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7-Day, 10-Year Low Flows of Streams in Northeastern Illinois

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Office of Surface Water Resources & Systems Analysis

Prepared for the
Illinois Environmental Protection Agency

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Illinois State Water Survey
Hydrology Division
Champaign, Illinois

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1 INTRODUCTION

The 7-day, 10-year low flows, or $Q_{7,10}$, values for Illinois streams, under the 1970 conditions of municipal and industrial effluent discharges, were derived and presented in Illinois State Water Survey (ISWS) Bulletin 57 (Singh and Stall, 1973). The Bulletin contains 11 maps, which show the $Q_{7,10}$ flows for all rivers and streams in Illinois, together with the effluent discharges and their locations, adjusted for effects of any flow regulation and consumptive use of water. These low flow values have been used by the Illinois Environmental Protection Agency (IEPA) in assessing the desirable level of treatment at a wastewater treatment facility, depending on the $Q_{7,10}$ value in the receiving stream. The $Q_{7,10}$ values for streams in northeastern Illinois (map 2 in Bulletin 57) were updated for 1980 conditions of effluents and water withdrawals in ISWS Contract Report 307 (Singh, 1983). The $Q_{7,10}$ values for streams in the remainder of the state were updated for 1984 conditions of effluents and water withdrawals in ISWS Contract Reports 440 and 441 (Singh et al., 1988a, 1988b).

The $Q_{7,10}$ map for the northeastern region of Illinois covers the area drained by the Chicago Sanitary and Ship Canal and its tributaries, and Des Plaines, Du Page, and Fox Rivers. The Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) operates three major wastewater treatment plants: Northside, West-Southwest (Stickney), and Calumet. Since the mid-1970s three new medium-sized plants have been put into operation: Hanover Park, John Egan, and O'Hare. The North Shore Sanitary District (NSSD) is also operating three new wastewater plants: Waukegan, Gurnee, and Clavey Road. The population in certain areas has increased or decreased and there have been changes in industrial activities. These have led to changes in municipal and industrial effluent discharges. Many industries have also decreased their effluent discharges through recycling and conservation measures. These changes for northeastern Illinois and similar changes for the rest of the state necessitate that the $Q_{7,10}$ flows and relevant information be updated for the 1990 conditions of effluent discharges and any flow regulation. The information on municipal and industrial effluent discharges was collected from the IEPA office in Springfield, Illinois, and from various municipalities and industries by correspondence or telephone inquiries. The change in town populations from 1970 to 1990 was analyzed with regard to change in effluent flow for purposes of verification and identification of any special circumstances. The daily streamflow data at the streamgaging stations in northeastern Illinois were analyzed to develop values of 7-day lowest flow each year as well as the $Q_{7,10}$ flow, both with and without effluent contributions. Finally, a map was prepared showing the $Q_{7,10}$ flows (adjusted for the 1990 conditions of effluent discharges to the streams and any water withdrawals for industrial uses) of the various streams and rivers in northeastern Illinois.

1.1 Acknowledgments

This study was jointly supported by the Illinois Environmental Protection Agency (IEPA) and the Illinois State Water Survey (ISWS), Illinois Department of Energy and Natural Resources. Robert Mosher of the IEPA served in a liaison capacity during the course of the study. The staff of the IEPA were very helpful in allowing use of their office and discharge monitoring report files for analysis. Vernon Knapp, Professional Scientist at the ISWS provided preliminary $Q_{7,10}$ values for selected streams in the Fox River basin using the Illinois Streamflow Assessment Model (ILSAM). Linda Hascall supervised the artwork and Eva Kingston edited the report.

2 METHODOLOGY

2.1 Preparation of Base Map

A map was prepared for northeastern Illinois, covering the areas drained by the Chicago River, Des Plaines River, Chicago Sanitary and Ship Canal, Calumet-Sag Channel, Du Page River, Hickory Creek, and Fox River, and the area north of the Illinois River to its confluence with the Fox River. The drainage area covered by a stream or river system was marked on the 2-degree maps of the U.S. Geological Survey (USGS). These maps have a scale of 1 to 250,000 or about 1 inch = 4 miles. Where the contours were not defined well enough to draw the drainage boundary accurately, the 15-minute USGS quadrangle maps were used, which have a scale of about 1 inch = 1 mile. A base map was then prepared showing the drainage boundary, the stream network, all towns having wastewater treatment plants discharging to the streams, and county lines. The USGS streamgaging stations were located on the base map from the detailed descriptions of the locations published in USGS Water Supply Papers and Water Resources Data for Illinois.

The locations of wastewater effluent outfalls to streams were obtained from the USGS 7 1/2-minute and 15-minute quadrangle maps, from the IEPA office in Springfield, from the areawide water quality management plans prepared by the Northeastern Illinois Planning Commission, and in some cases by direct telephone inquiries. Arrows were drawn on the base map to indicate the effluent outfall to a particular stream. The amounts of wastewater effluents indicated on the map represent the 1990-condition effluents entering the receiving stream during the $Q_{7,10}$ flow event.

Dams, regulating structures, and lakes were also shown on the base map. The dams and in-channel impoundments for municipal or industrial water supply were located on the various streams on the basis of the available information in USGS maps, county plat books, highway maps, river basin reports, and similar references. In addition, all large and medium-sized lakes, and some small ones, natural or man-made, were shown on the map because of their significant effect on the $Q_{7,10}$ values. Streams with a zero $Q_{7,10}$ value were designated first. From the natural low flow versus drainage area graphs, the streams with zero $Q_{7,10}$ values were determined and shown as dotted-dashed lines. Any wastewater effluents entering these intermittent-flow streams were then considered. If the effluent is lost in the dry streambed before reaching the perennial stream, the stream's $Q_{7,10}$ value remains zero. However, if the effluent is not lost entirely, the stream starts with a $Q_{7,10}$ value at the outfall equal to the magnitude of the effluent, and this flow is reduced in a downstream direction to the point where the natural $Q_{7,10}$ flow begins. Here the $Q_{7,10}$ value is then equal to the reduced effluent value plus the natural streamflow value.

Streams with $Q_{7,10}$ values greater than 0.0 were mapped next. To obtain the $Q_{7,10}$ values applicable for 1990 conditions, the lowest 7-day effluent flow estimates from wastewater plants are added to the natural $Q_{7,10}$ values along such streams. Any withdrawal of water from a stream for a municipal supply or industrial use is shown by a decrease in the $Q_{7,10}$ value. Symbols used in the low flow map are shown in figure A.1 in the appendix.

2.2 Flows at Streamgaging Stations

The primary data used in this study are the daily flows at 45 USGS gaging stations on streams in northeastern Illinois. These stations are shown in the $Q_{7,10}$ map for northeastern Illinois, enclosed in the pocket of this report. Daily flow data were available for periods ranging from 15 to 60 years at these stations. The flow data for the period of record up through 1990 were stored on disks for quick computer processing. The water year selected for low flow analysis was taken to begin April 1 and end March 31 of the following year.

A computer program was written in FORTRAN to compute the lowest 7-day low flow for each year of the available record at each station, and to print the year, the flow value, and the beginning day of the 7-day period. The computer program also ranks these low flows in ascending order of magnitude. The low flow values at some stations indicate an increasing trend in low flow when the drainage area upstream of the gaging station is slowly or rapidly urbanizing, and thus discharging more and more wastewater effluents to the stream. $Q_{7,10}$ values at the gaging stations for 1980 (Singh, 1983) and 1990 conditions are shown in table A.1 in the appendix.

2.3 Flows along the Streams

The $Q_{7,10}$ values at the gaging stations serve as control points for estimating these low flows along the streams and their tributaries. Other pertinent information is the location of wastewater treatment plant effluents entering the stream under the $Q_{7,10}$ conditions. For maximum utility, the $Q_{7,10}$ values need to be estimated at locations near towns, at junctions with medium and major tributaries, at sizable inflows from wastewater treatment plants, and at regulation or control works. The $Q_{7,10}$ values were estimated at these various points along the streams, but not all of them were shown on the map. The $Q_{7,10}$ values along the stream were derived by using procedures as dictated by the prevailing conditions in each general area.

2.3.1 Natural Low Flow versus Drainage Area Curves

The natural $Q_{7,10}$ versus drainage area curve, applicable to the area under consideration, indicates the maximum drainage area A_0 for which the $Q_{7,10}$ value is zero. The creeks, streams, and tributaries with drainage area less than A_0 are shown by dotted and dashed lines on the low flow map. When the drainage area equals A_0, the low flow value is shown as 0.00 and a solid line represents the stream thereafter. This means that the stream has become a perennial-flow stream during dry conditions represented by $Q_{7,10}$.

2.3.2 Wastewater Treatment Plant Effluents

If the effluents enter streams that have drainage areas less than A_0, an estimate has to be made of the losses occurring in the intermittent streams to determine whether these effluents would be absorbed before reaching the natural perennial-flow stream. If the effluent additions are small and enter the stream in the upper reach, generally they would be lost in the dry streambed. If the effluent additions are considerable, however, they may contribute to some flow at the stream point with drainage area A_0. The larger the effluent and the closer its point of entrance to the A_0 point, the greater will be the flow contribution. Once the stream has a nonzero $Q_{7,10}$ value, any effluent additions simply increase the $Q_{7,10}$ value by the amount of effluent.

2.3.3 Water Withdrawals for Offstream Uses

Generally any town or industry pumping water from a stream subsequently returns it to the stream in the form of effluents from its wastewater treatment plant. Such use does reduce the $Q_{7,10}$ value because less water is usually returned, although the deficit will vary. Adjustments in the $Q_{7,10}$ values are made for these losses where necessary. An example is the loss of 2.3 cubic feet per second (cfs) from the low flow value in the Chicago Sanitary and Ship Canal because of water use by the Commonwealth Edison Crawford Plant.

2.3.4 Timing of Low Flows in Two Major Branches

When two major branches drain sufficiently large areas before joining together, the $Q_{7,10}$ versus area curves applicable to these branches may be quite different because of hydrologic, geologic, and soil factors. Further, the low flows may not occur during the same period. Under such conditions, the $Q_{7,10}$ value below the junction will be greater than the sum of the $Q_{7,10}$ values in the two branches.

For example, the $Q_{7,10}$ value for the Des Plaines River at its mouth (just upstream of its junction with the Kankakee River) is 2045 cfs and occurs in December or March. The $Q_{7,10}$ value for the Kankakee River is 500 cfs and occurs in September. The $Q_{7,10}$ value in the Illinois River (below the junction of the Des Plaines and Kankakee Rivers) occurs in October or January and equals 3130 cfs, which is much greater than the sum of 2045 and 500 cfs.

2.3.5 Modification of Low Flows because of Lakes and Pools

In-stream lakes and pools generally reduce the $Q_{7,10}$ value. Lakes and pools expose considerable water surface areas to evaporation, thus reducing the natural low flows. An example of the effect of natural lakes on the $Q_{7,10}$ value is the upper part of the Fox River basin in Illinois, shown in figure 2.1. This part has a flat low-lying terrain abounding in lakes, swamps, marshes, and sloughs. Included in this area are the Fox Chain of Lakes with a combined water surface of 12.2 square miles. The principal lakes in the chain are: Pistakee, Nippersink, Fox, Petite, Channel, and Catherine. There are two dams in the

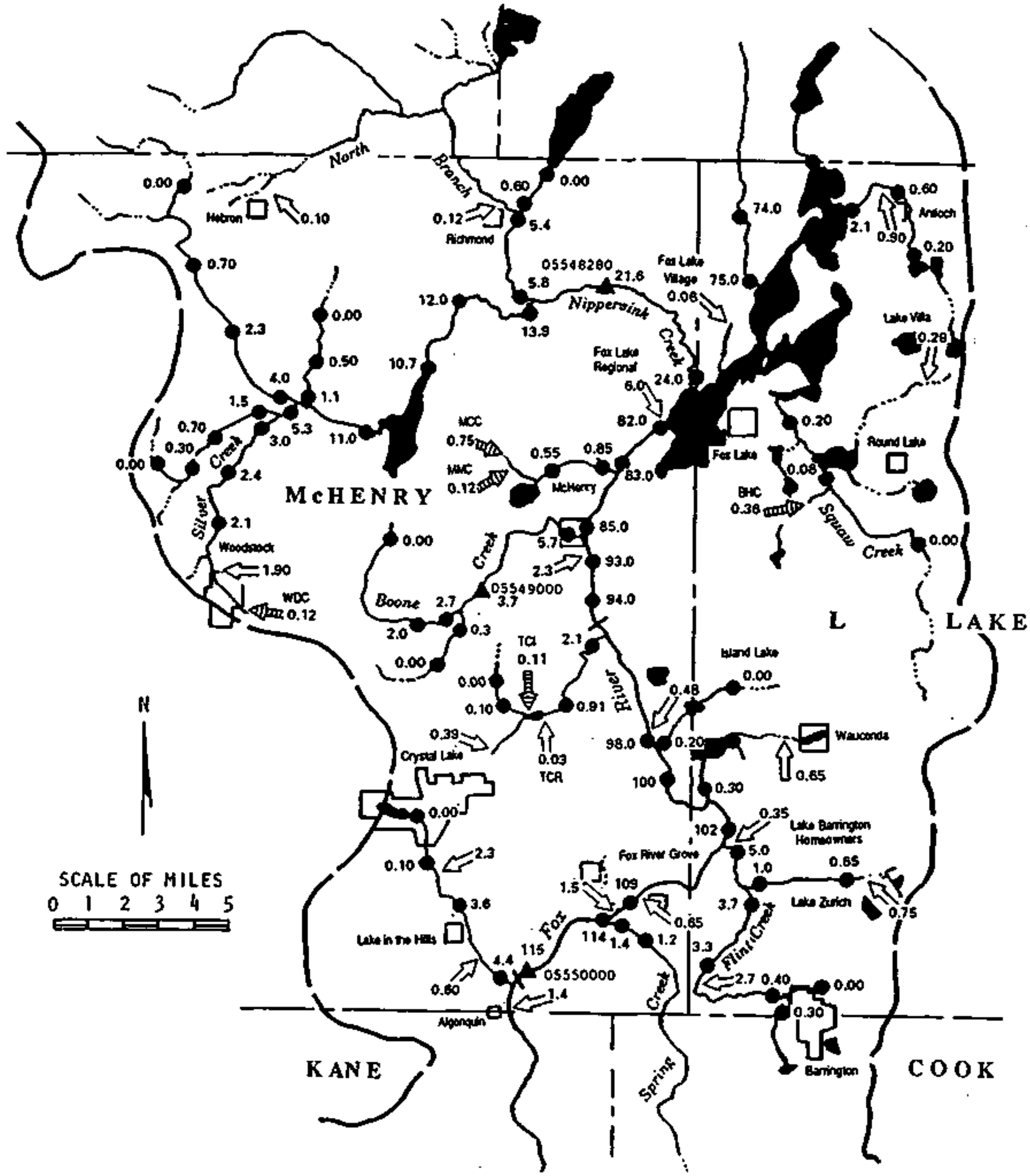

Figure 2.1: 7-day, 10-year low flows in the upper Fox River basin

Table 2.1: Contributions from Tributaries and Effluents: Fox River from Wilmot to Algonquin

Source	*Inflows (cfs)*
Trevor Creek at Channel Lake Outlet	0.5
Sequoit Creek	2.1
Nippersink Creek	24.0
Fox Lake and Round Lake (effluents)	6.0
Fox River (groundwater accretion)	2.0
Sub-total (Pistakee Lake outlet)	34.6
Unnamed Creek	0.8
Boone Creek	5.7
McHenry (effluent)	2.3
Unnamed Creek	2.1
Island Lake (effluent)	0.5
Unnamed Creek	0.2
Unnamed Creek	0.3
Lake Barrington (effluent)	0.3
Flint Creek	5.0
Fox River Grove	0.7
Cary (effluent)	1.5
Spring Creek	1.4
Total (Algonquin)	55.4

area: the Stratton (formerly McHenry) and Algonquin Dams. The Stratton Dam creates a pool extending upstream to the Pistakee Lake outlet. The surface area of the pool is 403 acres. The Algonquin Dam creates a 16.34-mile-long pool extending upstream to the Stratton Dam, and the pool has a surface area of 849 acres. Gates at the Stratton Dam are operated to maintain the water level in the Chain of Lakes for recreational purposes.

USGS streamgage records are available on the main river, at the upper and lower end of the lakes, at Wilmot, Wisconsin, and at Algonquin, Illinois; the respective drainage areas at these stations are 868 and 1402 square miles. Nippersink Creek is the major tributary, draining a total of 234 square miles. There is a gaging station near Spring Grove and another on Boone Creek near McHenry. The $Q_{7,10}$ values at Wilmot and Algonquin, adjusted for 1990 effluent discharge conditions, are 73.0 and 115 cfs, respectively. The various tributaries, groundwater accretion, and wastewater effluents from Wilmot to Algonquin add 55.4 cfs of flow to the $Q_{7,10}$ as shown in table 2.1. The net losses in the Fox Chain of Lakes and the two pools created by the Stratton and Algonquin Dams are

73.0 + 55.4 - 115, or 13.4 cfs. Lowest 7-day flows usually occur during September or late August.

Allowing a net 2.1 cfs loss per square mile of lake surface area, the evaporation loss from the Fox Chain of Lakes is estimated as 25.6 cfs. Thus, the $Q_{7,10}$ in the Fox River at the outlet of Pistakee Lake is 73.0 + 34.6 - 25.6 or 82.0 cfs. The net loss includes evaporation loss from the Fox Chain of Lakes and increase in streamflow from Stratton Dam under the new operation scheme. The effects of Stratton Dam operation on Fox River flows are explained in Knapp and Ortel (1992).

2.3.6 Flow Regulation for Navigation

Flows in the waterways of the MWRDGC and in the Illinois River are regulated through a series of locks and dams for navigation purposes. The observed losses are attributed to evaporation, leakage, and change in storage because of regulation. Because all these losses are proportional to water surface area, the distribution of losses along the river is found by the use of the lake, river, and backwater surface areas at different points along the river.

2.3.7 Groundwater Accretion to Low Flow

A stream becomes a gaining stream when groundwater flows into it. The amount of this accretion has been shown (Singh, 1968) to be related to the depth of streambed incision or entrenchment. The amount of this gain is estimated from the low flow data at gaging stations along a major stream, streambed conditions, existence of permeable deposits, and other pertinent factors.

2.3.8 Streams in Urbanizing Basins

For streams with a rapidly urbanizing drainage area, the lowest 7-day flows each year exhibit a pronounced upward trend with time. As an example, consider the lowest 7-day flows observed in the Salt Creek at Western Springs (station 05531500, drainage area 114 square miles) from 1946 to 1990, plotted in figure 2.2.

The lowest 7-day flow curve typifies the trend and yields a $Q_{7,10}$ value of 38.0 cfs for the 1990 condition of effluent inflows to Salt Creek above the gaging station. Various inflows above the gaging station for 1940, 1950, 1960, 1970, 1980, and 1990 are given in table 2.2.

The total effluent inflow in 1990 was 44.4 cfs and the $Q_{7,10}$ was 38.0 cfs. Thus, the loss in stream channel amounts to 44.4 - 38.0, or 6.4 cfs. Most of the communities in the basin depend on wells for their water supply. Water pumped from the ground or supplied from Lake Michigan is discharged as wastewater effluent. In the southern part of the creek, the glacial drift is thin, and the basal sand and gravel, though too thin to be used as an aquifer, do provide a hydraulic connection between the Salt Creek bed and the dolomite aquifer underlying the sand and gravel. This relationship is a critical factor in groundwater recharge in the southern part of the basin. The entire reach of the

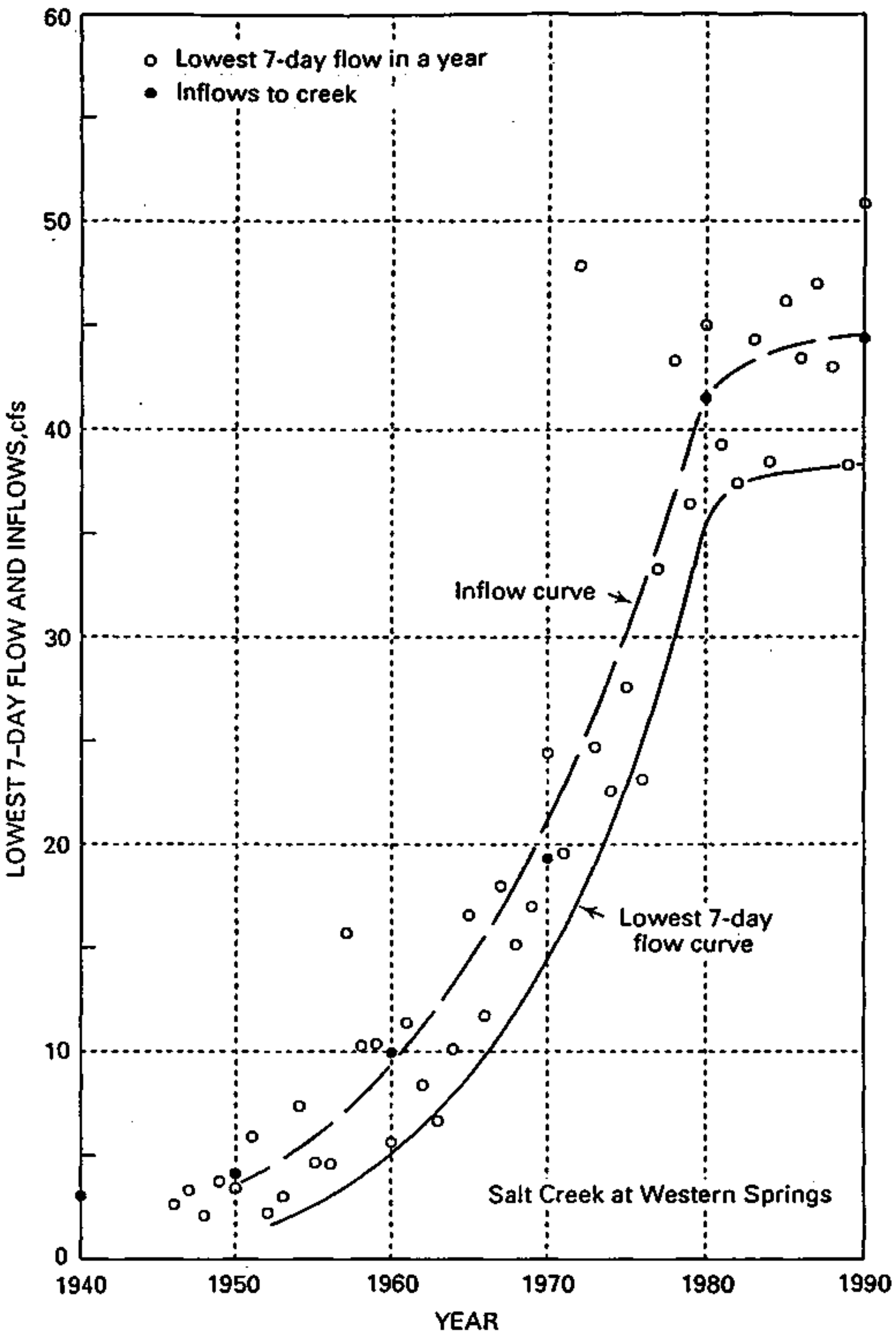

Figure 2.2: Annual 7-day low flows in the Salt Creek at Western Springs

Table 2.2: Inflows above Station 05531500: Salt Creek at Western Springs

Source	*Inflows (cfs)*					
	1940	*1950*	*1960*	*1970*	*1980*	*1990*
John Egan Plant	-	-	-	-	19.5	24.6
Elk Grove Devon	-	-	-	-	0.1	-
Springbrook	-	0.03	0.42	0.80	1.5	3.4
Wood Dale	-	-	0.36	1.1	1.7	2.0
Addison	0.08	0.08	0.88	3.8	5.5	5.9
Salt Creek S. D.	1.1	1.4	3.4	4.6	2.8	2.0
Elmhurst	1.9	2.6	4.8	7.3	10.4	6.5
Oakbrook Terrace	-	-	-	0.12	-	-
Oak Brook	-	-	0.09	1.6	-	-
Total	3.08	4.11	9.95	19.32	41.5	44.4

Salt Creek south and east of Elmhurst is regarded as an area of potential recharge to the shallow aquifers.

Favorable conditions for induced recharge exist in the general area near gaging station 05531500 because of an extensive cone of depression caused by groundwater pumping. Induced recharge from the streambed reduces streamflow; this effect will be more pronounced at low flow than at high flow. From a study (Spieker, 1970) of seepage runs made by the USGS in 1965 and 1966, the losses of streamflow from induced recharge were determined for the various reaches. These losses were used in determining the $Q_{7,10}$ values upstream of the gaging station.

2.3.9 Wastewater Treatment Plants

The monthly operation reports from various towns, cities, and industries are on file in the IEPA offices in Springfield and Maywood, Illinois. These reports contain information on the amount of water in gallons per day leaving the plant after treatment, any wastewater bypassed during rains in the case of combined sewer systems, and quality parameters such as Biochemical Oxygen Demand (BOD) and concentrations of suspended solids. The information from these reports varies in quality, but it helps to promote an understanding of the variability of the effluent.

The effluent records were inspected and analyzed to derive the 7-day low effluent flow from 1988 to 1990. Many municipal and industrial wastewater treatment plants were contacted by phone or by letter not only to fill in the missing information but also to verify the information collected from the files. The change in town population from 1980 to 1990 was analyzed with regard to change in effluent flows to ascertain any special cases and reasons for it.

The locations of wastewater effluent outfalls to receiving streams were obtained from the USGS quadrangle maps, the IEPA offices, area-wide water quality management plans prepared by the Northeastern Illinois Planning Commission (NIPC), and in some cases by direct telephone inquiries.

2.3.10 MWRDGC Waterways

The MWRDGC has three major wastewater reclamation plants (WRPs): Northside, West-Southwest (Stickney), and Calumet, which discharge to the North Shore Channel, Chicago Sanitary and Ship Canal, and Calumet-Sag Channel, respectively, of the MWRDGC waterways. These waterways serve a dual purpose. They provide open drainage for effluents from WRPs serving Greater Chicago, and navigation facilities both ways for shipping from Lake Michigan to the Mississippi River via the Illinois River. The water levels in these waterways are controlled primarily for navigation that requires wide and deep waterways.

In the past, about 1700 cfs of Lake Michigan water was used by municipalities for water supply. After deductions for storm runoff, pumpage, and lockage and leakage, the remainder allowable diversion or discretionary diversion has been used by the MWRDGC to dilute wastewater effluents in the waterways during certain periods. The discretionary diversion averages about 320 cfs over the year, but most of it is used during the summer months of July, August, and September. For the period January 1, 1982 to December 31, 1990, the lowest 7-day diversions from Lake Michigan, as determined from the data provided by MWRDGC and the Division of Water Resources, Illinois Department of Transportation, are as follows:

Location	*7-day period*	*Minimum* Q_7, *(cfs)*
North Shore Channel at Wilmette	March 11-17, 1982	0.14
Chicago River at Control Works	February 20-26, 1982	16.0
Calumet River at O'Brien Lock	February 20-26, 1982	12.0

The northside WRP discharges its effluent to the North Shore Channel, which joins the North Branch Chicago River about 3 miles downstream. The North Branch Chicago River meets the Chicago River, which carries Lake Michigan water coming through the lock facilities at Chicago Harbor. From this junction to Damen Avenue, the channel is known as the South Branch Chicago River. Downstream from Damen Avenue to Lockport, it is known as the Chicago Sanitary and Ship Canal. The largest MWRDGC WRP, West-Southwest (Stickney), discharges its effluent to this waterway. The canal is joined by the Calumet-Sag Channel from the east, which carries Lake Michigan water passing through the Calumet River and the O'Brien Lock and Dam, water from the Grand Calumet and Little Calumet Rivers, and the effluent from the Calumet WRP. Downstream of the Lockport Lock and Dam, the Chicago Sanitary and Ship Canal joins the Des Plaines River, which later combines with the Kankakee River to form the Illinois River.

2.3.11 Illinois River

Flow in the Illinois River is regulated through a series of locks and dams for navigational purposes. Below Lockport, there is one lock and dam on the Des Plaines River at Brandon Road and two locks at Dresden Island and Marseilles on the Illinois River. The $Q_{7,10}$ at Marseilles is estimated as 3185 cfs. The $Q_{7,10}$ at the beginning of the Illinois River has been determined as 3130 cfs from a study of concurrent flows at the following gaging stations:

USGS No.	*Stream and Gaging Station*
05527500	Kankakee River near Wilmington
05532500	Des Plaines River at Riverside
05537000	Chicago Sanitary and Ship Canal at Lockport
05539000	Hickory Creek at Joliet
05540500	Du Page River at Shorewood
05542000	Mazon River near Coal City
05543500	Illinois River at Marseilles

The groundwater accretion to flow during $Q_{7,10}$ conditions in the reach above Marseilles is estimated as 2.25 cfs per mile on the basis of balancing the inflows from the tributaries and the flows in the Illinois River. Some values of $Q_{7,10}$ along the Illinois River are given in Table 2.3.

2.3.12 Other Considerations

Important assumptions made in deriving the $Q_{7,10}$ of the streams in northeastern Illinois are as follows.

1. Effluents from any wastewater treatment plants (WTPs) serving schools have not been considered because these will be practically zero during school closures of one, two, or more weeks. Therefore, these are not shown on the $Q_{7,10}$ map.

2. Effluents from WTPs serving small trailer parks or recreational areas have not been considered because such flows are not only small but also transitory and seasonal. In intermittent streams, all such effluents would be lost before reaching the perennial stream. For similar reasons, effluents less than 0.01 cfs from small municipal or industrial WTPs are not considered.

Table 2.3: $Q_{7,10}$ Values along the Illinois River

River Mile	*Location*	$Q_{7,10}$ *(cfs)*
271.5	Dresden Island Lock and Dam	3130
268.3	Downstream of Aux Sable Creek	3140
263.2	Downstream of Mazon River	3150
258.0	0.6 mi downstream of Grist Island Light	3165
252.0	0.2 mi upstream of Spring Brook Light	3180
246.6	Marseilles gaging station	3185
242.0	0.5 mi upstream of Bulls Island Bend Light	3185
240.0	0.2 mi downstream of Scherer Island	3185
239.0	0.7 mi downstream of Fox River	3575

3. The $Q_{7,10}$ values for the 1990 condition of effluents may need adjustment in later years with increases in effluent flows because of increasing population. The impact of such increases may be greater in streams having small natural low flows. Other significant changes may come from relocation of WTPs and considerable changes in the magnitude of effluents.

REFERENCES

[1] Knapp, H.V., and T.W. Ortel. 1992. *Effect of Stratton Dam Operation on Flood Control Along the Fox River and Fox Chain of Lakes.* Illinois State Water Survey Contract Report 533.

[2] Singh, K.P. 1968. "Some Factors Affecting Baseflow." *Water Resources Research,* Vol. 4, No. 5. October.

[3] Singh, K.P. 1983. *7-Day 10-Year Low Flows of Streams in Northeastern Illinois.* Illinois State Water Survey Contract Report 307.

[4] Singh, K.P., G.S. Ramamurthy, and I.W. Seo. 1988a. *7-Day 10-Year Low Flows of Streams in the Rock, Spoon, La Moine, and Kaskaskia River Basins.* Illinois State Water Survey Contract Report 440.

[5] Singh, K.P., G.S. Ramamurthy, and I.W. Seo. 1988b. *7-Day 10-Year Low Flows of Streams in the Kankakee, Sangamon, Embarras, Little Wabash, and Southern Regions.* Illinois State Water Survey Contract Report 441.

[6] Singh, K.P., and J.B. Stall. 1973. *The 7-Day 10-Year Low Flows of Illinois Streams.* Illinois State Water Survey Bulletin 57.

[7] Spieker, A.M. 1970. *Water in Urban Planning, Salt Creek Basin, Illinois.* U.S. Geological Survey Water Supply Paper 2002.

APPENDIX A

Low Flow Map for Northeastern Illinois

The $Q_{7,10}$ values for northeastern Illinois streams, developed from this study, are shown in the map (in pocket). The various symbols used in the low flow map are explained in figure Al. The Q7,10 values at the 44 gaging stations are listed in table A.1, for 1990 conditions of effluent discharges. The effluent flows under $Q_{7,10}$ conditions for municipal and industrial wastewater treatment plants are given in tables A.2 and A.3. Negative flow values indicate water withdrawals from the stream and show a net loss from the stream under $Q_{7,10}$ conditions.

DCDEC	Du Page County Department of Environmental Concerns
LCDPW	Lake County Department of Public Works
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
NSSD	North Shore Sanitary District
MHP	Mobile Home Park
SD	Sanitary District
WRD	Water Reclamation District

- Streams having zero 7-day, 10-year low flow
- Streams having nonzero 7-day, 10-year low flow
- Location of municipal wastewater treatment plant outfall and 1990 effluent in cfs during a 7-day, 10-year low-flow period
- 7-day, 10-year low flow (natural plus 1990 effluent) in cfs
- Location of U.S. Geological Survey streamgaging station
- Dam
- Location of industrial wastewater treatment plant outfall and 1990 effluent in cfs during a 7-day, 10-year low-flow period
- Net loss to the stream during 7-day, 10-year low flow conditions due to water withdrawal for industrial use

Figure A.1: Symbols used in 7-day, 10-year low flow map

Table A.1: $Q_{7.10}$ Values at Gaging Stations in Northeastern Illinois

USGS Gage#	*Stream and Gaging Station*	*Area* (mi^2)	*Period of Record*	$Q_{7,10}$ *(cfs) 1980*	*1990*
05527500	Kankakee River near Wilmington	5150	72(1916-1987)	480	496
05527800	Des Plaines River at Russell	123	20(1968-1987)	0.20	0.40
05528000	Des Plaines River near Gurnee	232	19(1969-1987)	32.0	37.0
05528500	Buffalo Creek near Wheeling	19.6	24(1964-1987)	0.00	0.30
05529000	Des Plaines River near Des Plaines	360	47(1941-1987)	40.9	55.0
05529500	McDonald Creek near Mount Prospect	7.90	35(1953-1987)	0.00	0.00
05530000	Weller Creek at Des Plaines	13.2	37(1951-1987)	0.00	0.10
05530500	Willow Creek near Park Ridge	19.7	8(1951-1958)	31.0	40.0
05530990	Salt Creek at Rolling Meadows	30.5	14(1974-1987)	0.00	0.20
05531500	Salt Creek at Western Springs	114	42(1946-1987)	36.0	38.0
05532000	Addison Creek at Bellwood	17.9	36(1952-1987)	2.90	2.20
05532500	Des Plaines River at Riverside	630	44(1944-1987)	113	139
05533000	Flag Creek near Willow Springs	16.5	36(1952-1987)	7.40	9.0
05534500	N. Br. Chicago River at Deerfield	19.7	35(1953-1987)	0.00	0.30
05535000	Skokie River at Lake Forest	13.0	36(1952-1987)	0.30	0.40
05535070	Skokie River near Highland Park	21.1	20(1968-1987)	0.60	0.70
05535500	W. F. of N. Br. Chicago River at Northbrook	11.5	35(1953-1987)	2.20	2.7
05536000	N. Br. Chicago River at Niles	100	37(1951-1987)	16.5	17.0
05536195	Little Calumet River at Munster, IN	90.0	30(1959-1988)	5.70	6.9
05536210	Thorn Creek near Chicago Heights	17.2	16(1965-1980)	0.30	0.30
05536215	Thorn Creek at Glenwood	24.7	38(1950-1987)	14.0	16.0
05536235	Deer Creek near Chicago Heights	23.1	39(1949-1987)	0.30	0.23
05536255	Butterfield Creek at Flossmoor	23.5	39(1949-1987)	0.00	0.00
05536265	Lansing Ditch near Lansing	8.80	39(1949-1987)	0.20	0.20
05536270	North Creek near Lansing	16.8	32(1949-1980)	1.00	1.40
05536275	Thorn Creek at Thornton	104	39(1949-1987)	19.6	20.5
05536290	Little Calumet River at South Holland	205	40(1948-1987)	31.6	29.0
05536340	Midlothian Creek at Oak Forest	12.6	37(1951-1987)	0.00	0.25
05536500	Tinley Creek near Palos Park	11.2	36(1952-1987)	0.00	0.00
05537000	Chicago Sanitary and Ship Canal at Lockport	739	36(1954-1989)	1700	1755

Table A.1: Concluded

USGS *Gage#*	*Stream and Gaging Station*	*Area (mi^2)*	*Period of Record*	$Q_{7,10}$ *1980*	*(cfs) 1990*
05537500	Long Run near Lemont	20.9	36(1952-1987)	0.30	0.40
05539000	Hickory Creek at Joliet	107	43(1945-1987)	3.00	4.00
05539900	W. Br. Du Page River near West Chicago	28.5	26(1962-1987)	10.4	9.0
05540095	W. Br. Du Page River near Warrenville	90.4	19(1969-1987)	23.0	20.0
05540500	Du Page River at Shorewood	324	47(1941-1987)	78.0	87.0
05543500	Illinois River at Marseilles	8259	68(1920-1987)	3200	3185
05546500	Fox River at Wilmot, WI	868	49(1940-1988)	67.0	73.0
05548280	Nippersink Creek near Spring Grove	192	21(1967-1987)	21.6	21.6
05549000	Boone Creek near McHenry	15.5	34(1949-1982)	3.70	3.7
05550000	Fox River at Algonquin	1403	72(1916-1987)	68.0	115
05550500	Poplar Creek at Elgin	35.2	36(1952-1987)	0.50	0.50
05551200	Ferson Creek near St. Charles	51.7	26(1962-1987)	0.36	1.0
05551700	Blackberry Creek near Yorkville	70.2	27(1961-1987)	3.40	4.5
05552500	Fox River at Dayton	2642	63(1925-1987)	236	260

Table A.2: Municipal Effluent Discharges under $Q_{7,10}$ Conditions

NPDES #	*Municipal Wastewater Treatment Plant*	*County*	*Effluent Discharge (cfs)*
22586	Hinsdale	Cook	10.0
28061	MWRDGC - Calumet	Cook	290
36340	MWRDGC - Egan	Cook	24.6
36137	MWRDGC - Hanover Park	Cook	9.5
47741	MWRDGC - Kirie	Cook	40.9
28070	MWRDGC - Lemont	Cook	1.4
28088	MWRDGC - Northside	Cook	367
28053	MWRDGC - West-Southwest (Stickney)	Cook	1007
26794	Paradise MHP	Cook	0.04
27723	Thorn Creek Basin SD - (TCBSD)	Cook	15.0
49859	Touhy MHP	Cook	0.11
50628	Hinckley	De Kalb	0.10
30970	Sandwich	De Kalb	0.56
23001	Shabbona	De Kalb	0.06
23167	Waterman	De Kalb	0.06
33812	Addison - North	Du Page	2.6
27367	Addison - South	Du Page	3.3
27618	Bartlett	Du Page	0.85
21849	Bensenville	Du Page	3.0
21130	Bloomingdale - South	Du Page	2.0
26352	Carol Stream	Du Page	3.3
32760	Citizens Utility Co. - Santafe	Du Page	0.20
28380	Downers Grove	Du Page	10.0
65188	DCDEC - Knollwood	Du Page	6.5
28398	DCDEC - Nordic	Du Page	0.25
31844	DCDEC - Woodridge	Du Page	7.8
28746	Elmhurst	Du Page	6.5
21547	Glenbard Wasterwater Authority	Du Page	10.0
28967	Glendale Heights	Du Page	3.0
34479	Hanover Park #1	Du Page	0.50
34487	Hanover Park #2	Du Page	0.50
26280	Itasca	Du Page	2.0
30813	Roselle	Du Page	1.8
48721	Roselle - West	Du Page	0.8
30953	Salt Creek SD	Du Page	2.0

Table A.2: Continued

NPDES #	*Municipal Wastewater Treatment Plant*	*County*	*Effluent Discharge (cfs)*
23469	West Chicago	Du Page	3.2
31739	Wheaton	Du Page	7.0
20061	Wooddale - North	Du Page	1.7
34274	Wooddale - South	Du Page	0.45
21113	Morris	Grundy	1.50
22543	Batavia	Kane	1.8
27944	Carpentersville	Kane	2.3
25739	Carpentersville - Kimball Hill	Kane	0.10
28541	East Dundee	Kane	0.49
62260	Elburn	Kane	0.25
45411	Ferson Creek Utilities	Kane	0.05
35891	Fox River WRD - West	Kane	0.47
28665	Fox River WRD - North	Kane	4.3
28657	Fox River WRD - South	Kane	16.2
20087	Geneva	Kane	2.2
27260	Mooseheart	Kane	0.11
36641	Prestbury Utility Co. - Sugar Grove	Kane	0.44
22705	St. Charles	Kane	5.0
45667	St. Charles Skyline	Kane	0.10
20818	Aurora SD - (ASD)	Kendall	29.0
30104	Newark	Kendall	0.04
21857	Oswego	Kendall	0.27
20052	Piano	Kendall	0.67
31551	Valley Water Co. - (VWC)	Kendall	0.22
36412	Yorkville Bristol SD - (YBSD)	Kendall	0.70
20354	Antioch	Lake	0.90
21598	Barrington	Lake	2.7
28347	Deerfield	Lake	3.6
20958	Fox Lake	Lake	6.0
45144	Fox Lake Village	Lake	0.06
60224	Kildeer - Bishops Ridge	Lake	0.04
45110	Lake Barrington Homeowners	Lake	0.35
21342	Lake Villa	Lake	0.29
23230	Lake Zurich	Lake	0.94
22535	Lake Zurich - North	Lake	0.75

Table A.2: Continued

NPDES #	*Municipal Wastewater Treatment Plant*	*County*	*Effluent Discharge (cfs)*
20478	LCDPW Grandwood Park	Lake	0.22
22080	LCDPW Sylvan Lake	Lake	0.22
22055	LCDPW - Des Plaines	Lake	6.8
22071	LCDPW - New Century	Lake	1.7
29530	Libertyville	Lake	3.4
20796	Lindenhurst	Lake	1.0
22501	Mundelein	Lake	3.7
30171	NSSD - Clavey Road	Lake	15.2
35092	NSSD - Gurnee	Lake	16.2
30244	NSSD - Waukegan	Lake	18.5
20109	Wauconda	Lake	0.65
20877	Earlville	La Salle	0.13
21059	Marseilles	La Salle	0.90
30384	Ottawa	La Salle	2.8
22446	Seneca	La Salle	0.15
31062	Sheridan	La Salle	0.21
20265	Somonauk	La Salle	0.13
25682	Paw Paw	Lee	0.04
23329	Algonquin	McHenry	1.4
20516	Cary	McHenry	1.5
28282	Crystal Lake #1 & #2	McHenry	2.3
53457	Crystal Lake #3	McHenry	0.39
20583	Fox River Grove	McHenry	0.65
26433	Hebron	McHenry	0.10
31933	Island Lake	McHenry	0.48
21733	Lake in the Hills	McHenry	0.60
21067	McHenry *	McHenry	2.1
66257	McHenry South *	McHenry	0.22
26093	Richmond	McHenry	0.12
38202	Terra Cotta Realty - (TCR)	McHenry	0.03
31861	Woodstock - North	McHenry	1.9
32778	Arbury Utilities Co.	Will	0.16
32689	Bolingbrook	Will	1.6
60798	Bolingbrook Village	Will	0.12
21261	Bonnie Brae - Forest Manor	Will	0.15

* Shown as combined flow of 2.3 cfs on map

Table A.2: Concluded

NPDES #	*Municipal Wastewater Treatment Plant*	*County*	*Effluent Discharge (cfs)*
45381	Camelot Utilities	Will	0.05
31984	Chickasaw Hills Util. - Main	Will	0.60
32727	Citizens Utility Co. #1	Will	1.5
32735	Citizens Utility Co. #2	Will	1.7
24473	Consumers Water Company	Will	1.5
64998	Crest Hill	Will	0.90
21121	Crest Hill #2	Will	1.0
45993	Derby Meadows Utility Co.	Will	0.76
49867	Elwood	Will	0.11
20532	Frankfort #1	Will	0.90
45403	Frankfort #2	Will	0.51
45390	Frankfort South	Will	0.42
22519	Joliet	Will	17.0
33553	Joliet West	Will	3.7
47589	Lewis University	Will	0.08
29611	Lockport	Will	1.9
22144	Lockport Heights	Will	0.09
20222	Manhattan	Will	0.20
55981	Metro Utility Co., Chickasaw - (MUCC)	Will	0.27
55913	Minooka	Will	0.27
24201	Mokena	Will	0.64
34061	Naperville Springbrook	Will	19.0
20559	New Lenox	Will	0.75
46264	New Lenox #2	Will	0.28
24422	Oak Highlands - Ingalls Park	Will	0.18
20508	Plainfield	Will	0.56
48526	Romeoville	Will	1.5
22781	Shorewood	Will	0.55
31798	Willowbrook	Will	0.20

Table A.3: Industrial Effluent Discharges under $Q_{7,10}$ Conditions

NPDES #	*Industrial Wastewater Treatment Plant*	*Code*	*County*	*Effluent Discharge (cfs)*
02101	Acme Steel Co. - Chicago	ASCC	Cook	-0.70
02119	Acme Steel Co. - Riverdale	ASCR	Cook	-0.70
01627	Amoco Chemicals - Willow Springs	AMC	Cook	0.05
	Clark Oil & Refinery	CORC	Cook	-2.8
02186	Commonwealth Edison - Crawford	CWEC	Cook	-2.3
02178	Commonwealth Edison - Fisk	CWEF	Cook	-1.3
02593	LTV Steel - Chicago	LTV	Cook	-1.7
02640	PVS Chemicals	PVS	Cook	-0.10
01473	Quaker Oats Company	QOC	Cook	0.16
01341	Reynolds Metals	RM	Cook	1.0
02691	USS-South Works - Chicago	USSC	Cook	-3.0
34592	Argonne National Labs	ANL	Du Page	1.3
26069	Akzo Chemicals Inc.	ACI	Grundy	0.04
02224	Commonwealth Edison - Dresden	CWED	Grundy	-23.4
01767	ETI Explosives - Seneca	ETI	Grundy	1.0
02917	Quantum Chemical - Morris	QCM	Grundy	1.4
01899	Dial Corp - Montgomery	DCM	Kane	0.10
63304	Aptakisic Sand Corporation	ASC	Lake	2.8
24074	Baxter Healthcare - Round Lake	BHC	Lake	0.36
02259	Commonwealth Edison - Waukegan	CWEW	Lake	
02763	Commonwealth Edison - Zion	CWEZ	Lake	
20656	Foulds Inc	FI	Lake	0.50
01929	General Electric Co.	GEC	La Salle	1.4
48151	Commonwealth Edison - LaSalle	CWEL	La Salle	-4.0
01279	Modine Mfg. Co.	MMC	McHenry	0.12
01716	Morton Chemical - Ringwood	MCC	McHenry	0.75
26816	T C Industry - Crystal Lake	TCI	McHenry	0.11
33863	Woodstock Die Cast	WDC	McHenry	0.12
01643	Amoco Chemicals - Joliet	AmCC	Will	0.86
01732	Caterpillar Inc. - Joliet	CIJ	Will	0.43

Note: Negative discharge values indicate net water loss from receiving streams because of water withdrawals and returns from industrial plants.

Table A.3: Concluded

NPDES #	*Industrial Wastewater Treatment Plant*	*Code*	*County*	*Effluent Discharge (cfs)*
64254	Commonwealth Edison - Joliet	CWEJ	Will	-2.7
02208	Commonwealth Edison - Will County	CWEW	Will	-3.2
02666	Joliet Army Ammunition	JAA	Will	0.62
02861	Mobil Oil Co. - Joliet	MOC	Will	-13.0
02020	Olin Corp - Joliet	OCJ	Will	0.51
46779	Peoples Gas Light & Coke	PGLC	Will	0.05
02453	Stepan Chemical - Elwood	SCE	Will	0.60
02038	Unilever Vandenbergh - Joliet	ULV	Will	0.30
01589	Uno-Ven Company - Lemont	UVC	Will	0.30

Note: Negative discharge values indicate net water loss from receiving streams because of water withdrawals and returns from industrial plants.