U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Nutrients and Suspended Solids in Surface Waters of the Upper Illinois River Basin in Illinois, Indiana, and Wisconsin, 1978–97

By Daniel J. Sullivan

Water-Resources Investigations Report 99–4275

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U.S. DEPARTMENT OF THE INTERIOR
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summer and lowest in the winter. The increase during the summer can be attributed to higher streamflow and the associated increase in runoff and transport, as well as increased phytoplankton growth.

data for future examinations for trends, and (6) provide data to the NAWQA National Synthesis Team, who will assemble data from the individual NAWQA study areas and interpret this information from a national perspective.

Plaines River drains 2,111 mi^2 or 19.3 percent of the study area, and includes 673 mi^2 that originally drained to Lake Michigan through the Chicago and Calumet Rivers. The remaining 992 mi^2 or 9.2 percent is drained by tributaries that discharge to the 33-mi.-long main stem of the Illinois River between Morris and Ottawa, Ill. The Illinois River, the lower reaches of the Des Plaines River, and two canal systems in the Chicago metropolitan area provide a navigable link between Lake Michigan and the Mississippi River.

Five major changes in the upper Illinois River Basin have undoubtedly changed the quality of surface waters a great deal–construction of navigable waterways, diversion of Lake Michigan water, construction of wastewater-treatment plants, drainage of wetlands, establishment of farming and other agricultural activities, and most recently, the construction of the Tunnel and Reservoir Project (TARP), the Nation’s largest public works project for pollution and flood control. Some of the earliest activities were the development of transportation corridors. These corridors opened a passageway between the Great Lakes and the Mississippi River, first by the use of natural waterways and constructed canal systems and later by the use of railroads. With the ease of transportation came waves of immigrants. The basin population grew steadily, creating urban and industrial growth areas along the Lake Michigan shoreline and along major rivers such as the Illinois and Des Plaines. The rapid growth in the urban areas made wastewater disposal a serious issue. Agriculture also developed as farmers moved into the basin to supply the urban areas with food and other goods.

In 1990, agriculture, urban land, and forest accounted for about 75, 17, and 5 percent, respectively, of the land use in the basin (Arnold and others, 1999). Since the late 1970's, agriculture and forest has declined while urban land area has increased.

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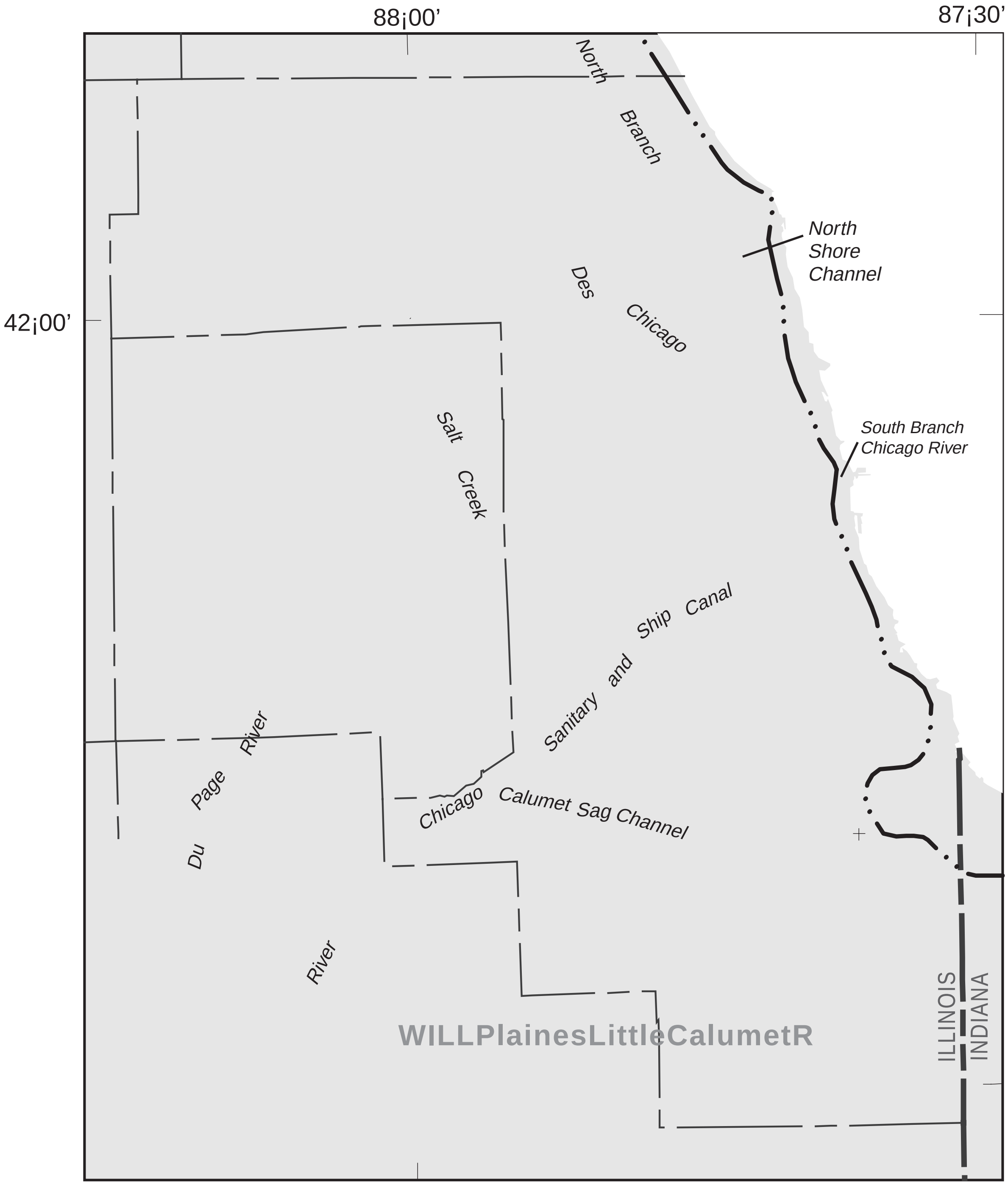

Figure 4. Location of canals, selected major wastewater-treatment plants, and completed Tunnel and Reservoir Project tunnels.

of 10.1 million people: 5.1 million residents, a commercial and industrial equivalent of 4.5 million people, and a combined-sewer-overflow equivalent of 0.5 million people. The MWRDGC has 547 mi of intercepting sewers that range in size from 12 in. to 27 ft in diameter and are fed by approximately 10,000 local sewer system connections. The return flow from its treatment operations averages about 2,200 ft^3/s (Metropolitan Water Reclamation District of Greater Chicago, 1995).

The two major sources of return flow in the study area are Lake Michigan water and ground water. Of the total flow leaving the study area, about 28 percent is contributed by the Chicago Sanitary and Ship Canal. The three largest wastewater-treatment plants in the study area discharge to the canal (or upstream from it) and contribute 73 percent of all effluent flow in the study area. Overall, wastewater-treatment plants in Illinois contribute about 97 percent of the effluent discharged to streams in the study area; wastewater-treatment plants in Indiana and Wisconsin contribute 1 and 2 percent, respectively (Zogorski and others, 1990).

Since 1985, runoff in the Chicago area has been diverted into a series of underground tunnels called the Tunnel and Reservoir Plan (TARP) (fig. 4), where the runoff is captured during intense precipitation and is stored until it can be treated and discharged as effluent. The TARP was designed to eliminate discharge of raw sewage during storms and thus decrease the resultant concentrations of pollutants discharged to streams (Metropolitan Water Reclamation District of Greater Chicago, 1999).

The average annual surface-water discharge from the upper Illinois River Basin is estimated to be 12,600 ft^3/s, on the basis of records from gaging stations near the terminus of the basin. These stations, the Fox River at Dayton, Ill. (site 39) and Illinois River at Marseilles, Ill. (site 29) are 2 of 81 active streamflow gaging stations in the study area as of 1997. The highest monthly streamflows in the study area typically are during June or July, and the lowest monthly streamflow is during November or December.

Trends in Streamflow

Long-term trends in streamflow were analyzed for seven stations that represent flow from major rivers in the study area. All of these stations had streamflow records dating back to at least 1950. Results of regression analyses indicate an upward trend in annual mean flows during 1950–97 at all seven stations (fig. 5).

The annual 7-day low flow also increased at five of the seven stations analyzed, whereas annual maximum flow increased at three of the seven stations. The most dramatic increases in all flow regimes were at stations draining urbanized land, although increases were noted at agricultural stations as well.

The most probable reasons for the increases in low flow are increased discharges of return flows to the streams as a result of urban growth and an upward trend in precipitation during the period. As a result, urban streams show a larger increase in flows than do agricultural streams. As population increases, more water is pumped from ground-water sources and discharged as effluent to the streams. Thus, for many of the rivers in areas that have undergone urban growth, some very low streamflows observed in the past may not occur again because point-source discharges now maintain a higher base rate of streamflow. This effect is further illustrated in flow-duration curves in Schmidt and Blanchard (1997), which show flows at the Des Plaines River at Riverside of below 20 ft^3/s for 1948–91, but no flows less than 100 ft^3/s for 1978–91.

A particularly large increase in annual mean flow was observed at the Des Plaines River site at Riverside, Ill., where data indicate an average increase in annual mean flow of almost 10 ft^3/s per year during 1950–97 (fig. 5); however, further analysis of mean annual streamflow data indicates a step increase around 1980. The two major treatment plants upstream from this site began operations in 1975 and 1980 and contributed an average of about 32 and 53 ft^3/s to the streamflow at this site during 1978–88 (Terrio, 1994). During 1975–97, mean annual streamflow was 682 ft^3/s, compared to 565 ft^3/s for the period 1950–97. Therefore, although there was increase above and beyond the additional discharge from the treatment plants, much of the streamflow increase was due to effluent flow. Prior to 1975, wastewater that is now routed to these two treatment plants was routed to treatment plants that discharged downstream from the Riverside site.

DESCRIPTION OF DATA USED IN REPORT

Also examined were total suspended solids and volatile solids.

In surface waters, the primary component of nitrite plus nitrate nitrogen is nitrate; thus, in this report, this constituent will be referred to as “nitrate”. Ammonia

Table 1. Selected information for Illinois Environmental Protection Agency monitoring sites in the upper Illinois River Basin—Continued

Map reference number	IEPA station number	USGS station number	Station name	Drainage area (square miles)	Mean annual streamflow	Period of record[1]	
						Stream-flow	Water quality
			Kankakee River Basin				
1	F 02	05520500	Kankakee River at Momence, Ill.	2,294[2]	2,081	1914	1975
2	FL 04	05525000	Iroquois River at Iroquois, Ill.	686	589	1945	1972
3	FLI 02	05525500	Sugar Creek at Milford, Ill.	446	380	1948	1978
4	FL 02	05526000	Iroquois River near Chebanse, Ill.	2,091	1,741	1923	1959
5	F 01	05527500	Kankakee River near Wilmington, Ill.	5,150	4,709	1934	1959
			Des Plaines River Basin				
6	G 08	05527800	Des Plaines River at Russell, Ill.	123	97.9	1967	1964
7	G 07	05528000	Des Plaines River near Gurnee, Ill.	232	237	1977	1972
8	G 22	05529000	Des Plaines River near Des Plaines, Ill.	360	289	1941	1977
9	G 15	05530590	Des Plaines River at Schiller Park, Ill.	444	--	--	1967
10	GL 09	05531500	Salt Creek at Western Springs, Ill.	115	128	1946	1977
11	GLA 02	05532000	Addison Creek at Bellwood, Ill.	17.9	16.5		

			Des Plaines River Basin—Continued				
24	GBL 10	05540210	East Branch Du Page River at Route 34 bridge at Lisle, Ill.	57	--	--	1977
25	GB 10	05540290	Du Page River near Naperville, Ill.	220	--	--	1968
26	GB 11	05540500	Du Page River at Shorewood, Ill.	324	286	1941	1978
			Illinois River Basin				
27	DW 01	05541710	Aux Sable Creek near Morris, Ill.	172	--	--	1979
28	DV 04	05542000	Mazon River near Coal City, Ill.	455	355	1940–95	1978
29	D 23	05543500	Illinois River at Marseilles, Ill.	8,259[3]	10,820	1920	1975
			Fox River Basin				
30	DT 35	05546700	Fox River near Channel Lake, Ill.	1,256	--	--	1971
31	DTK 04	05548280	Nippersink Creek near Spring Grove, Ill.	192	152	1976	1976
32	DT 22	05549600	Fox River near Crystal Lake, Ill.	1,278	--	--	1979
33	DT 06	05550000	Fox River at Algonquin, Ill.	1,403	885	1916	1959
34	DTG 02	05550500	Poplar Creek at Elgin, Ill.	35.2	26.2	1951	1977
35	DT 09	05551000	Fox River at South Elgin, Ill.	1,556	1,290	1990	1969
36	DT 38	05551540	Fox River at Montgomery, Ill.	1,732	--	--	1971
37	DTD 02	05551700	Blackberry Creek near Yorkville, Ill.	70.2	54.2	1961	1977
38	DTB 01	05551995	Somonauk Creek near Sheridan, Ill.	83.3	--	--	1979
39							

tion/evaporation method; however, suspended-sediment concentration is determined by filtering the entire volume of water sample in a pint or quart bottle (Guy, 1969; Knott and others, 1993), whereas suspended-solids concentration is determined by filtering a 250-mL aliquot from a sample (Illinois Environmental Protection Agency, 1987). Scatterplots of the data indicated strong correlations between results from the two methods (fig. 6). Regression analyses of data from the eight sites indicated that differences between the two methods were statistically different except at the Chicago Sanitary and Ship Canal ($p<0.05$). The data show strong correlation at all the sites, however, with *r*-values ranging from 0.22 to 0.98 and average percent differences of less than 10 percent at five sites. The largest differences between results were at two sites in the agricultural Kankakee River Basin, where the USGS suspended-

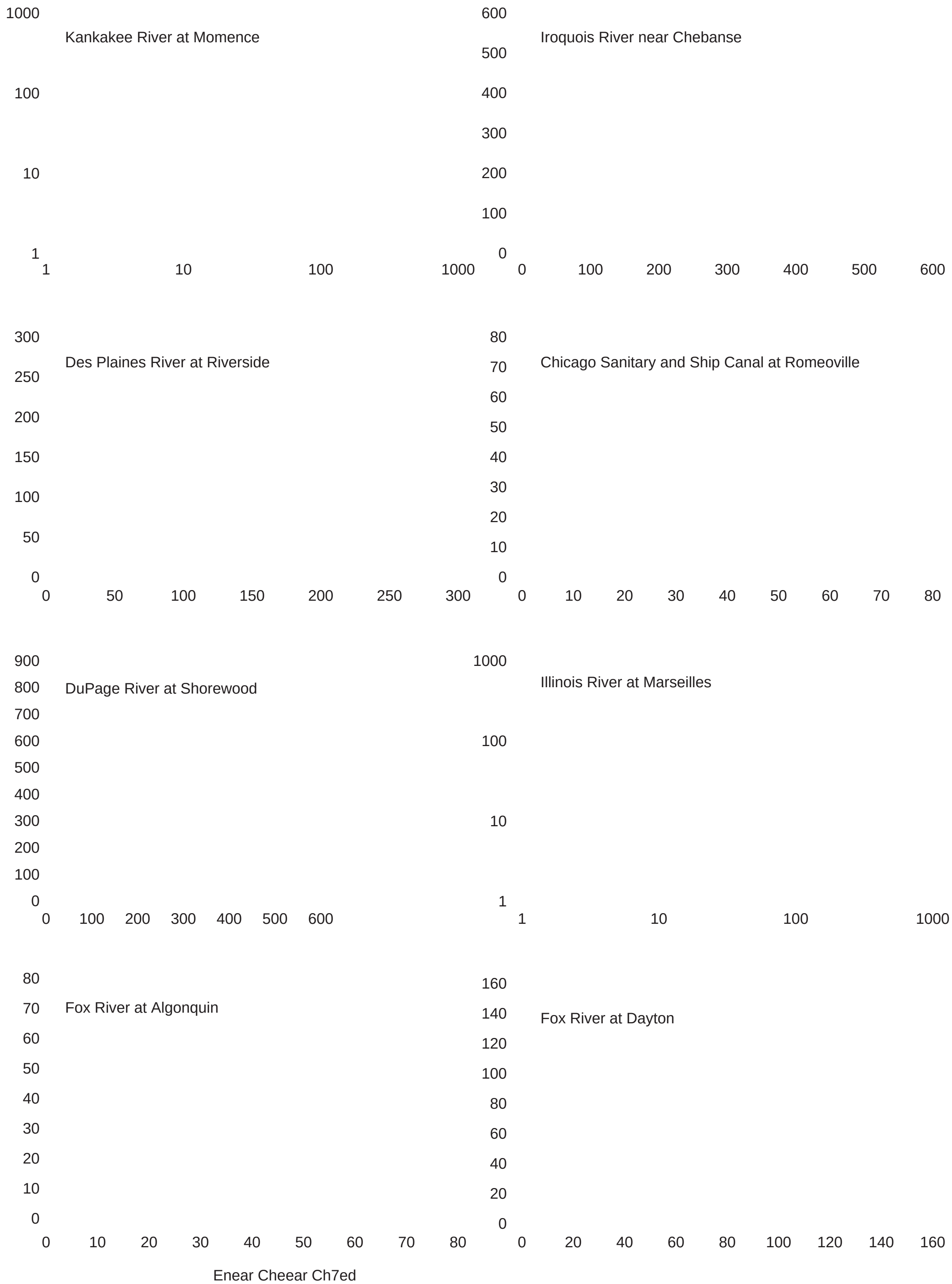

Figure 6. Suspended-sediment and total-suspended-solids concentrations in split samples of water from upper Illinois River Basin streams.

Table 3. Sources and estimated inputs of nutrients and sediment to streams in the upper Illinois River Basin

[From Terrio, 1995 unless otherwise noted; ton/yr, tons per year; --, undetermined, unknown, or not applicable]

Source	Estimated input to basin (ton/yr)				Estimated		eams (ton/yr)	
	Total nitrogen	Total phosphorus	Ammonia	Nitrite plus nitrate	Total nitrogen	Total phosphorus		Nitrite plus

Environmental Protection Agency, 1996b). Other sources may include industrial and mine wastes, construction projects, and detrital remains of aquatic and terrestrial plants and animals. Concentrations of total suspended solids are generally affected by runoff and not necessarily stream discharge. During periods of low flow, a locally heavy rainfall can significantly increase the total suspended solids in a stream while only slightly increasing streamflow.

Nitrogen Concentrations

Nitrogen is present in water in anionic form 70.004

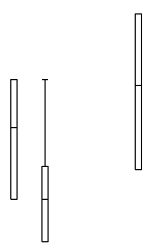

Figure 8. Total ammonia-plus-organic (Kjeldahl) nitrogen concentrations in streams of the upper Illinois River Basin, 1978–97.

Total Ammonia-Plus-Organic (Kjeldahl) Nitrogen

Median Kjeldahl nitrogen concentrations mirrored those of ammonia, and were highest at the same three sites (fig. 8). The lowest median Kjeldahl nitrogen concentrations were found at a Fox River tributary (site 38, Somonauk Creek) and the Kankakee River at Momence, Ill. (site 1).

Total Nitrite Plus Nitrate

The highest median nitrate concentration was at an Illinois River tributary, Aux Sable Creek (site 27), where the median nearly equaled the 10 mg/L drinking-water limit for nitrate (fig. 9). The median at a nearby stream, the Mazon River (site 28), was only slightly lower. Other streams with median nitrate concentrations between 5 and 10 mg/L were three Iroquois River sites (sites 2,3,4), two sites in the Des Plaines River Basin (sites 7 and 10) and all the sites in the Du Page River Basin (sites 22-26). Median nitrate concentrations were lowest (about 0.7 mg/L) at a Fox River main-stem site (site 33) and the upstream site on the North Branch Chicago River (site 14) (fig. 9). A Fox River tributary, Poplar Creek (site 34) was the only other site where median nitrate concentration was less than 1 mg/L (about 0.9 mg/L). Median nitrate concentrations were generally lowest at sites in the Fox River Basin.

Concentrations of nitrate were higher in tributaries of the Fox River than in the main stem. These tributary streams drain agricultural lands with clayey soils, in contrast to the coarser soils and suburbanizing land in the northern (upstream) parts of the Fox River Basin. Concentrations of nitrate were considerably higher at the Fox River at Dayton (site 39), the most downstream site on the Fox River, than at sites upstream on the main stem, a reflection of the input of the tributary streams in the southwestern part of the Fox River Basin.

Concentrations of nitrate at the Illinois River at Marseilles (site 29) were among the highest of those at 42 sites studied as part of a comprehensive study of the entire Mississippi River Basin (Goolsby and others, 1999). Most of the other basins with simi512(ns o)12()-2m
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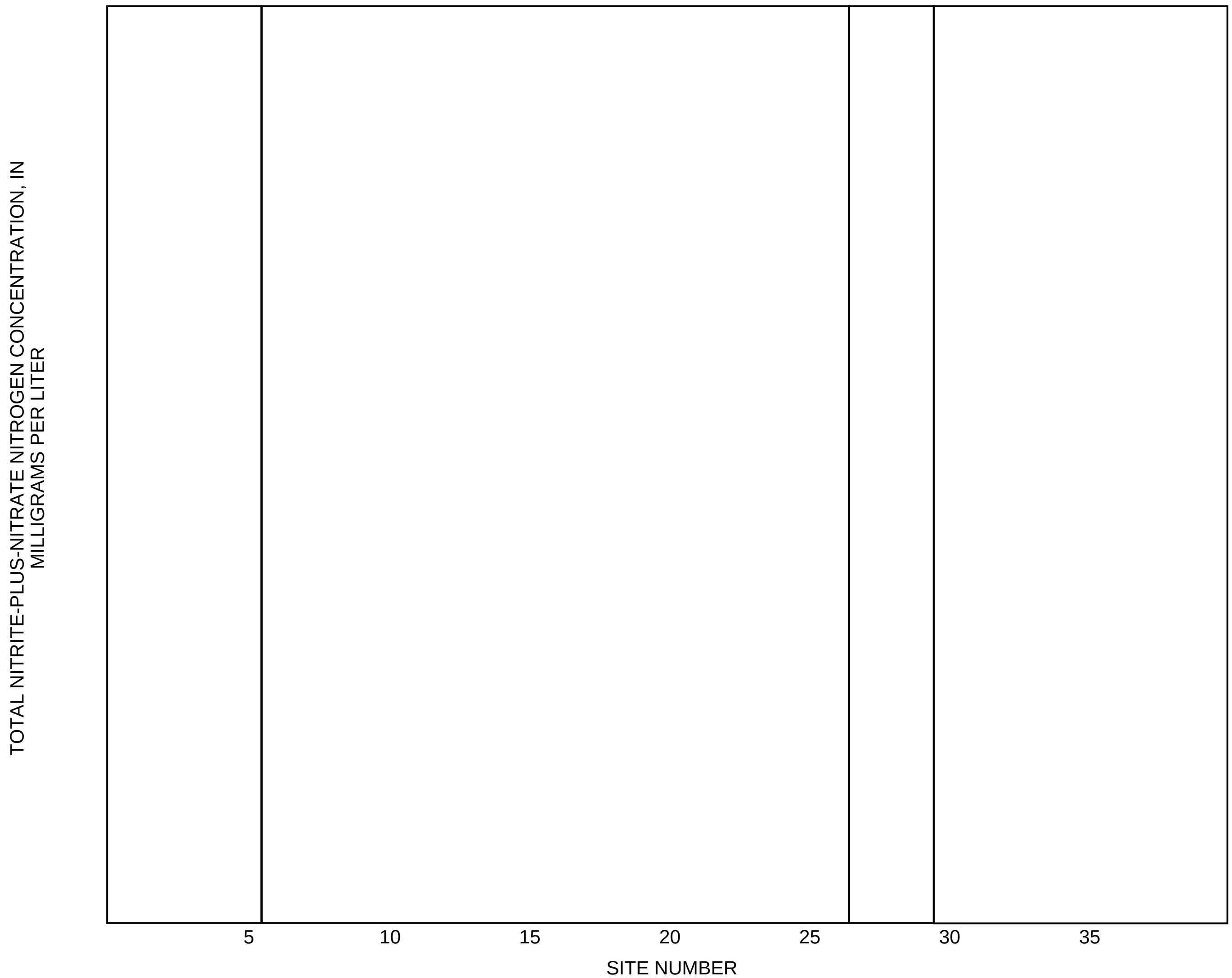

Figure 9. Total nitrite-plus-nitrate nitrogen concentrations in streams of the upper Illinois River Basin, 1978–97

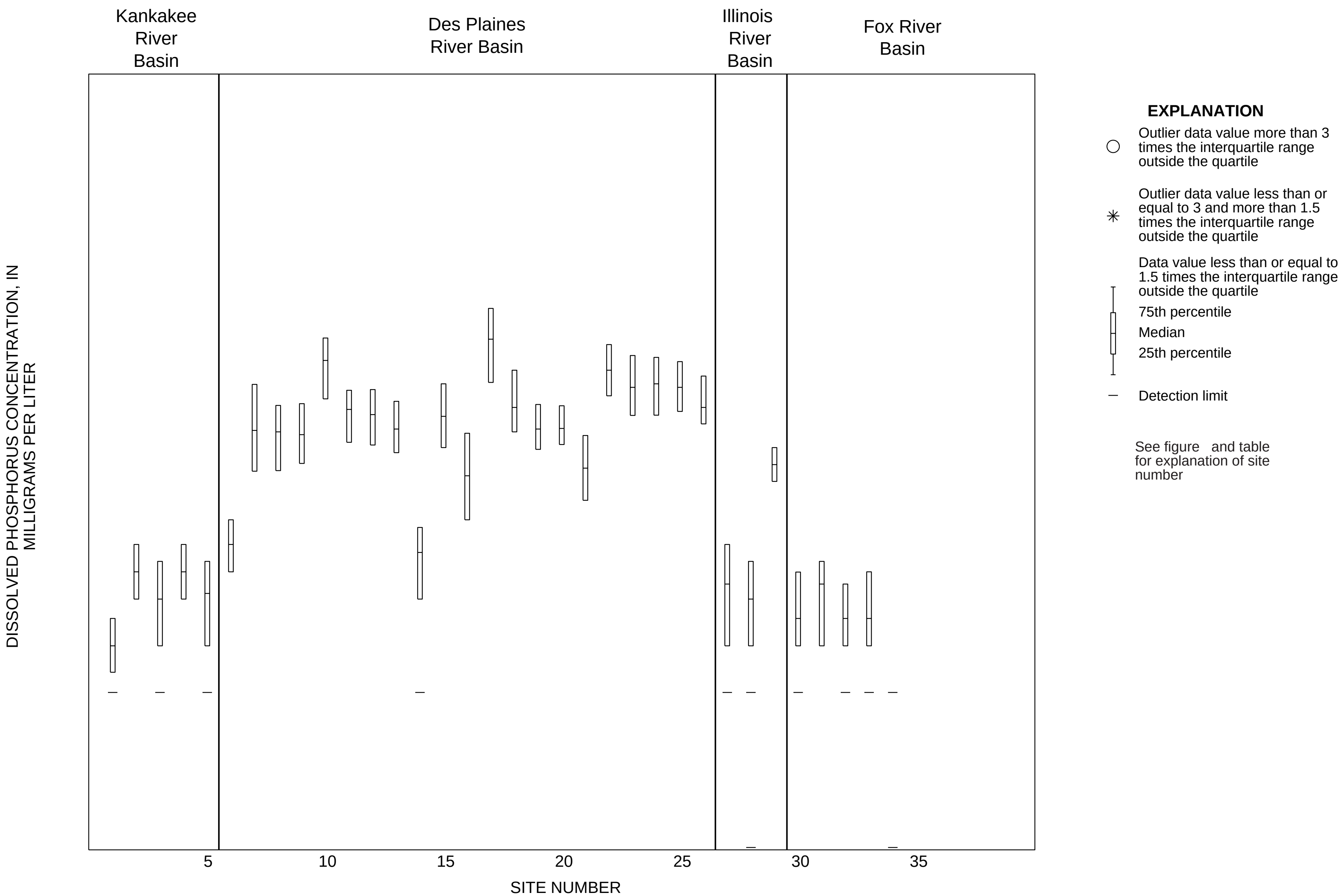

Figure 11. Dissolved-phosphorus concentrations in streams of the upper Illinois River Basin, 1978–97.

mirrored the sum of inputs for various land-use categories. In a review of published literature on nutrient exports from various watershed types, Beaulac and Reckhow (1982) compiled substantial evidence that agricultural and urbanized watersheds produce larger nutrient outputs than do forested watersheds; however,

Figure 12.

als, silt, sand, and organic matter. Particulate matter, in suspension or at the streambed, plays an important role in the chemistry of aquatic systems (Stumm and Morgan, 1981). Particulate matter commonly affects the degree and rate at which many aqueous chemical reactions proceed, in particular, ion-exchange reactions between sediment minerals and cations in solution.

Organic matter contributes to the suspended-solids concentration and to the sediment-related chemistry of a stream. Many of the large particles found in streams are primarily organic material. Particulates that fall out of suspension and are deposited in stream bottoms commonly reduce the dissolved-oxygen content of the water column because of oxygen-consuming reactions and organic-matter decomposition that takes place in the

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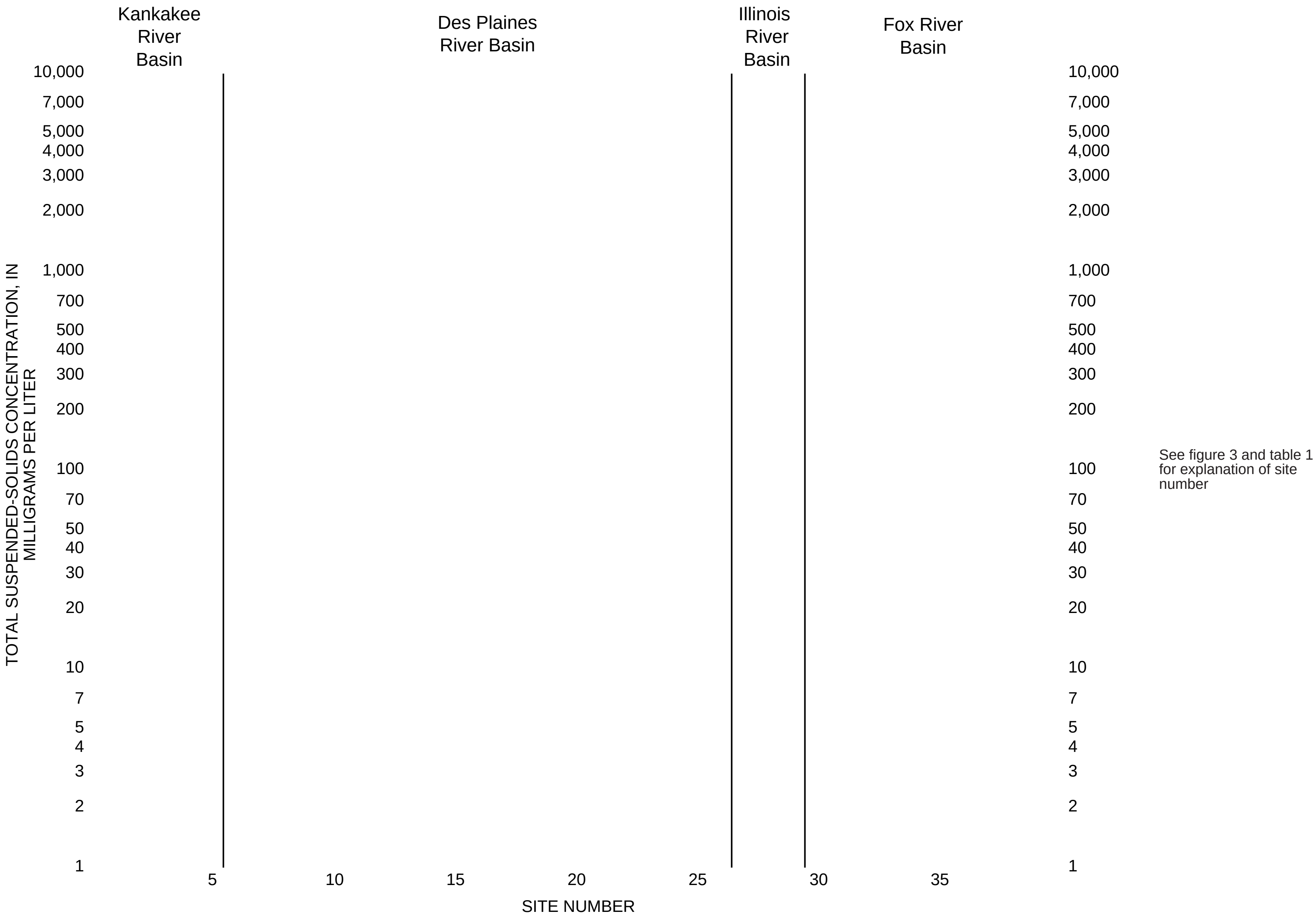

Figure 13. Total suspended-solids concentrations in streams of the upper Illinois River Basin, 1978–97.

ammonia nitrogen seem most closely related to urban land use and wastewater discharge.

Total nitrate loads were highest in the agricultural Kankakee River Basin, with the Fox and Des Plaines River Basins contributing roughly similar loads. Yields were about 2-1/2 times higher from sites in the Kankakee than most other sites in the Fox and Des Plaines River Basins.

The total nitrogen export from the upper Illinois River Basin for 1978–97 was 91,800 ton/yr. This amount corresponds well with estimates of loads from urban, agricultural, and other sources, and is about 30 percent of the estimated total nitrogen input to the basin of about 300,000 ton/yr. The total phosphorus export from the study area for 1978–97 was about 5,400 ton/yr, or about 6 percent of estimated phosphorus inputs of 94,000 ton/yr.

Suspended-solids loads were highest in the Kankakee River Basin, with an average annual load of about 470,000 ton/yr. The Iroquois River, with its high-clay-content surficial deposits and intensive row-crop agriculture, contributes more than 375,000 ton/yr to the total output from the Kankakee River Basin. The mean annual yield of 180 ton/mi^2 measured at site 4 on the Iroquois River was more than 4 times higher than the mean annual yield of 43 tons/mi^2 from a comparable drainage area on the main stem Kankakee River (site 1). The Fox River Basin contributed the next highest amount, much of that coming from agricultural lands in the southern parts of the basin.

The importance of surficial deposits on suspended-solids loads is illustrated in the following example. In the Iroquois River Basin, about 41,000 ton/yr was transported past site 2 on the Iroquois main stem. Furthermore, the load from the Sugar Creek site (site 3), which drains 446 mi^2 in the Illinois part of the Iroquois River Basin, was about 3 times the load at site 2 on the Iroquois River main stem, which drains 686 mi^2. Overall, of the approximate 375,000 ton/yr of suspended solids that was transported past the site on the Iroquois River near its mouth (site 4), about 89 percent came from the Illinois part of the basin, either by erosion from farm fields and streambanks or resuspended from the river channel in Illinois. In the Indiana part of the Iroquois River Basin, the soils are primarily loam, while in Illinois they are predominantly clays and silts, .77 Tmı˝0et-11(dr)9

Table 5. Estimated transport of total ammonia nitrogen at selected sites in the upper Illinois River Basin
[USGS, U.S. Geological Survey]

Map reference number	USGS station number	Station name	Period of record for load computations	Average annual load (tons)	Average annual yield (tons per mi^2)	Load model statistics: Number of samples	Load model statistics: Standard deviation	Load model statistics: Coefficient of determination (R^2)	Load model statistics: Root-mean-square standard error
1	05520500	Kankakee River at Momence, Ill.	12/16/77–11/25/96	251	0.12	198	59.6	53.8	132
2	05525000	Iroquois River at Iroquois, Ill.	1/25/78–11/25/96	79.8	.12	162	32.9	78.5	56.3
2	05525500	Sugar Creek near Milford, Ill.	10/11/78–11/25/96	50.5	.11	161	24.2	74.2	46.9
4	05526000	Iroquois River near Chebanse, Ill.	10/19/78–11/25/96	261	.12	184	110	79.6	165
5	05527500	Kankakee River near Wilmington, Ill.	4/30/80–11/25/96	655	.13	165	269	69.8	495
6	05527800	Des Plaines River at Russell, Ill.	11/17/77–11/18/96	15.0	.12	186	0.5	76.7	0.7
7	05528000	Des Plaines River near Gurnee, Ill.	10/29/80–11/18/96	85.7	.37	150	58.9	43.9	77.4
8	05529000	Des Plaines River near Des Plaines, Ill.	12/19/77–12/4/96	115	.32	186	59.7	68.1	53.2
10	05531500	Salt Creek at Western Springs, Ill.	12/14/77–12/9/96	126	1.10	195	92.2	75.4	51.6
11	05532000	Addison Creek at Bellwood, Ill.	6/18/79–12/9/96	8.61	.48	174	2.25	63	4.6
12	05532500	Des Plaines River at Riverside, Ill.	7/7/87–12/9/96	495	.79	104	356	70.2	523
14	05534500	North Branch Chicago River at Deerfield, Ill.	12/19/77–12/4/96	4.43	.22	186	1.5	70.2	2.5
15	05536000	North Branch Chicago River at Niles, Ill.	9/13/78–12/4/96	39.4	.39	178	14.1	63.5	18.6
17	05536275	Thorn Creek at Thornton, Ill.	6/19/79–12/30/96	73.0	.68	167	32.2	50.1	42.2
19	05537000	Chicago Sanitary and Ship Canal at Lockport, Ill.	11/16/77–9/13/79,						

Table 6. Estimated transport of total ammonia-plus-organic (Kjeldahl) nitrogen at selected sites in the upper Illinois River Basin
[USGS, U.S. Geological Survey]

Map reference number	USGS station number	Station name

Table 7. Estimated transport of total nitrite-plus-nitrate nitrogen in the upper Illinois River Basin
[USGS, U.S. Geological Survey]

Map reference number	USGS station number	Station name	Period of record for load computations	Average annual load (tons)	Average annual yield (tons per mi^2)	Load model statistics			
						Number of samples	Standard deviation	Coefficient of determination (R^2)	Root-mean-square standard error
1	05520500	Kankakee River at Momence, Ill.	12/16/77–11/25/96	5,600	2.67	200	1,540	89.1	1,430
2	05525000	Iroquois River at Iroquois, Ill.	10/11/78–11/25/96	6,200	9.05	162	2,190	96.1	1,850
2	05525500	Sugar Creek near Milford, Ill.	10/11/78–11/25/96	4,250	9.52	166	1,550	95.1	1,570
4	05526000	Iroquois River near Chebanse, Ill.	10/19/78–11/25/96	18,900	9.06	185	6,320	95.6	5,521
5	05527500	Kankakee River near Wilmington, Ill.	4/30/80–11/25/96	32,800	6.37	170	12,300	90.8	11,300
6	05527800	Des Plaines River at Russell, Ill.	11/17/77–11/18/96	477	3.88	179	121	94.1	21.1
7	05528000	Des Plaines River near Gurnee, Ill.	10/29/80–11/18/96	987	4.26	150	257	70.6	289
8	05529000	Des Plaines River near Des Plaines, Ill.	12/19/77–12/4/96	1,310	3.64	186	285	80.9	249
10	05531500	Salt Creek at Western Springs, Ill.	12/14/77–12/9/96	776	6.74	195	166	65	144
11	05532000	Addison Creek at Bellwood, Ill.	6/18/79–12/9/96	81.7	4.56	176	19.2	71.1	27.3
12	05532500	Des Plaines River at Riverside, Ill.	7/7/87–12/9/96	2,560	4.07	104	297	76.7	333
14	05534500	North Branch Chicago River at Deerfield, Ill.	12/19/77–12/4/96	28.4	1.44	187	12.8	84.8	15.8
15	05536000	North Branch Chicago River at Niles, Ill.	9/13/78–12/4/96	341	3.41	180	66.4	64	92.4
17	05536275	Thorn Creek at Thornton, Ill.	6/19/79–12/30/96	391	3.62	167	47.9	71.4	84.1
19	05537000	Chicago Sanitary and Ship Canal at Lockport, Ill.	11/17/77–9/13/79, 10/29/84–4/9/97	19,900	--	137	27,400	--	--
21	05539000	Hickory Creek at Joliet, Ill.	6/14/79–12/3/96	332	3.10	163	90.5	92.8	199
22	05539900	West Branch Du Page River near West Chicago, Ill.	6/18/79–12/3/96	222	7.79	165	30.8	70.2	33.1
23	05540095	West Branch Du Page River near Warrenville, Ill.	10/28/80–12/3/96	493	5.46	148	67.6	82	60.5
26	05540500	Du Page River at Shorewood, Ill.	10/18/78–11/25/96	1,890	5.85	212	414	85.8	328
28	05542000	Mazon River near Coal City, Ill.	5/2/78–9/18/95	5,070	11.14	165	1,790	96.4	1,930
29	05543500	Illinois River at Marseilles, Ill.	4/29/80–12/17/96	51,900	6.29	165	12,400	87.8	10,900
31	05548280	Nippersink Creek near Spring Grove, Ill.	12/29/77–11/18/96	560	2.92	186	256	90.7	142
33	05550000	Fox River at Algonquin, Ill.	11/8/77–11/19/96	2,560	1.83	224	1,130	82.3	1,290
35	05551000	Fox River at South Elgin, Ill.	10/23/89–11/19/96	2,860	1.84	62	1,020	77.4	991
37	05551700	Blackberry Creek near Yorkville, Ill.	12/14/77–11/26/96	241	3.43	186	90.5	92.1	65.2
39	05552500	Fox River at Dayton, Ill.	10/4/78–11/26/96	13,200	4.98	195	4,870	79.7	6,470

Table 8. Estimated transport of total phosphorus in the upper Illinois River Basin, 1978–97
[USGS, U.S. Geological Survey]

Map reference number	USGS station number	Station name	Period of record for load computations	Average annual load (tons)	Average annual yield (tons per mi^2)	Load model statistics			
						Number of samples	Standard deviation	Coefficient of determination (R^2)	Root-mean-square standard error
1	05520500	Kankakee River at Momence, Ill.	1/19/78–11/25/96	266	0.13	183	75.2	69.3	71.6
2	05525000	Iroquois River at Iroquois, Ill.	4/10/84–11/25/96	108	.16	113	38.6	90.9	52.1
2	05525500	Sugar Creek near Milford, Ill.	7/30/81–11/25/96	150	.34	113	84.2	93.2	157
4	05526000	Iroquois River near Chebanse, Ill.	10/19/78–11/25/96	545	.26	155	269	94	232
5	05527500	Kankakee River near Wilmington, Ill.	10/22/80–11/25/96	1,050	.20	168	462	84.1	490
6	05527800	Des Plaines River at Russell, Ill.	12/29/77–11/18/96	18.0	.15	133	4.8	92.7	4.4
7	05528000	Des Plaines River near Gurnee, Ill.	8/12/81–11/18/96	77.1	.33	126	26.8	30.6	31.8
8	05529000	Des Plaines River near Des Plaines, Ill.	1/18/78–12/4/96	150	.42	129	26.4	64.8	39.8
10	05531500	Salt Creek at Western Springs, Ill.	1/22/80–12/9/96	148	1.29	133	9.1	38	25.4
11	05532000	Addison Creek at Bellwood, Ill.	6/18/79–12/9/96	16.0	.89	141	3.0	74.7	5.6
12	05532500	Des Plaines River at Riverside, Ill.	7/7/87–12/9/96	419	.67	104	49.3	67.3	69.0
14	05534500	North Branch Chicago River at Deerfield, Ill.	3/15/78–12/4/96	3.3	.17	156	1.2	91.5	1.4
15	05536000	North Branch Chicago River at Niles, Ill.	9/13/78–12/4/96	71.1	.71	150	15.1	68.1	19.2
17	05536275	Thorn Creek at Thornton, Ill.	7/24/79–12/30/96	202	1.87	126	20.5	24.6	82.9
19	05537000	Chicago Sanitary and Ship Canal at Lockport, Ill.	1/19/78–2/6/79, 10/29/84–4/9/97	4,300	--	119	3,350	--	--
21	05539000	Hickory Creek at Joliet, Ill.	6/14/79–12/3/96	37.8	.35	127	13.0	85.5	19.2
22	05539900	West Branch Du Page River near West Chicago, Ill.	6/18/79–12/3/96	48.3	1.70	128	6.6	62.3	8.6
23	05540095	West Branch Du Page River near Warrenville, Ill.	8/12/81–12/3/96	89.7	.99	124	7.5	63.3	10.4
26	05540500	Du Page River at Shorewood, Ill.	11/16/78–11/25/96	295	.91	169	53.5	71.2	67.7
28	05542000	Mazon River near Coal City, Ill.	6/20/78–9/18/95	119	.26	111	66.4	92.5	129
29	05543500	Illinois River at Marseilles, Ill.	4/29/80–12/17/96	4,680	.57	166	1,120	83.5	1,040
31	05548280	Nippersink Creek near Spring Grove, Ill.	12/29/77–11/18/96	34.5	.18	180	23.2	71.8	38.3
33	05550000	Fox River at Algonquin, Ill.	11/08/77–11/19/96	175	.12	222	48.6	72.1	42.0
35	05551000	Fox River at South Elgin, Ill.	10/23/89–11/19/96	252	.16	62	61.4	81.6	45.5
37	05551700	Blackberry Creek near Yorkville, Ill.	12/14/77–11/26/96	15.0	.21	186	15.9	87.4	28.6
39	05552500	Fox River at Dayton, Ill.	10/23/78–11/26/96	726	.27	195	262	77.3	215

Table 9. Estimated transport of dissolved phosphorus in the upper Illinois River Basin, 1978–97

[USGS, U.S. Geological Survey]

						Load model statistics			
Map reference number	USGS station number	Station name	Period of record for load computations	Average annual load (tons)	Average annual yield (tons per mi²)	Number of samples	Standard deviation	Coefficient of determination (R^2)	Root-mean-square standard error
1	05520500	Kankakee River at Momence, Ill.	10/1/79–4/24/97	79.5	0.20	158	18.5	54.3	26.9
2	05525000	Iroquois River at Iroquois, Ill.							

Table 10. Estimated transport of total suspended solids at selected sites in the upper Illinois River Basin

[USGS, U.S. Geological Survey]

Map reference number	USGS station number	Station name	Period of record for load computations	Average annual load (tons)	Average annual yield (tons per mi^2)	Load model statistics		
						Number of samples	Standard deviation	Coefficient of

Figure 15.

Figure 16. Estimated annual load of total nitrite-plus-nitrate nitrogen (left) and estimated load of total nitrogen (right) in streams of the upper Illinois River Basin, 1978–97.

Figure 17. Estimated annual load of total phosphorus (left) and dissolved phosphorus (right) in streams of the upper Illinois River Basin, 1978–97.

more prone to erosion. These results are similar to results from a study of suspended-sediment loading in the Kankakee River Basin done during 1993–95, where 86 percent of the suspended-sediment load in the Iroquois River Basin was found to originate in the Illinois part of the basin (Holmes, 1997).

Yields of total suspended solids appear to be more strongly related to surficial deposits than to land use. Yields were highest at Hickory Creek (site 21) and Mazon River (28). Drainage above both sites is on poorly permeable surficial deposits, but site 21 is 32 percent urban land and site 28 is 95 percent agricultural. Other sites with high yields of total suspended solids (3, 4, 10, 11, 17, 23, 26, and 39) are also below drainages of poorly permeable soils or have significant input from streams draining poorly permeable soils, but with land use ranging from 99 percent agricultural (site 3) to 98.5 percent urban (site 11).

Loads and yields of nitrogen and phosphorus from the upper Illinois River Basin were compared to results from other NAWQA study areas in the upper Midwest (figs. 19–20). Yields from the upper Illinois River Basin are the highest of all the basins shown for nitrate, total nitrogen, and total phosphorus. Loads were greater for

Figure 19.

Figure 20. Estimated nutrient yields from selected watersheds in the Mississippi River Basin.

Table 11. Trend test results for selected nutrients and suspended solids at Illinois Environmental Protection Agency monitoring sites in the upper Illinois River Basin, 1978–97

Map reference number	Station name	Direction of trend	Concentrations			Flow-adjusted concentrations		
			Probability level	Trend	Percent per year	Probability level	Trend	Percent per year
			Ammonia					
1	Kankakee River at Momence, Ill.	↓	0.004	-<0.005	-3.4	*	*	*
2	Iroquois River at Iroquois, Ill.	↓	<.0005	-.01	-5.8	*	*	*
3	Sugar Creek near Milford, Ill.	↓	<.0005	-.01	-5.8	*	*	*
4	Iroquois River near Chebanse, Ill.	↓	.087	-<.005	-2.0	*	*	*
5	Kankakee River near Wilmington, Ill.	↓	<.0005	-.01	-7.0	*	*	*
7	Des Plaines River near Gurnee, Ill.	↓	<.0005	-.04	-10.4	*	*	*
8	Des Plaines River near Des Plaines, Ill.	↓	<.0005	-.03	-7.9	*	*	*
9	Des Plaines River near Schiller Park, Ill.	↓	.001	-.02	-3.9	*	*	*
10	Salt Creek at Western Springs, Ill.	↓	<.0005	-.13	-14.0	*	*	*
11	Addison Creek at Bellwood, Ill.	↓	.040	-.01	-2.5	*	*	*
13	Des Plaines River at Lockport, Ill.	↓	<.0005	-.02	-5.6	*	*	*
14	Des Plaines R7.4 D h1259(-.)-9(02)(t.19)-6u10(040)-3760uRlt.19040-5845(*)-6225(*)]TJ -32.9161 -1.9829.1035 TD 0.00I4P0I4P0(8 0.1207v)]TJ r3 0.103MTj 32l35 TD 0226(*)]TJ -3							

Figure 23.

(-0.005)

(-0.005)

(+0.03)

(-0.06)

(+0.03)

(+0.005)

(+0.01)

Figure 24. Trends in total phosphorus in streams of the upper Illinois River Basin, 1978–97.

(-1.7) Slope magnitude, in milligrams per liter.

Figure 25. Trends in dissolved phosphorus in streams of the upper Illinois River Basin, 1978–97.

Figure 26. Trends in total suspended solids in streams of the upper Illinois River Basin, 1978–97.

basins. The elevated concentrations of ammonia and phosphorus in the urbanized Des Plaines River Basin with respect to other sites in the study area provide evidence that municipal- and industrial-waste discharges into streams of the basin increase concentrations of these nutrients in the receiving streams. In contrast, nitrate concentrations were highest in agricultural areas. Relatively large ratios of nitrogen to phosphorus and nitrate to ammonia are characteristic of agricultural drainage in comparison to urban-area drainage. The apparent, but nonuniform, correspondence of nutrient transport to urban and agricultural land use in the upper Illinois River Basin was generally consistent with findings in other river basins.

Monthly median concentrations of ammonia and nitrate were at minimum levels from July through Octo-

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