< .10	--	--	1,380	6.5	--	--	--
	07/19	0400	6.7	7.6	.89	< .10	5.4	--	1,410	9.9	--	--	--
		0810	6.4	7.5	1.0	.26	5.2	--	1,430	--	--	--	--
		0845	6.5	7.5	--	--	--	--	1,430	--	--	--	--
		1245	7.4	7.6	1.0	.15	5.0	--	1,380	13	--	--	--
		1620	8.5	7.8	1.1	< .10	5.3	.09	1,370	12	910	620	.8
		1840	8.3	7.9	--	--	--	--	1,370	--	--	--	--
	08/08	1800	9.1	7.8	1.3	< .10	5.6	--	1,680	10	--	--	--
		2005	9.0	7.7	--	--	--	--	1,690	9.9	--	--	--
		2155	8.5	7.8	1.4	< .10	6.2	--	1,690	--	--	--	--
	08/09	0200	8.2	7.8	1.3	.14	6.3	.13	1,700	8.0	1,180	1,500	1.1
		0615	6.8	7.5	1.3	.12	6.2	--	1,770	8.0	--	--	--
		0830	7.0	7.5	--	--	--	--	1,810	--	--	--	--
		1000	6.8	7.7	1.4	.11	6.5	--	1,780	5.0	--	--	--
		1230	7.7	7.6	--	--	--	--	1,850	--	--	--	--
		1400	9.0	7.6	1.5	< .10	6.6	--	1,850	8.8	--	--	--
		1540	9.6	7.7	--	--	--	--	1,790	--	--	--	--

Table 13.--Selected constituent concentrations measured in the West Branch and Main Stem Du Page River on July 18-19 and August 8-9, 1983--Continued

Site number	Date (month/ day)	Time (hours)	Oxygen, dis- solved (mg/L)	pH (units)	Phos- phorus, dis- solved (mg/L)	Nitro- gen, ammonia dis- solved (mg/L)	Nitro- gen, NO2+NO3 dis- solved (mg/L)	Nitro- gen, ammonia total (mg/L)	Spe- cific con- duct- ance (µS/cm)	Oxygen demand, bio- chemi- cal ulti- mate (mg/L)	Solids, residue at 180 deg. C dis- solved (mg/L)	Iron, total recov- erable (µg/L)	Fluo- ride, total (mg/L)
31	07/18	1827	10.2	7.8	0.79	<0.10	5.4	--	1,260	7.8	--	--	--
		2117	7.4	7.6	--	--	--	--	1,280	--	--	--	--
		2210	6.5	7.6	.80	< .10	5.6	--	1,240	7.6	--	--	--
	07/19	0158	5.6	7.6	.83	< .10	5.3	--	1,300	6.6	--	--	--
		0442	5.4	7.6	--	--	--	--	1,230	--	--	--	--
		0615	4.7	7.5	1.0	< .10	4.1	--	1,140	7.6	--	--	--
		0845	5.6	7.5	--	--	--	--	1,280	--	--	--	--
		1005	6.6	7.6	.87	< .10	4.4	--	1,270	10	--	--	--
		1145	8.5	7.7	--	--	--	--	1,300	--	--	--	--
		1400	9.2	7.7	.83	< .10	4.6	0.07	1,370	9.1	1,190	1,100	0.7
	08/08	1815	15.2	8.2	1.1	< .10	5.4	--	1,620	11	--	--	--
		2015	14.9	8.1	--	--	--	--	1,620	--	--	--	--
		2213	9.2	8.0	1.2	< .10	5.2	--	1,640	9.1	--	--	--
	08/09	0230	5.8	7.7	1.1	.12	5.7	.11	1,650	9.1	1,110	930	1.1
		0645	4.8	7.6	1.3	.14	6.3	--	1,710	10	--	--	--
		0845	5.1	7.6	--	--	--	--	1,700	--	--	--	--
		1015	6.1	7.2	1.1	< .10	5.9	--	1,660	11	--	--	--
		1240	10.7	8.0	--	--	--	--	1,680	--	--	--	--
		1415	14.2	8.0	1.1	.17	6.0	--	1,690	10	--	--	--
		1550	16.1	8.0	--	--	--	--	1,700	--	--	--	--
32	07/18	1854	9.2	7.8	.74	< .10	5.0	--	1,320	9.0	--	--	--
		2134	7.9	7.8	--	--	--	--	1,330	--	--	--	--
		2230	7.5	7.8	.78	< .10	5.0	--	1,300	7.7	--	--	--
	07/19	0221	6.3	7.6	.75	< .10	4.6	--	1,340	10	--	--	--
		0453	6.0	7.6	--	--	--	--	1,280	--	--	--	--
		0640	5.8	7.6	1.0	< .10	4.8	--	1,250	7.6	--	--	--
		0900	6.4	7.6	--	--	--	--	1,280	--	--	--	--
		1020	6.9	7.6	.88	< .10	4.8	--	1,260	8.2	--	--	--
		1155	8.0	7.7	--	--	--	--	1,270	--	--	--	--
		1425	10.6	7.8	.84	< .10	4.7	.03	1,290	11	1,160	1,200	.8

	08/08	1835	15.1	8.2	1.1	< .10	4.9	--	1,600	18	--	--	--
		2025	13.2	8.2	--	--	--	--	1,610	--	--	--	--
		2230	10.1	8.2	1.0	< .10	4.8	--	1,630	11	--	--	--
	08/09	0257	7.0	8.0	1.0	< .10	5.0	.04	1,650	9.0	1,130	1,300	1.1
		0700	5.5	7.7	1.0	< .10	5.2	--	1,700	10	--	--	--
		0900	6.5	7.8	--	--	--	--	1,710	--	--	--	--
		1035	8.0	8.0	1.1	< .10	5.6	--	1,650	11	--	--	--
		1250	12.7	8.0	--	--	--	--	1,670	--	--	--	--
		1430	14.0	8.0	1.0	.14	5.5	--	1,670	13	--	--	--
		1600	15.7	8.1	--	--	--	--	1,660	--	--	--	--
33	07/18	1917	9.1	7.8	.76	< .10	4.5	--	1,280	7.6	--	--	--
		2258	6.9	7.7	.71	< .10	5.1	--	1,300	9.3	--	--	--
	07/19	0048	6.5	7.7	--	--	--	--	1,290	--	--	--	--
		0246	6.2	7.7	.70	< .10	4.5	--	1,330	9.6	--	--	--
		0505	5.9	7.6	--	--	--	--	1,270	--	--	--	--
		0715	5.6	7.6	.85	< .10	4.6	--	1,270	6.8	--	--	--
		0915	6.2	7.6	--	--	--	--	1,280	--	--	--	--
		1040	7.0	7.6	.84	< .10	4.9	--	1,280	6.5	--	--	--
		1210	8.0	7.7	--	--	--	--	1,300	--	--	--	--
		1450	9.9	7.8	.82	< .10	4.5	--	1,290	7.8	1,130	--	.8
	08/08	1855	12.1	8.2	.92	< .10	4.4	--	1,570	9.3	--	--	--
		2035	9.7	8.0	--	--	--	--	1,580	--	--	--	--
		2250	7.1	8.1	.99	< .10	4.3	--	1,590	7.7	--	--	--
	08/09	0055	6.6	8.0	--	--	--	--	1,600	--	--	--	--
		0340	6.2	7.9	.99	< .10	4.3	.02	1,620	9.7	1,060	890	1.0
		0720	6.5	8.4	.98	< .10	4.6	--	1,680	12	--	--	--
		0915	7.0	7.8	--	--	--	--	1,680	--	--	--	--
		1050	9.6	7.9	.94	.17	4.6	--	1,630	8.3	--	--	--
		1300	14.0	8.3	--	--	--	--	1,630	--	--	--	--
		1450	15.5	8.1	.91	.17	4.6	--	1,620	11	--	--	--
		1615	15.4	8.2	--	--	--	--	1,620	--	--	--	--
34	07/18	1942	8.5	7.8	.71	< .10	4.6	--	1,260	5.8	--	--	--
		2321	7.0	7.8	.74	< .10	4.4	--	1,260	6.4	--	--	--
	07/19	0059	6.2	7.7	--	--	--	--	1,320	--	--	--	--
		0320	5.9	7.6	.69	< .10	4.4	--	1,290	--	--	--	--
		0514	5.9	7.6	--	--	--	--	1,270	--	--	--	--
		0735	5.9	7.6	.83	< .10	4.5	--	1,270	6.0	--	--	--
		0930	6.5	7.6	--	--	--	--	1,270	--	--	--	--
		1050	7.3	7.6	.77	< .10	4.7	--	1,270	6.4	--	--	--
		1220	8.6	7.7	--	--	--	--	1,290	--	--	--	--
		1515	10.0	7.9	.81	< .10	5.4	.02	1,280	10	1,110	550	.8

Table 13.--Selected constituent concentrations measured in the West Branch and Main Stem Du Page River on July 18-19 and August 8-9, 1983--Continued

Site number	Date (month/day)	Time (hours)	Oxygen, dissolved (mg/L)	pH (units)	Phosphorus, dissolved (mg/L)	Nitrogen, ammonia dissolved (mg/L)	Nitrogen, NO2+NO3 dissolved (mg/L)	Nitrogen, ammonia total (mg/L)	Specific conductance (µS/cm)	Oxygen demand, biochemical ultimate (mg/L)	Solids, residue at 180 deg. C dissolved (mg/L)	Iron, total recoverable (µg/L)	Fluoride, total (mg/L)
34	08/08	1915	12.8	8.5	0.86	<0.10	4.1	--	1,550	12	--	--	--
(Cont.)		2050	10.0	8.3	--	--	--	--	1,550	--	--	--	--
		2320	6.8	8.4	.91	< .10	4.3	--	1,560	9.7	--	--	--
	08/09	0045	6.6	8.1	--	--	--	--	1,560	--	--	--	--
		0410	5.3	7.8	.80	< .10	4.1	0.01	1,580	8.7	1,030	970	0.9
		0740	6.6	7.8	.91	< .10	4.2	--	1,630	15	--	--	--
		0930	8.1	7.8	--	--	--	--	1,640	--	--	--	--
		1110	11.0	7.8	.87	< .10	4.1	--	1,560	9.7	--	--	--
		1315	15.8	8.3	--	--	--	--	1,590	--	--	--	--
		1510	17.7	8.5	.82	.37	4.1	--	1,580	12	--	--	--
		1620	18.0	8.3	--	--	--	--	1,580	--	--	--	--
35	07/18	2007	8.6	7.9	.62	< .10	4.1	--	1,220	6.4	--	--	--
		2354	6.3	7.7	.63	< .10	4.3	--	1,230	6.9	--	--	--
	07/19	0117	6.2	7.7	--	--	--	--	1,230	--	--	--	--
		0343	6.1	7.7	.64	< .10	4.1	--	1,250	--	--	--	--
		0525	6.0	7.6	--	--	--	--	1,290	--	--	--	--
		0750	6.8	7.6	.79	< .10	4.4	--	1,200	5.4	--	--	--
		0945	8.4	7.8	--	--	--	--	1,200	--	--	--	--
		1115	11.0	7.9	.69	< .10	4.6	--	1,190	4.8	--	--	--
		1230	12.9	8.0	--	--	--	--	1,250	--	--	--	--
		1545	14.2	8.1	.64	< .10	5.0	--	1,250	5.3	1,040	--	.7
	08/08	1820	8.6	8.5	.66	< .10	3.8	--	1,550	13	--	--	--
		2005	6.9	8.3	--	--	--	--	1,560	--	--	--	--
		2208	4.8	8.2	.73	< .10	3.7	--	1,560	13	--	--	--
	08/09	0008	4.8	8.1	--	--	--	--	1,550	--	--	--	--
		0206	4.3	8.1	.78	< .10	3.6	.03	1,560	8.9	1,000	1,100	.9
		0453	4.3	7.9	--	--	--	--	1,560	--	--	--	--
		0710	5.9	7.9	.82	< .10	3.8	--	1,560	11	--	--	--
		0925	9.1	7.9	--	--	--	--	1,560	--	--	--	--
		1030	11.2	8.0	.84	< .10	3.5	--	1,560	12	--	--	--
		1325	18.2	8.4	--	--	--	--	1,540	--	--	--	--
		1500	18.4	8.4	.67	< .10	3.5	--	1,530	12	--	--	--
		1650	17.8	8.4	--	--	--	--	1,530	--	--	--	--

36	07/18	1852	11.2	8.0	.64	< .10	3.9	--	1,170	6.3	--	--	--
		2055	7.9	7.8	--	--	--	--	1,180	--	--	--	--
		2235	6.2	7.6	.59	< .10	4.0	--	1,190	5.3	--	--	--
	07/19	0055	5.7	7.6	--	--	--	--	1,220	--	--	--	--
		0242	5.7	7.6	.67	< .10	4.1	--	1,240	5.8	--	--	--
		0430	5.5	7.6	--	--	--	--	1,250	--	--	--	--
		0730	6.3	7.5	.60	< .10	4.1	--	1,270	5.5	--	--	--
		1100	8.3	7.7	.61	< .10	4.5	--	1,260	7.9	--	--	--
		1500	12.1	8.1	--	--	--	.89	1,260	--	1,030	1,100	.5
		1700	13.2	8.2	--	--	--	--	1,250	--	--	--	--
	08/08	1858	9.1	8.4	.60	< .10	3.5	--	1,520	13	--	--	--
		2044	6.3	8.6	--	--	--	--	1,540	--	--	--	--
		2245	4.2	8.1	.67	< .10	3.6	--	1,550	12	--	--	--
	08/09	0029	4.2	8.2	--	--	--	--	1,560	--	--	--	--
		0306	4.0	8.2	.79	< .10	3.5	.02	1,550	11	1,030	500	.9
		0516	4.3	7.9	--	--	--	--	1,550	--	--	--	--
		0735	5.7	7.9	.78	< .10	3.5	--	1,550	12	--	--	--
		0945	9.7	8.0	--	--	--	--	1,540	--	--	--	--
		1120	13.9	8.1	.78	< .10	3.3	--	1,530	9.5	--	--	--
		1350	18.1	8.3	--	--	--	--	1,510	--	--	--	--
		1540	18.5	8.5	.63	.36	3.2	--	1,500	14	--	--	--
		1710	18.4	8.5	--	--	--	--	1,500	--	--	--	--
37	07/18	1918	5.9	7.4	.70	.22	4.2	--	1,430	7.6	--	--	--
		2120	4.1	7.3	--	--	--	--	1,420	--	--	--	--
		2301	3.8	7.2	.74	.17	4.2	--	1,400	7.4	--	--	--
	07.19	0110	3.4	7.2	--	--	--	--	1,430	--	--	--	--
		0309	3.3	7.3	.87	.28	4.2	--	1,460	--	--	--	--
		0450	3.3	7.3	--	--	--	--	1,470	--	--	--	--
		0815	4.4	7.2	.78	.25	3.9	--	1,490	6.9	--	--	--
		1130	6.2	7.4	.83	< .10	4.4	--	1,490	17	--	--	--
		1330	6.6	7.5	--	--	--	--	1,490	--	--	--	--
		1545	7.4	7.6	--	--	--	.03	1,510	--	862	260	.7
		1725	7.2	7.7	--	--	--	--	1,500	--	--	--	--
	08/08	1925	5.2	7.8	1.2	.27	4.6	--	1,710	14	--	--	--
		2058	3.1	7.7	--	--	--	--	1,740	--	--	--	--
		2303	2.1	7.6	1.3	.50	4.5	--	1,760	12	--	--	--
	08/09	0046	2.1	7.6	--	--	--	--	1,760	--	--	--	--
		0352	2.1	7.5	1.4	.89	4.3	.82	1,760	14	1,150	610	.7
		0529	2.2	7.5	--	--	--	--	1,760	--	--	--	--
		0815	4.9	7.6	1.4	.81	4.1	--	1,730	--	--	--	--
		1000	7.4	7.6	--	--	--	--	1,740	--	--	--	--
		1210	10.4	7.8	1.4	.77	4.3	--	1,750	8.1	--	--	--
		1400	12.3	7.9	--	--	--	--	1,760	--	--	--	--
		1600	13.1	8.0	1.4	.38	4.7	--	1,760	9.1	--	--	--
		1730	12.1	8.1	--	--	--	--	1,750	--	--	--	--

Table 13.--Selected constituent concentrations measured in the West Branch and Main Stem Du Page River on July 18-19 and August 8-9, 1983--Continued

Site number	Date (month/ day)	Time (hours)	Oxygen, dis- solved (mg/L)	pH (units)	Phos- phorus, dis- solved (mg/L)	Nitro- gen, ammonia dis- solved (mg/L)	Nitro- gen, NO2+NO3 dis- solved (mg/L)	Nitro- gen, ammonia total (mg/L)	Spe- cific con- duct- ance (µS/cm)	Oxygen demand, bio- chemi- cal ulti- mate (mg/L)	Solids, residue at 180 deg. C dis- solved (mg/L)	Iron, total recov- erable (µg/L)	Fluo- ride, total (mg/L)
38	07/18	1805	12.3	7.9	0.80	<0.10	4.6	--	1,410	8.5	--	--	--
		2145	6.8	7.9	.81	< .10	4.7	--	1,420	10	--	--	--
	07/19	0005	5.9	7.7	--	--	--	--	1,410	--	--	--	--
		0215	4.8	7.6	.79	< .10	4.6	--	1,380	6.9	--	--	--
		0430	4.8	7.5	--	--	--	--	1,380	--	--	--	--
		0630	4.6	7.1	.85	< .10	4.7	--	1,390	6.4	--	--	--
		0945	7.8	7.2	.79	< .10	4.2	--	1,380	9.9	--	--	--
		1215	11.1	7.4	--	--	--	--	1,400	--	--	--	--
		1400	12.6	7.5	.77	< .10	4.9	0.06	1,380	12	1,000	550	0.6
	08/08	1750	19.5	8.1	1.2	< .10	4.9	--	1,600	11	--	--	--
		1950	13.7	8.0	--	--	--	--	1,650	--	--	--	--
		2145	8.3	7.8	1.3	< .10	5.2	--	1,690	13	--	--	--
	08/09	0040	4.7	7.7	--	--	--	--	1,690	--	--	--	--
		0200	4.2	7.6	1.4	.14	5.3	.10	1,700	6.5	1,160	430	.7
		0440	3.7	7.5	--	--	--	--	1,680	--	--	--	--
		0635	3.0	7.5	1.4	.14	5.0	--	1,680	6.5	--	--	--
		0815	5.2	7.5	--	--	--	--	1,660	--	--	--	--
		1020	9.8	7.8	1.4	.16	4.5	--	1,660	--	--	--	--
		1220	15.7	7.9	--	--	--	--	1,620	--	--	--	--
		1410	17.0	8.1	1.3	< .10	4.8	--	1,590	9.5	--	--	--
		1545	21.6	8.2	--	--	--	--	1,580	--	--	--	--
39	07/18	1835	12.0	8.0	.70	< .10	4.6	--	1,310	9.3	--	--	--
		2210	8.6	8.0	.76	< .10	4.6	--	1,340	5.4	--	--	--
	07/19	0020	7.4	7.9	--	--	--	--	1,350	--	--	--	--
		0230	6.2	7.8	.75	< .10	5.0	--	1,360	8.9	--	--	--
		0445	5.5	7.7	--	--	--	--	1,340	--	--	--	--
		0700	5.3	7.2	.81	< .10	5.1	--	1,330	5.9	--	--	--
		1010	9.1	7.3	.71	< .10	4.8	--	1,290	5.6	--	--	--
		1230	11.4	7.5	--	--	--	--	1,280	--	--	--	--
		1440	13.2	7.6	.70	< .10	4.9	.02	1,310	6.2	940	560	.6

	08/08	1825	19.4	8.3	.73	< .10	4.2	--	1,540	18	--	--	--
		2000	15.5	8.2	--	--	--	--	1,550	--	--	--	--
		2210	11.4	8.2	1.1	< .10	4.5	--	1,580	12	--	--	--
	08/09	0050	7.9	7.9	--	--	--	--	1,630	--	--	--	--
		0240	5.8	7.8	1.2	< .10	4.9	.02	1,660	9.2	1,130	660	.7
		0450	5.0	7.6	--	--	--	--	1,660	--	--	--	--
		0650	4.4	7.6	1.3	< .10	5.0	--	1,660	12	--	--	--
		0825	6.7	7.3	--	--	--	--	1,670	--	--	--	--
		1045	11.4	7.7	1.3	< .10	4.6	--	1,650	12	--	--	--
		1230	15.6	7.8	--	--	--	--	1,630	--	--	--	--
		1430	19.0	8.1	1.2	< .10	4.6	--	1,590	11	--	--	--
		1600	22.8	8.2	--	--	--	--	1,570	--	--	--	--
40	07/18	1905	11.4	8.1	.62	< .10	4.6	--	1,260	9.2	--	--	--
		2230	8.7	8.1	.69	< .10	4.5	--	1,280	6.4	--	--	--
	07/19	0035	8.0	8.0	--	--	--	--	1,290	--	--	--	--
		0245	7.0	8.0	.71	< .10	4.5	--	1,300	5.4	--	--	--
		0500	6.6	7.9	--	--	--	--	1,320	--	--	--	--
		0730	5.8	7.4	.71	< .10	9.1	--	1,330	6.2	--	--	--
		1030	9.5	7.5	.71	< .10	5.0	--	1,300	7.5	--	--	--
		1240	10.9	7.6	--	--	--	--	1,280	--	--	--	--
		1500	12.8	7.6	.66	< .10	5.0	.02	1,290	8.3	774	510	.6
	08/08	1845	20.5	8.3	.98	< .10	4.3	--	1,560	14	--	--	--
		2020	15.0	8.2	--	--	--	--	1,550	--	--	--	--
		2230	11.1	8.2	.99	< .10	4.1	--	1,550	14	--	--	--
	08/09	0100	8.2	8.1	--	--	--	--	1,550	--	--	--	--
		0310	6.2	8.1	.88	< .10	3.9	.01	1,550	14	1,050	700	.7
		0505	6.0	8.0	--	--	--	--	1,560	--	--	--	--
		0720	6.0	7.9	1.0	< .10	4.3	--	1,570	11	--	--	--
		0830	7.8	8.0	--	--	--	--	1,590	--	--	--	--
		1100	12.8	8.0	1.1	< .10	4.1	--	1,610	16	--	--	--
		1240	18.8	8.1	--	--	--	--	1,590	--	--	--	--
		1445	24.1	8.3	1.1	< .10	4.3	--	1,570	14	--	--	--
		1610	24.8	8.4	--	--	--	--	1,550	--	--	--	--
42	07/18	1950	10.1	8.0	.57	< .10	4.3	--	1,180	10	--	--	--
		2315	8.1	8.0	.56	< .10	4.3	--	1,180	7.1	--	--	--
	07/19	0145	8.3	8.0	--	--	--	--	1,200	--	--	--	--
		0320	7.6	7.9	.59	< .10	4.2	--	1,200	7.3	--	--	--
		0530	7.0	7.9	--	--	--	--					
		0815	6.5	7.4	.60	< .10	4.5	--	1,190	6.8	--	--	--
		1115	10.7	7.6	.61	< .10	4.6	--	1,190	6.7	--	--	--
		1300	12.4	7.7	--	--	--	--	1,180	--	--	--	--
		1550	14.3	7.8	.59	< .10	4.8	.05	1,190	8.0	750	730	.5

Table 13.--Selected constituent concentrations measured in the West Branch and Main Stem Du Page River on July 18-19 and August 8-9, 1983--Continued

Site number	Date (month/ day)	Time (hours)	Oxygen, dis- solved (mg/L)	pH (units)	Phos- phorus, dis- solved (mg/L)	Nitro- gen, ammonia dis- solved (mg/L)	Nitro- gen, NO2+NO3 dis- solved (mg/L)	Nitro- gen, ammonia total (mg/L)	Spe- cific con- duct- ance (µS/cm)	Oxygen demand, bio- chemi- cal ulti- mate (mg/L)	Solids, residue at 180 deg. C dis- solved (mg/L)	Iron, total recov- erable (µg/L)	Fluo- ride, total (mg/L)
42	08/08	1920	20.7	8.4	0.84	<0.10	3.6	--	1,400	16	--	--	--
(Cont.)		2055	15.5	8.3	--	--	--	--	1,460	--	--	--	--
		2300	11.4	8.2	.88	< .10	3.6	--	1,450	13	--	--	--
	08/09	0135	8.7	8.1	--	--	--	--	1,450	--	--	--	--
		0400	6.9	8.0	.81	< .10	3.6	0.01	1,430	17	1,010	680	0.6
		0530	6.2	7.9	--	--	--	--	1,430	--	--	--	--
		0800	6.1	7.9	.79	< .10	3.5	--	1,400	12	--	--	--
		0850	8.7	7.9	--	--	--	--	1,380	--	--	--	--
		1130	15.8	8.2	.81	< .10	3.2	--	1,400	12	--	--	--
		1300	22.4	8.3	--	--	--	--	1,390	--	--	--	--
		1515	26.3	8.5	.75	< .10	3.1	--	1,360	16	--	--	--
		1630	29.3	8.5	--	--	--	--	1,380	--	--	--	--