Research Report 126

Indicator Bacterial Quality in the Illinois River at Peoria, Illinois, 1976-1986

by
Shun Dar Lin and Davis B. Beuscher

ILLINOIS STATE WATER SURVEY
DEPARTMENT OF ENERGY AND NATURAL RESOURCES

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Indexing Terms: Bacteria, fecal coliform, fecal streptococcus, Illinois River, time series analysis, total coliform, water pollution.

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INDICATOR BACTERIAL QUALITY IN THE ILLINOIS RIVER AT PEORIA, ILLINOIS, 1976-1986

by Shun Dar Lin and Davis B. Beuscher

ABSTRACT

Weekly monitoring for total coliform (TC), fecal coliform (FC), and fecal streptococcus (FS) densities has been carried out on water from the Illinois River at Peoria (river milepoint, MP 161.6) since June 1971. This report covers the results for the second and third five-year periods (June 1976-May 1981 and June 1981-May 1986) and compares them with results from the first five-year period (June 1971-May 1976).The objectives of the study were to compile long-term indicator bacteria densities for comparison with the FC regulations, and then evaluate the FC7TC and FC/FS ratios. The data gathered were investigated for monthly, seasonal, yearly, and five-year period trends. Observations showed considerably wide ranges of bacterial counts. Bacterial densities were generally higher in the summer months and lower in the winter months. The FS counts fluctuated less with time. For the 15-year average, only about 17 percent of the samples were in compliance with the "geometric mean of the 200 FC per 100 mL" standard. Only 11 percent of samples collected met the "400 FC per 100 mL" density limit. The bacterial quality (not TC) in the Illinois River at Peoria has deteriorated since 1980. Compliance with the rule regarding 400 FC per 100 mL was found to be the limiting factor. For the 15-year average, approximately 16 percent of the TC densities are FC bacteria. For the last ten years of the study, however, the percentage has increased considerably. The FC/TC ratio values were low in the cold months and were high in warmer months. On the basis of FC/FS values, major fecal contamination was derived from human sources during the summer and fall, whereas it was derived from nonhuman sources during the winter and spring.

INTRODUCTION

Almost seven decades ago, the Illinois State Water Survey conducted bacteriological surveys on the Illinois River for approximately 80 miles or 130 kilometers (km) from LaSalle to Kingston Mines (Greenfield et al., 1924) and for about 300 miles (480 km), the whole length of the river (Hoskins et al., 1927). The Water Survey also performed weekly standard plate counts (for total bacterial density) and some coliform tests on samples collected from the Illinois River at Peoria during the period from January 1959-September 1962.

During the summer of 1971, a study to define the waste assimilative capacity of the Upper Illinois Waterway was undertaken by the Water Survey. As part of the study, approximately 150 river water samples were examined for total coliform (TC) and fecal coliform (FC) in the waterway at 19 river stations from Lockport to Chillicothe, a distance of about 113 miles (182 km). The results have been reported elsewhere (Lin and Evans, 1974; Butts et al., 1975). The Metropolitan Water Reclamation District of Greater Chicago (MWRDGC), formerly the Metropolitan Sanitary District of Greater Chicago, has been and is monitoring the bacterial quality of the Illinois River for certain years.

Beginning October 31, 1966, weekly samples of Illinois River water were collected at Peoria and analyzed for 17 physical and chemical characteristics. The results for the period 1967-1972 were summarized by Kothandaraman and Sinclair (1975). Beginning in June 1971, weekly bacterial enumerations were made for TC and FC densities. Also, weekly fecal streptococcus (FS) determinations began in June 1972. The sampling program has continued since then. The results of the first five-year study (June 1971-May 1976) have been reported elsewhere (Lin and Evans, 1980).

This report deals principally with the weekly TC, FC, and FS data obtained for the second five-year period, June 1976-May 1981, and the third five-year period, June 1981—May 1986. A previous study (ibid.) found no correlation between any physical or chemical characteristics of river waters and the indicator bacterial densities. Hence, no other water quality parameter is evaluated.

The Illinois Waterway

The Illinois Waterway is unique among the many water courses within the state of Illinois. It drains 43 percent of the area of the state, and during dry weather its headwaters frequently consist of treated Chicago-area wastewaters diluted with flow diverted from Lake Michigan.

The waterway has three distinct sections. The uppermost portion includes the Chicago Sanitary and Ship (CS&S) Canal and its associated branches, which extend from Lake Michigan to the confluence of the Des Plaines River (mile point (MP) 289.9). Approximately 17 miles of the Des Plaines River, between the confluences of the CS&S Canal and the Kankakee River, is the middle section of the waterway. The lower and major part of the waterway is the Illinois River.

The Illinois River is formed by the confluence of the Des Plaines and Kankakee Rivers (MP 273.0) southwest of Joliet. The river flows westward to DePue, where it turns abruptly southwest and joins the Mississippi River at Grafton, above St. Louis (figure 1). The Illinois River is about 273 miles (439 km) long, whereas the entire waterway from Lake Michigan to Grafton is 327.2 miles (527 km) long. The total watershed area for the waterway is about 29,010 square miles or 75,140 square kilometers (km^2). The watershed area for the waterway at Peoria, where the weekly samples are being taken, is 14,200 square miles (36,800 km^2). Besides the Des Plaines and Kankakee Rivers, other major tributaries above Peoria are the DuPage (MP 276.9), Fox (MP 239.7), and Vermilion (MP 226.3) Rivers.

The Illinois Waterway is a series of eight navigation pools created by locks and dams to maintain water depths needed for commercial barge navigation. The wastewater effluents from the Chicago area are frequently diluted with Lake Michigan water diverted through control structures maintained and operated by the MWRDGC. Diversion for dilution purposes by the MWRDGC is limited to an annual average rate not exceeding 1,500 cubic feet per second (cfs) or 42.5 cubic meters per second (m^3/s). The average flow as measured at Kingston Mines, 16 miles (26 km) downstream from Peoria, is about 14,425 cfs (408.2 m^3/s). The recorded minimum and maximum flows are 1,810 cfs (51.2 m^3/s) and 83,100 cfs (2350 m^3/s), respectively. The velocity of streamflow is less than 1 mile per hour or 1.6 kilometers per hour (km/h) at normal river stages. The very small hydraulic gradient, an average of 0.267 feet per mile or 5.06 centimeters per kilometer (cm/km), partially accounts for the low flow velocity in the river.

Wastewater Sources

Sixteen waste treatment facilities owned and operated by municipalities or sanitary districts discharge effluents directly into the Illinois Waterway upstream of Peoria (Lin and Evans, 1980). In addition, the waterway between Lockport and Chillicothe receives discharges from 21 industries, such as petroleum refining, metal finishing and plating, steel, fermentation and distillation, food, meat packing, paper and pulp, fertilizer, and others.

The three wastewater treatment plants operated by the MWRDGC contribute about 98 percent of the Chicago area's total municipal flow. This flow makes up more than 93 percent of the total wastewater flows direcdy discharging

Figure 1. Illinois River basin showing the Illinois River and its tributaries

into the Upper Illinois Waterway. The average flows of the MWRDGC, other municipalities, and industries are 1,466, 33.2, and 71.9 million gallons a day (mgd) or 5.55 x 10^6, 0.126 x 10^6, and 0.272 x 10^6 cubic meters a day (m^3/d), respectively. The Chicago metropolitan area wastewater discharges have a significant influence on downstream water quality.

Indicator Bacteria

Pathogenic bacteria, pathogenic protozoan cysts, and viruses have been isolated from public water supplies, wastewaters, sewage treatment plant effluents, stormwaters, stream and lake waters, and recreational waters. The sources of these pathogens are the feces of humans and of wild and domestic animals.

Identification of these disease-causing organisms and enumeration of their densities in water and wastewater are not recommended because no single technique is currently available to isolate and identify all the pathogens. In fact, concentrations of these pathogens in water and wastewater are generally low. In addition, the methods for identification and enumeration of pathogens are tedious, complicated, expensive, and cannot detect pathogens. Furthermore, the facilities and trained personnel necessary for routine examination of pathogens in drinking water, wastewater, and other waters are not always available.

Indicators of possible public health risk have been used instead of direct isolation and enumeration of pathogens for many years. The ideal indicator of a pathogen would have several attributes. It would be present when the pathogen is present and absent when the pathogen is absent. The ideal indicator and the pathogen would always be present in precisely the same numbers or in a constant ratio. The ideal indicator would be easily and inexpensively quantifiable and as resistant as the pathogen to disinfectants and to environmental stresses.

Unfortunately, there is no ideal indicator. But for many years, the coliform group of bacteria (TC and FC) has been used to indicate water pollution in the United States. Experience has established the significance of coliform group density as an indicator of the degree of pollution and of the results of sanitary surveys. The significance of coliform tests and the interpretation of the results are well authenticated and have been used as the basis for standards of bacteriological quality of public water supplies.

The coliform group of bacteria includes all aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas and acid formation within 48 hours at 35 °C (APHA et al., 1989). TC bacteria may originate in the intestines of animals, including humans, or may occur naturally in the environment. Four genera *(Enterobacter, Escherichia, Klebsiella,* and *Citrobacter)* are the most commonly enumerated organisms (Caballi et al., 1983). Only *Escherichia coli* is consistently and exclusively found in the feces of warm-blooded animals (Dufour, 1976). TC bacteria are generally not harmful.

The presence of coliform bacteria in water is generally regarded as evidence of pollution by warm-blooded animals. TC bacteria have been used as a measure of the fecal contamination of lakes and streams for almost seven decades. These bacteria include a group of heterotrophic bacteria, many having little in common with each other except that they are always present in the intestinal tracts of humans and other warm-blooded animals. Thus, the occurrence and densities of TC bacteria have been useful in assessing the sanitary conditions of water. The absence of TC bacteria is evidence of a bacteriologically safe water, but it does not necessarily indicate that the water is safe from virus.

The shortcomings of TC bacteria as an indicator include the fact that these bacteria are nonspecific with respect to fecal contamination and that some strains *(Enterobacter aerogenus* and *Klebsiella pneumoniae)* have regrowth potential in nutrient-rich water and sediments (Kittrell and Fuirfari, 1963; James and Evison, 1985). Several strains of TC bacteria do not originate from fecal matter but rather originate in the soil, which complicates their use as a water quality indicator. Several years ago, FC bacteria, a subgroup of TC bacteria, were introduced as an indicator of pollution from warm-blooded animal feces. They are a more precise bacteriological tool for assessing water quality. The Illinois Pollution Control Board (IPCB) has adopted rules requiring adherence to certain limitations on bacterial quality in waters based on FC densities (IEPA, 1990).

FC bacteria consist of thermotolerant *Klebsiella* and *E. coli* biotypes present in the intestines and feces of warm-blooded animals (Caballi et al., 1983). One of the drawbacks of using FC bacteria as an indicator, however, is that it is difficult to distinguish between human sources and other warm-blooded animal sources. Geldreich et al. (1964) first proposed the use of an FC/FS ratio as a more valuable tool for assessing pollution sources than the sole use of FC densities. Their findings (ibid.; Geldreich, 1967; Geldreich and Kenner, 1969) showed that FS densities were significantly higher than FC densities in all warm-blooded animal feces examined except those of humans. The application of these findings permits, within limits, the use of FS densities to differentiate among sources of bacterial pollution in surface waters.

The FS group comprises a number of species of the genus Streptococcus, such as *S. faecalis, S. faecium, S. avium, S. bovis, S. equinus,* and *S. gallinarum* (APHA et al., 1989). The normal habitat of these organisms is generally the gastrointestinal tract of humans and animals. Because FS bacteria rarely multiply in polluted water, FS data may be of particular value for stream pollution surveys and for determining the sanitary quality of waters from wells, shallow lakes, and beaches.

FS tests are commonly used in the sanitary analysis of water supplies in Europe. In the United States, TC, FC, and FS bacteria have all been pollution indicators at various times (ibid.; Kabler, 1968). Correlations between coliforms and pathogenic bacteria have been studied by many investigators, who found little evidence that enteroviral or other microbial diseases are transmitted frequently from drinking water in which coliforms are absent (The Working Group of Water Quality of the Subcommittee on Water Quality, Interdepartmental Committee on Water, 1972). Unfortunately, bacterial indicators are generally not reliable indexes of the presence of viruses; the absence of indicators does not assure that viruses are also absent. Until a good alternative is discovered, however, it is valid to use the presence of TC bacteria in water supplies and FC and FS bacteria in sewage and streamwater as indicators of enteric pollution.

The bacterial population in a natural waterway is influenced by many factors, including human activities, biological competition, and physical and chemical characteristics of the water, such as river flow stages, flood phase, runoff, sunlight, etc. (Flint, 1987; Chao and Feng, 1990; Elder, 1986, 1987; Takita, 1981; Tudor et al., 1990). Recently, the development of mathematical models to describe the various water quality parameters has been encouraged. Several models relating to coliform density in streams have been proposed.

Objectives and Report Plan

Evaluating the quality of the Illinois Waterway at Peoria is a continuing process. The data subject to evaluation here were obtained from June 1976-May 1986: the second five-year study period (June 1976-May 1981) and the third five-year study period (June 1981-May 1986). The objectives of this report were:

1) To compile bacterial density data for comparison to existing rules and regulations governing bacterial quality in Illinois streams.

2) To evaluate the significance of the FC/TC and FC/FS ratios.

This report describes the procedures used for bacteria enumeration. It also includes data on the type of bacteria examined, FC standards, and bacterial type ratios. The tabulations of observed data for TC, FC, and FS are given in appendices A-1 and A-2.

Acknowledgments

The study was conducted under the general supervision of Stanley A. Changnon, Jr. and Richard G. Semonin, former Chiefs of the Illinois State Water Survey. Linda Dexter typed the original manuscript; Linda Hascall and David Cox prepared the illustrations; Eva Kingston edited the manuscript; and Sarah Hibbeler formatted the final report.

METHODS AND PROCEDURES

Beginning in June 1971, samples were collected weekly from the Illinois River (MP 161.6) at Peoria for chemical and bacteriological analyses. The location is 1.4 miles (2.2 km) upstream of the effluent from the Greater Peoria Sanitary District's facilities. The samples were taken from the nearby Franklin Street Bridge, about 0.5 miles upstream, when ice covered the river.

Besides bacteria enumerations, 17 other parameters were determined: water temperature, pH, dissolved oxygen, alkalinity, ammonia, nitrate, calcium, chloride, fluoride, hardness, iron, magnesium, silica, sodium, sulfate, total dissolved minerals, and turbidity. The units are expressed as milligrams per liter (mg/L) except pH (unitless), temperature (°C), and turbidity (nephelometric turbidity units or NTU). Streamflows were estimated by subtracting flows of the Mackinaw River, Kickapoo Creek, and the Peoria Sanitary District effluent from the flow at Kingston Mines.

Bacteria enumerations for TC and FC began in June 1971, and tests for FS started in June 1972. Bacteria samples were collected 1 foot (30 cm) below the surface of the water and refrigerated immediately. Bacterial determinations were performed within four hours after collection.

Membrane filter techniques for TC, FC, and FS were performed in accordance with *Standard Methods for the Examination of Water and Wastewater* (APHA et al., 1989). Previous studies (Lin, 1973, 1974, 1976) suggest mat the membrane filter procedures are comparable to the multiple-tube methods for determinations of TC, FC, and FS in river waters. TC counts were performed with the M-Endo agar LES two-step method at 35 °C for 24 hours. M-FC agar was used for the FC test at 44.5 °C for 24 hours. For the FS determinations, KF-Streptococcus agar has been used at 35 °C for 48 hours. For each test, three replications of each sample were filtered through 0.45 micrometer (μm) membrane filters.

RESULTS AND DISCUSSION

Bacterial Density

Appendices A-1 and A-2 show the tabulated bacterial densities determined for TC, FC, and FS on all sampling dates for the second five-year study (June 1976-May 1981) and the third five-year study (June 1981-May 1986), respectively. Previous studies (Lin and Evans, 1974, 1980; Lin et al., 1974) suggest that the central tendencies and dispersion of bacteria data can best be expressed in geometric terms, i.e., geometric mean and geometric standard deviation. Table 1 summarizes the yearly, five-year, and ten-year ranges, geometric means, and geometric standard deviations of all three types of bacterial densities obtained.

Total Coliform

Inspection of appendices A-l and A-2 and table 1 indicates that TC bacterial densities varied from sample to sample. Apparently, the intra-station variations in bacteria counts were also reported in other studies (Greenfield et al., 1924; Hoskins et al., 1927; Lin and Evans, 1974; Lin et al., 1974; Bennett, 1969; Lee et al., 1970; Presnell and Miescier, 1971; Gray, 1975; Bagde and Verma, 1982; Nelson and Hansen, 1984; Feresu and Van Sickle, 1990; Khalaf, 1990; Goyal et al., 1977; Gerba and Schaiberger, 1973). From June 1976-May 1981, TC counts ranged from a low of 130/100 mL on July 19, 1976, to a high of 73,000/100 mL on May 14, 1979. For the third five-year study (appendix A-2), TC counts varied randomly from a minimum of 160/100 mL on April 30, 1984, to a maximum of 78,000/100 mL on March 4, 1985. In the previous study (Lin and Evans, 1980), extremely high TC counts of 2,300,000/100 mL were detected on March 17, 1975, and 2,200,000/100 mL on March 24, 1975.

Figure 2 depicts monthly geometric means of TC and FS bacteria for all three five-year study periods. Monthly fluctuations of TC counts occurred from year to year. Peaks in TC density were observed almost every month (not in the same year) over the 15-year study period. On the basis of the monthly geometric mean of bacteria data obtained, the results of the 5-year 10-year, and 15-year statistical analyses of TC, FC, and FS are presented in table 2; and their 10-year and 15-year results are shown in figure 3.

The first five-year study period values for monthly geometric mean TC densities were significantly greater than those in the second and third five-year study periods (table 2). Furthermore, for longer (10-year and 15-year) periods, figure 3 shows that the peak TC monthly geometric mean occurred in March and relatively high TC counts were detected through August The geometric mean TC densities for the 15-year period were found to be significantly higher than those for the 10-year period. In a study of the River Tigris in Iraq, it was reported that the densities of all types of TC, FC, and FS bacteria examined were higher in winter and spring than in summer and fall (Khalaf, 1990).

Table 1 indicates that, during the ten-year period June 1976-May 1986, the annual geometric mean TC densities ranged from 780 counts/100 mL (June 1976-May 1977) to 3,800 counts/100 mL (June 1981-May 1982), and a ten-year geometric mean was 1,900 counts/100 mL. The annual geometric mean TC density for each of the last ten years was significantly less than that observed during the previous four years (June 1972-May 1976). For each of the five-year periods, the geometric mean TC densities were 7,900 counts/100 mL, 1,500/100 mL, and 2,600/100 mL for the first (June 1971-May 1976), second (June 1976-May 1981), and third (June 1981-May 1986) period, respectively. Solely on the basis of TC density, the bacterial quality of the Illinois River water at Peoria has improved.

During the ten-year period from June 1976-May 1986, the TC yearly geometric standard deviation was between 1.99 and 3.65. These values are generally lower than those observed during the first five-year period (table 1). This means that the yearly variation in TC densities for the second and third five-year periods was less than that for the first five-year period.

Fecal Coliform

From June 1976-May 1981, FC counts reached a minimum of 4/100 mL on December 26, 1978, and a maximum of 5,900/100 mLon July 21, 1980 (appendixA-1) with a five-year geometric mean of 210/100 mL (table 1). From June 1981-May 1986, FC counts were found to range from 15/100 mL on December 27, 1983, to 16,000/100 mL on September 19, 1983 (appendix A-2) with a geometric mean of 370/100 mL (table 1). For the first five-year study, the highest FC density was 12,000/100 mL on May 28, 1974 (Lin and Evans, 1980).

Comparing the monthly FC geometric means for all three study periods indicates that the third five-year period (C, June 1981-May 1986) had higher FC counts for most months except January, April, and May (table 2). Figure 3 reveals that monthly geometric mean FC densities were not much different for the last 10-year and 15-year periods. Also the peaks in FC occurred from June-September.

An examination of the data in appendices A-l and A-2 and table 1 shows that FC counts for the four-year period from June 1976-May 1980 were lower than other periods with yearly geometric means between 140 and 180/100 mL. After this period, FC counts increased significantly for six years (until May 1986). On the basis of FC results, there was no improvement in bacteria quality in the Illinois River water at Peoria. In fact, bacteria quality deteriorated in the last five-year period. Nevertheless, a later section of this report evaluates FC to determine its compliance with IPCB standards.

Table 1. Statistical Data of Bacteria Counts per 100 mL

	Total coliform			*Fecal coliform*			*Fecal streptococcus*		
Study period	*Range*	*Mg**	*Og†*	*Range*	*Mg*	*σg*	*Range*	*Mg*	*σg*
6/1971-5/1972	190-38,000	2,100	3.01	19-2,200	150	2.90	-	-	-
6/1972-5/1973	420-1,500,000	8,200	4.13	20-5,300	300	3.58	8-900	120	3.84
6/1973-5/1974	150-180,000	5,000	4.22	48-12,000	330	3.52	12-2,600	120	3.05
6/1974-5/1975	2,400-2,300,000	67,000	4.99	20-8,300	290	3.78	3-1,000	100	2.81
6/1975-5/1976	500-110,000	5,800	3.40	16-3,700	200	3.60	10-7,700	140	3.24
6/1971-5/1976	**150-2,300,000**	**7,900**	**5.91**	**16-12,000**	**240**	**3.50**	**3-7,700**	**120**	**2.98**
6/1976-5/1977	130-37,000	780	2.92	15-3,000	140	3.84	9-3,000	100	2.85
6/1977-5/1978	250-11,000	2,100	2.78	14-2,300	140	3.45	22-2,200	220	2.58
6/1978-5/1979	230-73,000	1,900	3.65	4-2,600	180	4.00	15-3,500	180	4.40
6/1979-5/1980	210-28,000	1,200	2.86	7-2,000	160	3.12	8-2,000	130	3.04
6/1980-5/1981	690-13,000	2,400	1.99	140-5,900	770	2.32	10-540	97	2.36
6/1976-5/1981	130-73,000	**1,500**	**3.06**	4-5,900	210	**4.01**	8-3,500	**140**	**3.04**
6/1981-5/1982	640-41,000	3,800	2.40	80-3,400	440	2.53	28-1,200	140	2.63
6/1982-5/1983	350-9,300	2,000	2.13	40-2,500	310	2.32	25-490	91	1.90
6/1983-5/1984	160-25,000	1,300	2.95	15-16,000	460	3.63	12-2,700	110	3.32
6/1984-5/1985	380-78,000	2,700	2.90	44-3,800	350	3.20	5-1,500	97	3.66
6/1985-5/1986	410-37,000	3,600	2.59	25-3,400	310	3.79	12-1,600	160	3.19
6/1981-5/1986	**160-78,000**	**2,600**	**2.74**	**15-16,000**	**370**	**3.10**	**5-2,700**	**120**	**2.99**
6/1971-5/1981	**130-2,300,000**	**3,400**	·	**4-12,000**	**220**	·	**3-7,700**	**130**	
6/1976-5/1986	**130-78,000**	**1,900**	-	**4-5,900**	**270**	-	**5-3,500**	**130**	-
6/1971-5/1986	**130-2,300,000**	**3,100**	-	**4-12,000**	**260**	-	**3-7,700**	**130**	-

Notes:

* Geometric mean

† Geometric standard deviation

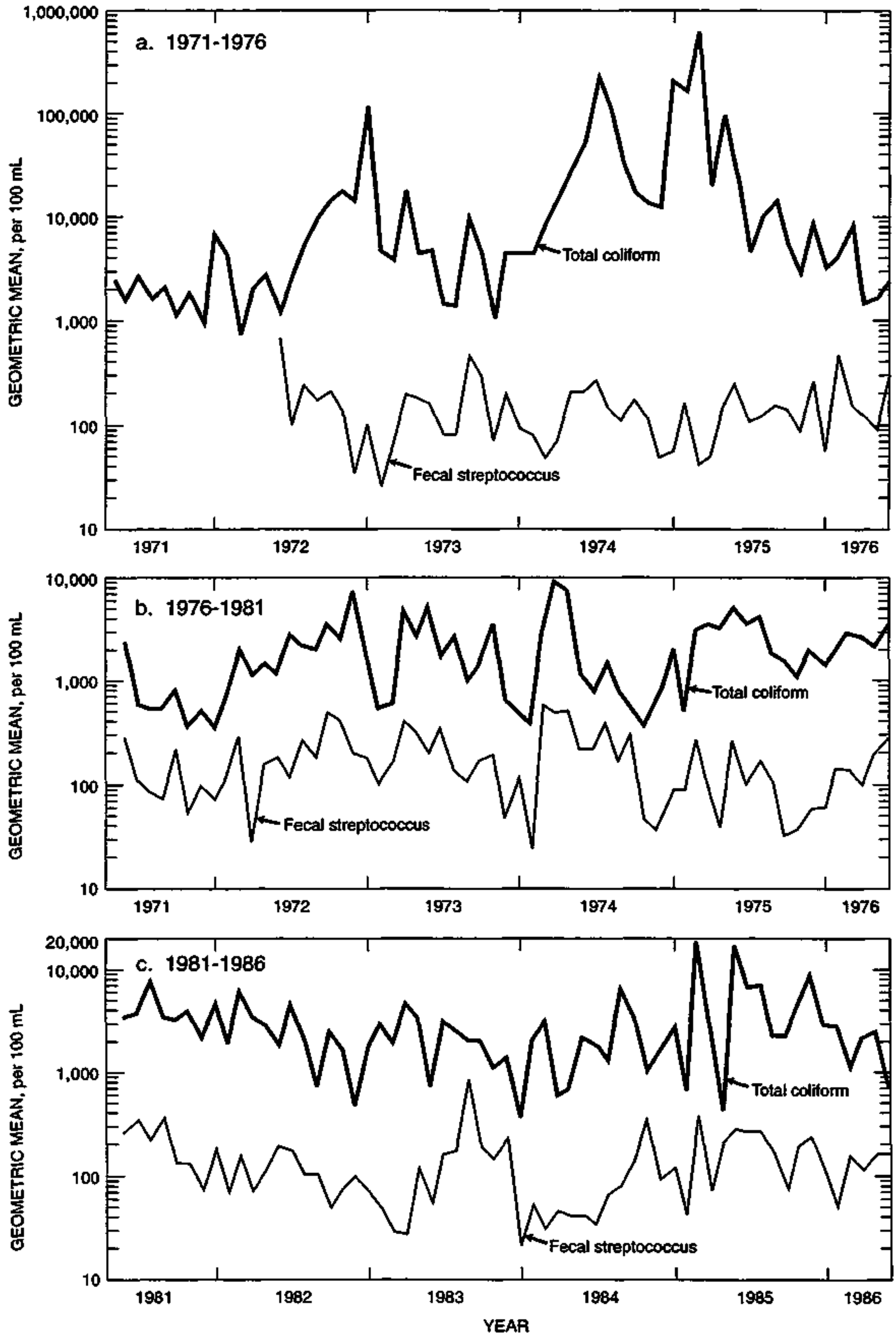

Figure 2. Monthly geometric means of total coliform and fecal streptococcus
in the Illinois River at Peoria

Table 2. Comparison of Bacterial Data on a Monthly Basis

*Month, period**	*Total coliform*			*Fecal coliform*			*Fecal streptococcus*		
	N[†]	*Mg*	*Og*	*N*	*Mg*	*σg*	*N*	*Mg*	*Og*
January									
A	23	16,000	8.05	23	200	2.77	18	74	3.21
B	23	950	2.54	22	63	4.67	21	96	2.00
C	19	2,000	3.09	20	160	2.17	22	75	3.46
D	42	1,300	2.94	42	97	3.19	43	88	2.69
E	65	3,200	6.80	65	130	3.50	61	78	2.91
February									
A	20	6,900	8.25	20	130	2.85	16	110	4.63
B	19	710	2.28	19	89	3.95	19	380	3.81
C	19	2,400	2.30	20	170	2.31	20	66	3.98
D	38	1,300	2.78	39	120	3.31	39	77	4.05
E	58	2,300	5.33	59	120	3.45	55	85	4.19
March									
A	22	17,000	9.38	22	140	3.05	18	67	3.18
B	21	2,200	3.12	22	250	3.89	22	237	2.29
C	22	4,300	3.54	24	260	3.83	24	120	3.45
D	43	3,100	3.45	46	250	3.72	46	160	3.33
E	54	5,800	6.28	68	200	3.81	64	130	3.47
April									
A	22	7,000	4.29	22	150	4.21	18	99	4.07
B	21	3,800	2.53	21	345	4.23	21	140	3.82
C	22	2,000	2.63	22	220	3.06	22	74	2.58
D	43	2,700	2.69	43	280	3.64	43	100	3.28
E	65	3,800	3.45	65	220	3.91	61	100	3.46
May									
A	20	7,000	6.44	21	190	5.04	16	150	2.56
B	21	2,800	3.30	22	290	3.46	19	140	4.28
C	21	1,800	2.38	21	270	1.97	21	99	3.28
D	42	2,200	2.86	43	280	2.72	40	120	3.51
E	62	3,500	4.50	64	250	3.45	56	130	3.27
June									
A	20	6,900	4.98	20	460	2.23	16	240	2.63
B	19	2,100	4.41	20	280	6.06	21	230	2.54
C	16	2,700	3.01	18	610	3.05	18	120	3.19
D	35	2,400	3.71	38	400	4.56	39	170	2.95
E	55	3,500	4.49	58	420	3.70	55	190	2.91
July									
A	23	5,800	9.91	22	480	3.44	19	120	2.20
B	22	1,500	2.96	21	340	3.65	22	150	2.62
C	20	3,700	2.06	21	860	2.76	21	130	3.06
D	42	2,300	2.80	42	540	3.41	43	140	2.80
E	65	3,100	4.81	64	520	3.39	62	130	2.61
August									
A	20	6,500	5.96	21	290	2.99	16	130	1.92
B	21	1,700	2.80	18	300	4.20	22	160	2.40
C	19	2,700	2.40	24	540	2.70	24	160	2.52
D	40	2,400	2.88	42	470	3.39	46	160	2.44
E	60	3,400	4.53	63	370	3.92	62	150	2.31

Table 2. Concluded

Month, period*	Total coliform N[†]	Total coliform Mg	Total coliform Gg	Fecal coliform N	Fecal coliform Mg	Fecal coliform Gg	Fecal streptococcus N	Fecal streptococcus Mg	Fecal streptococcus Gg
September									
A	22	8,900	3.71	22	420	2.91	18	180	2.24
B	21	1,000	2.89	19	310	3.36	21	130	2.51
C	18	3,100	3.01	20	740	3.97	21	210	2.96
D	39	1,700	3.33	39	520	3.38	42	170	2.77
E	61	3,100	4.33	61	500	3.35	60	170	2.60
October									
A	22	6,500	3.29	22	380	3.12	18	190	2.26
B	21	1,200	2.59	23	320	2.98	22	210	4.07
C	19	2,600	1.77	22	460	2.19	22	100	2.08
D	40	1,700	2.42	45	390	2.61	44	150	3.20
E	62	2,800	3.27	67	390	2.75	62	160	2.93
November									
A	20	3,300	4.06	21	190	3.26	16	99	2.56
B	19	1,000	2.93	20	130	2.47	21	100	3.25
C	22	2,100	2.53	20	400	2.24	21	150	2.41
D	41	1,500	2.86	40	230	2.77	42	120	2.85
E	61	1,900	3.29	61	210	2.92	58	110	2.75
December									
A	22	8,400	3.61	21	240	2.81	18	94	3.19
B	22	1,300	3.34	20	110	2.91	21	77	2.55
C	20	2,000	3.39	20	270	3.35	21	130	2.59
D	42	1,600	3.40	40	170	3.34	42	100	2.64
E	64	2,800	4.36	61	200	3.17	60	99	2.78

Notes:
* A = 6/1971-5/1976 for TC and FC, and 6/1972-5/1976 for FS
B = 6/1976-5/1981
C = 6/1981-5/1986
D = 6/1976-5/1986
E = 6/1971-5/1986
† N = number of samples for each month during 4- or 5-year period

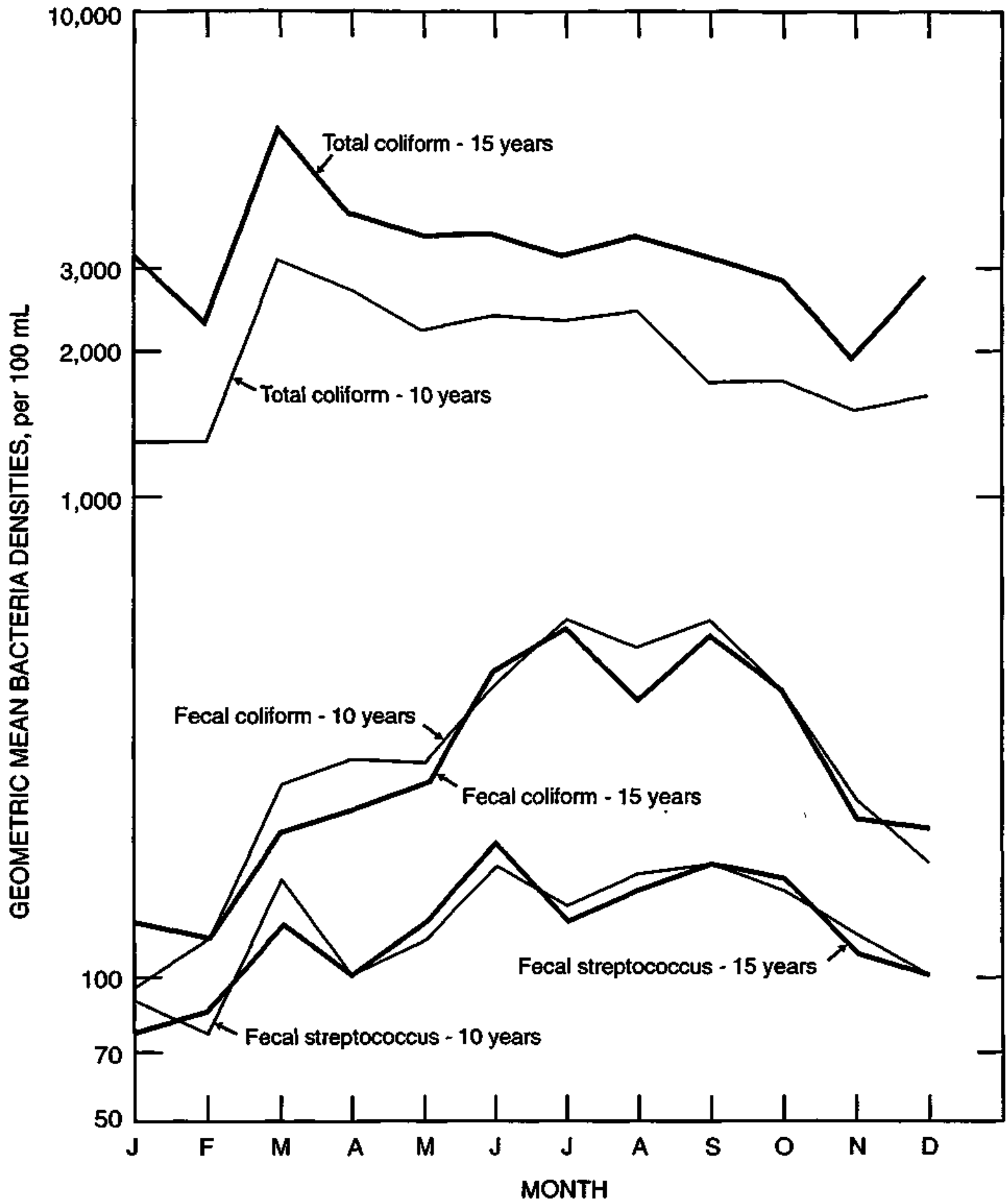

Figure 3. Long-term monthly geometric means of indicator bacteria

It is apparent from table 1 that the yearly geometric standard deviations of FC counts were in a narrow range between 2.3 and 4.0. These values show no trend or pattern.

Fecal ***Streptococcus***

For the second five-year data period, FS densities ranged from a low of 8/100 mL on February 4, 1980 to a high of 3,500/100 mL on May 14, 1979 (appendix A-1). During the third five-year period, FS counts ranged from a low of 5/100 mL on February 4, 1985 to a high of 2,700/100 mL on September 19, 1983 (appendix A-2). A higher FS maximum value (7,700/100 mL) was detected on February 16, 1976 during the first five-year study (Lin and Evans, 1980). For all 15 years of the study period, both minimum and maximum FS values were detected in February.

As shown in figure 2, in contrast to TC densities, the pattern of monthly fluctuation of FS densities generally did not vary much from year to year. An examination of the data in table 2 reveals that the monthly geometric mean FS counts for the second five-year period (B, June 1976-May 1981) were the highest or close to the highest among the three five-year periods for all the months except September and December. The monthly FS geometric mean densities for last 10-year and 15-year periods were found to be identical (table 2, figure 3). Figure 3 also indicates the overall seasonal variation of FS values, with peaks occurring in March and June-October.

Yearly geometric mean FS densities, ranged from 97/100 mL to 220/100 mL. The five-year geometric means are between 120/100 mL and 140/100 mL; and the 10-year and 15-year geometric means are identical at 130/100 mL (table 1). Thus, it is concluded that FS densities in the Illinois River at Peoria were steady for 15 years without improvement or deterioration.

Table 1 shows that the annual geometric standard deviation of FS counts ranged from 1.90 (June 1982-May 1983) to 4.40 (June 1978-May 1979). However, the geometric standard deviations for all three five-year periods are about 3.0.

Correlation

As mentioned earlier, high bacteria counts may be associated with precipitation, urban runoff, stream stages, competition, and other biological factors. Nelson and Hansen (1984) reported that high FC density was usually associated with periods of heavy use of recreation areas of the Salt River in Arizona. No correlation was found between water clarity measurements and FC densities. Similarly, a previous study (Lin and Evans, 1980) indicated that bacterial (TC, FC, or FS) densities were not correlated to any of 17 chemical parameters measured.

Several studies have indicated mat peaks in the number of bacteria in water are associated with precipitation. Bennett (1969) reported that increases occurred in counts of TC, total plate, FC, and FS at Toronto Harbor (Canada) within 24 to 48 hours after rainfall. Gray (1975) found peaks of *E. coli* associated with precipitation during the previous 12 hours on three occasions, and a decrease on two occasions. Goyal et al. (1977) observed that peaks of TC densities in water and sediment samples collected from canals along the Texas coast at polluted sites were always associated with precipitation within 48 hours of sampling. However, this is not the case for FC bacteria. Gerba and Schaiberger (1973) observed a similar situation in Biscayne Bay, Florida. Feachem (1974) reported that FS densities in streams of the New Guinea Highlands peaked rapidly after stormwater runoff mainly because of fecal pollution by animals (pigs). Rises and falls of FC counts were not associated with rainfall. Runoff from pastures and other agricultural land has been implicated as a major bacterial source in streams, however (ISWS, 1983).

Daily precipitation data for 1976-1986 recorded at the Greater Peoria Airport are presented in appendix B. On the basis of these rainfall data and the observed bacterial densities (appendices A-l and A-2), the effect of precipitation on high counts of any type of bacteria was judged. Whether or not any correlation existed was determined by comparing bacteria levels with the previous sample at the time when significant precipitation (>0.1 inches) occurred on that date and/or one day before the sampling date. Appendices A-l and A-2 also indicate whether or not the bacterial densities were associated with precipitation.

Overall during the ten-year study, the increase in bacterial density in the Illinois River at Peoria was associated with rainfall in Peoria 63 percent of the time (90 of 143 samples, see appendices A-l and A-2). This percentage might be a conservative one because the river water samples were generally collected about 9 A.M. every Monday. The sampling program was not designed to define the effect of precipitation on the river's bacterial quality characteristics. Sixteen combined sewer overflow outlets (Feresu and Van Sickle, 1990) from the city of Peoria above the sampling location discharged directly into the Illinois River without any treatment during the study period. Urban runoff did influence the bacteria levels in the Illinois River water, however.

Comparison with FC Standards

The IPCB (IEPA, 1990) has adopted rules regarding FC limits for general use water-quality standards applicable to the Illinois Waterway. The rules of Section 302.209 are:

"a) During the months May through October, based on a minimum of five samples taken over not more than a 30-day period, fecal coliforms (STORET number 31616) shall not exceed a geometric mean of 200 per 100 mL, nor shall more than 10 percent of the samples during any 30-day period exceed 400 per 100 mL in protected waters. Protected waters are defined as waters mat, due to natural characteristics, aesthetic value, or environmental significance, are deserving of protection from pathogenic organisms. Protected waters must meet one or both of the following conditions:

1) They presently support or have the physical characteristics to support primary contact.
2) They flow through or adjacent to parks or residential areas.

b) Water [is exempt from this standard if it is] unsuited to support primary contact uses because of physical, hydrologic, or geographic configuration and located in areas unlikely to be frequented by the public on a routine basis as determined by the Agency (35 Illinois Administration Code 309, Subpart A)."

The FC standards were for year-round use. The current, new FC rules (effective from July 11, 1988) cover only the months May-October. Therefore, the first five-year study's FC data is reevaluated along with the following ten-year FC results.

The FC data obtained for the Illinois River at Peoria from June 1971-May 1986 were evaluated in terms of Rule 302.209(a). The 30-day FC moving geometric means are presented in figure 4. The geometric mean is plotted at the first sampling date of a 30-day period. Due to the weekly sampling program of this study, at most only five samples were collected during a 30-day period. If one sample was missed or a determination failed during a 30-day period, the requirement to use at least five samples was not met. If the FC count of one sample (20 percent) exceeded 400/100 mL, the sample did not meet the density requirement during a 30-day period. For the evaluation of FC data collected in October, the calculation had to include FC data collected in November due to the 30-day moving average. This approach is not clearly stated in IPCB rules and regulations (ibid.).

The FC standard promulgated by the IPCB, i.e., the geometric mean of 200 counts/100 mL that must not be exceeded from May-October, is also shown as solid lines in figure 4. This figure indicates that there is no trend with regard to compliance with the FC standards. In most cases, FC standards were not met, especially from June-September. Acceptable FC quality, as measured by the geometric mean, generally occurred only in May and October.

A detailed evaluation along with the FC standards is summarized in table 3. It shows that, based on yearly observed data, the acceptable bacterial quality as measured by the geometric mean ranged from 0 to 39 percent with a 15-year average of 17 percent. Similarly, there was compliance with the rule of the FC density limit ranging from 0 to 44 percent, with a 15-year average of 11 percent. Violations of 100 percent occurred from May-October in 1973, 1980, 1981, 1984, and 1985. With the adjustment for missing data, the 15-year overall average complied with Rule 302.209(a) for FC standards only 10 percent of the time. Table 3 also suggests that the bacterial (FC) quality of the Illinois River at Peoria deteriorated during the last six years (1980-1985). On the basis of the results shown in table 3, it is apparent that the last part of Rule 302.209(a), whereby no more than 10 percent of the samples during any 30-day period shall exceed 400 FC/100 mL, is the limiting factor in assessing bacterial quality.

Since the new Rule 302.209(a) became effective in July 1988, similar bacterial quality evaluation is not available for any other stream. In a previous study on the Spoon River (Lin et al., 1974), FC data were evaluated year-round instead of from May-October.

FC/TC Values

The historical record of bacteria data in the Illinois Waterway as well as other surface waters deals mainly with TC test results. Thus, it seems worthwhile to assess the FC/TC ratio values. On the basis of these values, FC densities can be calculated from historical TC densities.

The arithmetic mean and standard deviation were employed to evaluate the FC/TC values. The values in percent of yearly mean of the ratio are shown in table 4. A wide range (0 to 86 percent) of FC/TC values was observed. The range of the ratios for the Elinois River at Peoria was greater than that of the Upper Illinois Waterway [0.2 to 38 percent (Lin and Evans, 1974)], the Spoon River [0.3 to 57 percent (Lin et al., 1974)], and the Ohio River [0.4 to 45 percent (ORSANCO Water Users Committee, 1971)].

The yearly averages ranged from a low of 1.2 percent in the fourth study year (June 1974-May 1975) to a high of 34.8 percent in the 13th study year (June 1983-May 1984). Five-year averages also varied. The first five-year average was a low of 7.1 percent. The second and third five-year averages were close (20 and 27 percent, respectively). The overall 15-year average for the Illinois River at Peoria (16 percent) was found to be higher than overall values for the Upper Illinois Waterway [8.8 percent (Lin and Evans, 1974)], the Spoon River [9.5 percent (Lin et al., 1974)], and the Ohio River [14 percent (ORSANCO Water Users Committee, 1971)].

Since considerable variations in yearly average of FC/TC ratios were discerned, seasonal analyses of the ratios seemed more proper. On the basis of the 15-year data, the monthly average FC/TC ratios for each 5-year period and overall 15-year period, as well as other statistical results, are summarized in table 5. The results show that ratios were low (11-14 percent) in winter and spring (December-May), while high ratios occurred in summer and fall, especially in July, September, and October. In those three months, the 15-year overall average FC/TC ratios exceeded 20 percent. Similar monthly patterns were also found in the Spoon River (Lin et al., 1974). The monthly standard deviations followed the same pattern as the monthly average FC/TC ratios, i.e., the higher the monthly average, the higher the standard deviation.

To generate low FC/TC ratios, either the TC densities must increase, the FC counts must decrease, or both. Inspection of appendices A-l and A-2 and table 2 indicates that the lower FC/TC in the winter and spring are caused by the increase in TC counts, and the higher ratios in summer and fall are due to the increases in FC densities. Table 5 also suggests that the monthly average FC/TC ratios for each month during the second and third five-year periods are significantly greater than those for the first five-year period.

Strobel (1968) pointed out that the relationship between FC and TC varied with the source of pollution, level of wastewater treatment, characteristics of the receiving waters, and precipitation on the watershed. Since so many factors may influence the FC/TC ratio value, it would seem unwise to rely on an overall average value based on a year or more of observation. In fact, it would be preferable to limit judgment to only those ratio values

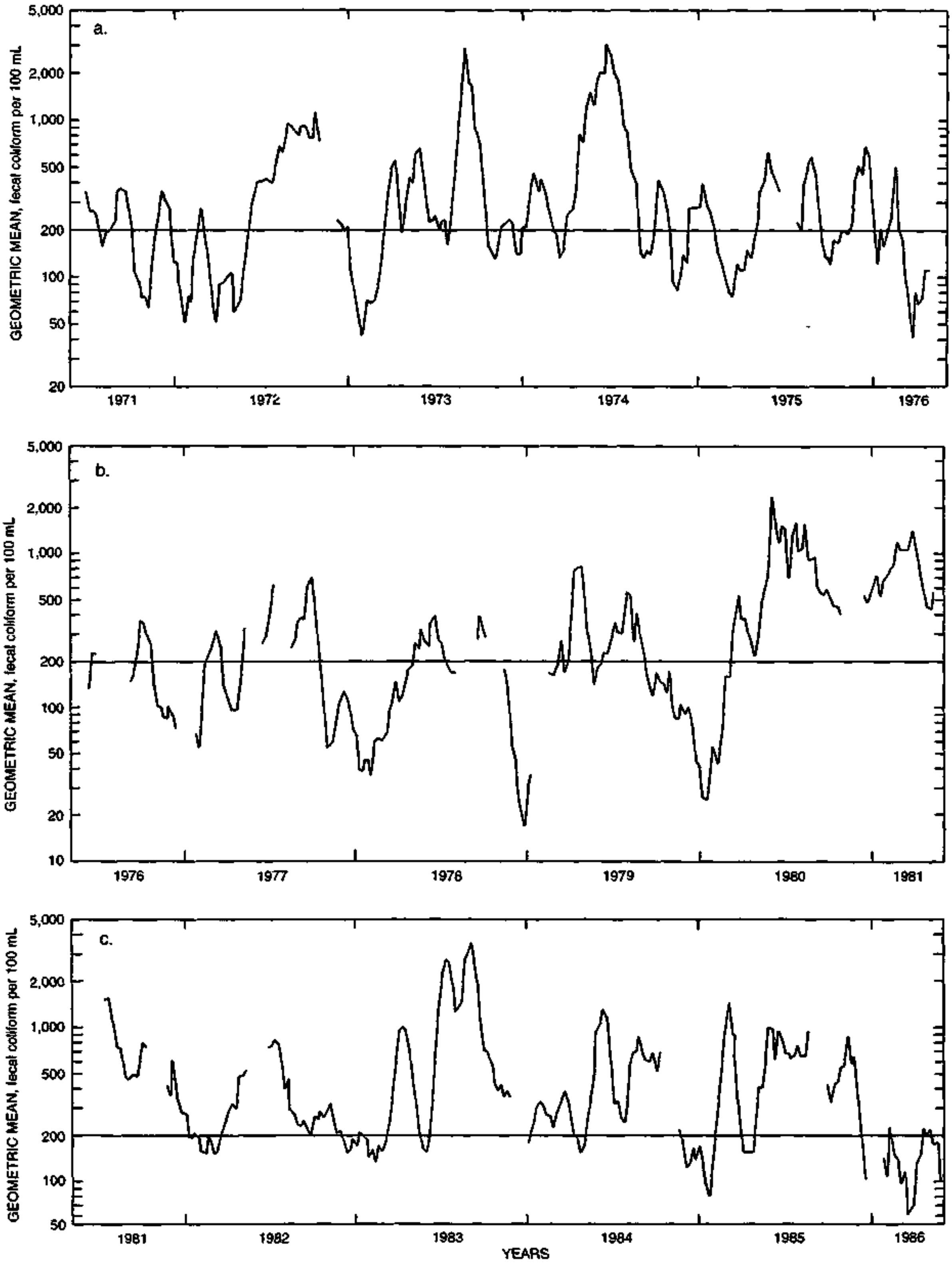

Figure 4. Moving geometric means of fecal coliform densities in the Illinois River at Peoria

Table 3. Compliance with the IPCB's Fecal Coliform Rule 302.209(a)

	Observed Data					*Data adjusted with omissions*		
		Compliance with geometric mean (<200/100 mL)		*Compliance with 10% of sample during 30 days (<400/100 mL)*			*Compliance with IPCB Rule 302.209(a)*	
May through October	*Total number of 30-day periods evaluated*	*Number of 30-day periods*	*Percentage of 30-day periods*	*Number of 30-day periods*	*Percentage of 30-day periods*	*Total number of 30-day periods evaluated*	*Number of 30-day periods*	*Percentage of 30-day periods*
1971	18	7	38.9	8	4.44	22	7	31.8
1972	27	5	18.5	4	14.8	27	4	14.8
1973	26	5	19.2	0	0	26	0	0
1974	26	5	19.2	5	19.2	26	5	19.2
1975	21	7	33.3	4	19.0	26	4	15.4
1976	15	4	26.7	2	13.3	20	4	20.0
1977	17	3	17.6	2	11.8	26	2	7.7
1978	17	4	23.5	3	17.6	27	5	18.5
1979	26	11	42.3	5	19.2	26	5	19.2
1980	26	0	0	0	0	26	0	0
1981	16	0	0	0	0	25	0	0
1982	21	1	4.8	1	4.8	27	1	3.7
1983	27	3	11.1	2	7.4	27	2	7.4
1984	23	0	0	1	4.3	26	0	0
1985	21	0	0	0	0	26	0	0
15-year	327	55	16.8	37	11.3	383	39	10.2

Table 4. Yearly Statistical Summary of FC/TC Values in Percent

Study period	*Number of samples*	*Range*	*Average*	*Standard deviation*
6/1971-5/1972	51	0.81-53.33	11.81	12.40
6/1972-5/1973	51	0.07-30.95	7.36	6.90
6/1973-5/1974	52	0.54-44.83	10.10	8.70
6/1974-5/1975	50	0.00-5.23	1.20	15.34
6/1975-5/1976	49	0.81-22.35	5.22	4.62
First 5-year	253	**10.00-53.33**	7.11	**8.57**
6/1976-5/1977	47	3.01-86.44	23.86	21.08
6/1977-5/1978	49	1.09-50.00	13.62	18.53
6/1978-5/1979	47	0.34-72.22	13.13	11.88
6/1979-5/1980	47	0.38-48.18	21.29	30.30
6/1980-5/1981	47	2.83-85.11	37.87	19.74
Second 5-year	**237**	**0.34-86.44**	**21.88**	**20.09**
6/1981-5/1982	48	1.83-62.14	16.92	14.49
6/1982-5/1983	51	2.63-59.62	20.56	14.96
6/1983-5/1984	36	2.54-82.50	34.82	23.37
6/1984-5/1985	50	1.71-85.71	17.06	20.35
6/1985-5/1986	46	0.90-68.45	12.54	12.07
Third 5-year	**231**	**0.90-85.71**	**19.67**	**16.90**
15-year	721	0.00-86.44	15.99	16.19

Table 5. Monthly Statistical Summary of FC/TC Values in Percent

Month	*Study period*	*Number of samples*	*Range*	*Average*	*Standard deviation*
January	6/1971-5/1976	23	0.02-14.25	3.53	3.98
	6/1976-5/1981	22	0.38-84.21	15.65	21.17
	6/1981-5/1986	19	0.90-23.57	15.78	20.51
	15 years	**64**		**11.33**	**16.87**
February	6/1971-5/1976	20	0.06-11.08	5.37	8.34
	6/1976-5/1981	18	1.17-64.71	18.82	17.23
	6/1981-5/1986	19	1.23-44.38	10.32	11.05
	15 years	**57**		**11.27**	**12.60**
March	6/1971-5/1976	22	0.02-15.00	2.90	3.53
	6/1976-5/1981	20	0.79-46.15	18.93	16.14
	6/1981-5/1986	22	0.34-30.00	7.95	6.62
	15 years	**64**		**9.65**	**10.04**
April	6/1971-5/1976	22	0.54-16.67	3.38	3.55
	6/1976-5/1981	21	0.34-75.00	15.88	13.84
	6/1981-5/1986	22	2.19-56.25	18.54	16.93
	15 years	**65**		**12.55**	**12.77**
May	6/1971-5/1976	20	0.09-10.76	4.28	3.41
	6/1976-5/1981	21	2.05-49.23	15.88	13.84
	6/1981-5/1986	21	4.18-73.91	22.45	18.85
	15 years	**62**		**14.36**	**13.75**
June	6/1971-5/1976	19	0.81-53.33	11.66	13.67
	6/1976-5/1981	18	3.33-49.23	17.27	20.29
	6/1981-5/1986	14	3.23-67.35	23.79	15.47
	15 years	**51**		**16.97**	**16.75**
July	6/1971-5/1976	22	0.08-52.63	14.66	12.44
	6/1976-5/1981	21	8.87-68.65	28.45	15.24
	6/1981-5/1986	20	5.00-82.50	28.70	22.40
	15 years	**63**		**23.71**	**17.05**
August	6/1971-5/1976	20	0.07-15.22	6.95	5.06
	6/1976-5/1981	17	2.83-46.15	20.42	13.86
	6/1981-5/1986	19	3.27-52.53	23.68	17.68
	15 years	**56**		**16.72**	**13.17**
September	6/1971-5/1976	22	0.13-44.83	11.40	12.73
	6/1976-5/1981	19	9.40-85.11	28.63	17.80
	6/1981-5/1986	17	2.93-73.08	29.47	24.20
	15 years	**58**		**22.34**	**18.36**

Table 5. Concluded.

Month	*Study period*	*Number of samples*	*Range*	*Average*	*Standard deviation*
October	6/1971-5/1976	22	1.00-24.77	8.80	7.01
	6/1976-5/1981	21	2.00-86.44	34.62	24.57
	6/1981-5/1986	19	7.06-47.50	19.84	11.52
	15 years	**62**		**20.93**	**16.20**
November	6/1971-5/1976	20	1.33-22.35	7.85	5.74
	6/1976-5/1981	19	1.00-54.54	19.85	15.74
	6/1981-5/1986	20	5.90-85.71	23.05	20.11
	15 years	**59**		**17.01**	**15.10**
December	6/1971-5/1976	21	0.07-18.09	4.87	4.49
	6/1976-5/1981	20	1.09-50.00	14.45	12.21
	6/1981-5/1986	19	2.76-59.62	20.39	16.89
	15 years	**60**		**12.98**	**12.13**

obtained during stable streamflow conditions. Thus, on the basis of results shown in tables 4 and 5, the monthly average (rather than the yearly average) might be more useful in assessing the historical bacterial data.

The ORSANCO Water Users Committee (1971) suggests that higher FC/TC ratio values might indicate the proximity of inefficient wastewater treatment operations or conditions where treatment facilities are being bypassed. Low ratios (<0.20) are most likely caused by aftergrowths of *Aerobacter aerogens* resulting in abnormally high TC counts (ibid.). In the Illinois Waterway at Peoria, 533 of 721 samples (73.9 percent) have FC/TC ratios < 0.20; of which 94.1, 60.3, and 65.8 percent occurred during the first, second, and third five-year study periods, respectively. This is most likely indicative of *A. aerogens* aftergrowths in the river as opposed to improper operation of wastewater treatment facilities.

FC/FS Values

The use of FS in conjunction with FC was first suggested by Geldreich et al. (1964), who felt that the relationship of FC to FS density may be a more valuable informational tool for assessing pollution source(s) of water than sole reliance upon FC density. Estimated per capita contributions of FC/FS ratio values from feces of warm-blooded animals follow:

Animal	*FC/FS ratio*
Human	4.4
Duck	0.6
Sheep	0.4
Chicken	0.4
Pig	0.4
Cow	0.2
Turkey	0.1

The FC/FS ratios show that a ratio value > 4 indicates fecal bacteria derived principally from human waste such as domestic wastewaters. Values < 0.7 suggest fecal contamination derived principally from warm-blooded animals other than humans, i.e., livestock and poultry waste, milk and food processing waste, or stormwater runoff of a nonhuman source.

In applying the FC/FS technique to assess the source of waste, there are several precautions to be observed (Geldreich and Kenner, 1969; Bordner and Winter, 1978). The best results are obtained if the sample is collected within a 24-hour streamflow time downstream of a pollution source because some species of fecal streptococci, such as *S. bovis and S. equinus,* have limited survival capabilities. Furthermore, the ratio values should not be used if FS densities are < 100/100 mL. It is difficult to use FC/FS ratios effectively when mixed pollution sources are present. Bacterial densities can be altered drastically if the pH of the water is > 9.0 or < 4.0. The FC/FS ratios have been of limited value in accurately defining major pollution sources for marine waters, bays, estuaries, and irrigation returns.

From studies of the relationship of indicator and pathogenic bacteria in the Saline and Huron Rivers, Michigan, Smith and Twedt (1971) and Smith et al. (1973) reported that reaches of either river flowing through suburban areas of relatively low human population density might be expected to yield samples with no *Salmonella* but high FC/FS values. Conversely, samples from rural areas might yield salmonellae but exhibit low FC/FS ratios. High FC densities can occur in conjunction with low *Salmonella* counts and vice versa.

During a ten-year period of this study (June 1976-May 1986), 299 of 509 water samples collected had FS densities > 100 counts/100 mL. Only 289 FC/FS ratio values were calculated due to insufficient FC counts, however. Approximately one-half (49.5 percent) of the FC/FS values were between 0.7 and 4.0, 22.5 percent were > 4.0, and 28 percent < 0.7. In a previous study (May 1976-June 1982), approximately 62 percent of the 120 water samples had FC/FS ratio values in a range between 0.7 and 4.0; and 24 percent were > 4.0 while 14 percent were < 0.7 (Lin and Evans, 1980). Figure 5 depicts the yearly distribution of FC/FS values. There was no consistent trend for the ranges of FC/FS values. No FC/FS value < 0.7 was observed during 1980-1981 and 1983-1984. Fewer higher ratio values (>4.0) occurred from June 1975-May 1980. During this period, low ratio values (<0.7) occurred more frequently. Overall, the source of fecal organisms in the Illinois River at Peoria is not clear-cut based on annual evaluation of data.

To examine seasonal fluctuations of FC/FS values, the data collected were divided into four seasons for each of three five-year study periods and into two categories representing FC/FS > 4.0 and < 0.7. The statistical results are presented in table 6, which suggests that there are differences in percentage of FC/FS ranges based on each set of five-year results. The overall results show, however, that fecal contamination was mainly from wastes derived from human sources during the summer and fall months (30 and 29 percent of the time); whereas during the winter and spring months, 44 and 30 percent of the samples, respectively, reflected fecal contamination from nonhuman sources, presumably from urban surface runoff or storms. These winter and spring trends showed up remarkably during the second five-year study period (1976-1981).

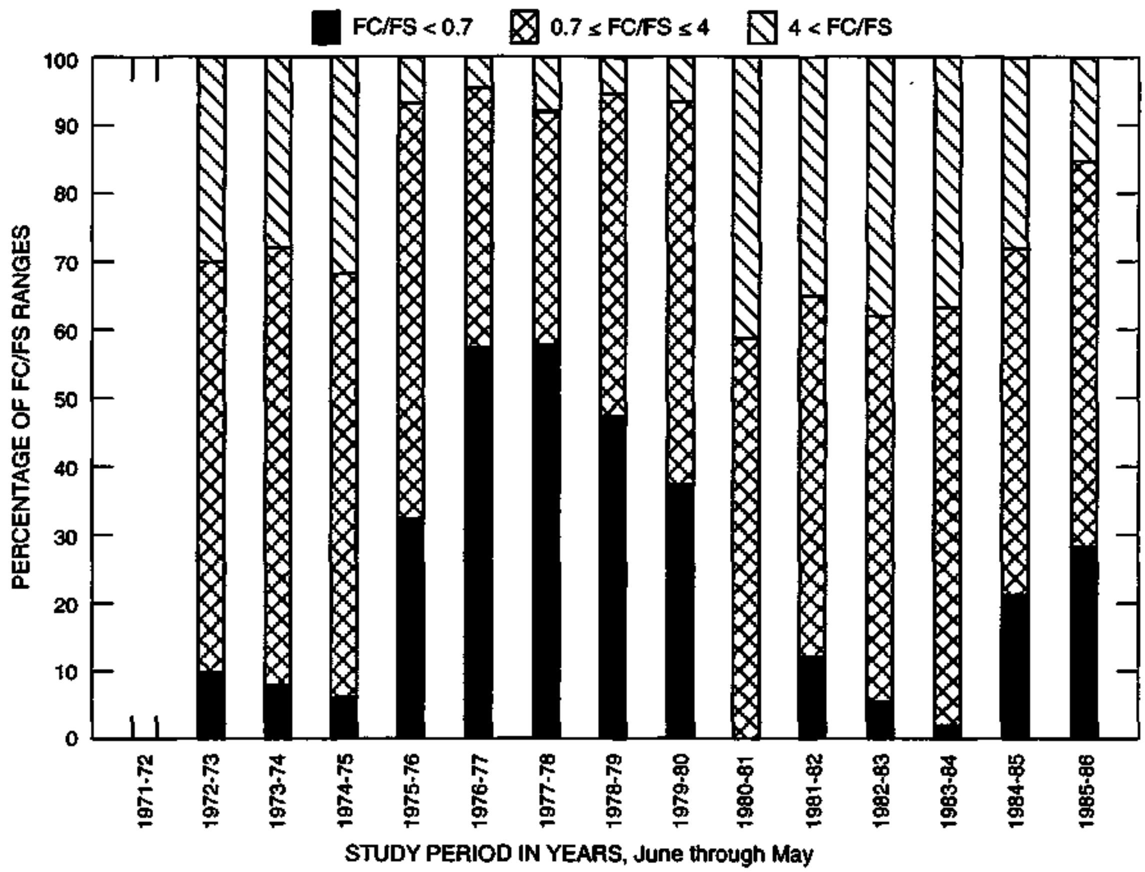

Figure 5. Distribution of fecal coliform (FC)/fecal streptococcus (FS) ratio values

Table 6. Seasonal Variation of FC/FS Values

Season	*Year*	*Total number of samples*	*FC/FS > 4.0* *Number of samples*	*FC/FS > 4.0* *Percentage*	*FC/FS < 0.7* *Number of samples*	*FC/FS < 0.7* *Percentage*
Summer	1972-1976	32	13	41	3	9
(Jun-Aug)	1976-1981	46	5	11	12	26
	1981-1986	40	17	43	1	3
	14-year	**118**	**35**	**30**	**16**	**14**
Fall	1972-1976	37	9	24	3	8
(Sep-Nov)	1976-1981	37	7	19	12	32
	1981-1986	41	17	41	3	7
	14-year	**115**	**33**	**29**	**18**	**15**
Winter	1972-1976	26	2	8	7	27
(Dec-Feb)	1976-1981	25	1	4	18	72
	1981-1986	28	4	15	10	36
	14-year	**79**	**7**	**9**	**35**	**44**
Spring	1972-1976	25	5	20	4	16
(Mar-May)	1976-1981	43	9	21	18	42
	1981-1986	29	5	17	7	24
	14-year	**97**	**19**	**20**	**29**	**30**

SUMMARY AND CONCLUSIONS

Bacterial samples for the Illinois River at Peoria were collected weekly since June 1971 and examined for TC, FC, and FS to document long-term information. FC densities were compared with the standards. Ratios of FC/TC and FC/FS were evaluated with ten-year data from June 1976-May 1986. On the basis of the data obtained, the following conclusions are drawn:

- Substantial variations in bacterial densities were observed during the ten-year period. TC ranged from 130 to 73,000 counts per 100 mL; FC were between 4 and 16,000 counts per 100 mL; and FS varied from 5 to 3,500 counts per 100 mL.
- The ten-year geometric means for TC, FC, and FS were 1,900, 270, and 130 counts per 100 mL, respectively. The respective values for the 15-year period were 3,100, 260, and 130 per 100 mL.
- For TC bacteria, high monthly geometric means occurred from March-August, with March having the highest mean. High monthly geometric means for FS were observed in June and August-October.
- During the ten-year study period, increases in bacterial densities were associated with a precipitation event approximately 63 percent of the time.
- Comparison of FC counts at Peoria and the IPCB's Rule 302.209(a) governing the acceptable FC limit in Illinois streams indicates that the bacterial standards were never met from May-October in 1973, 1980, 1981, 1984, and 1985. In 15 years, the 200 counts/100 mL geometric mean standard was met only 17 percent of the time. In general, from June-September for each year, the river water did not meet this standard.
- In 1973, 1980, 1981, and 1985, however, FC counts did not meet the 400 FC/100 mL density standard. The FC density standard for the overall 15-year average was met only 11 percent of the time. The density standard is a more critical factor for the Illinois River.
- On average, for the five-year study periods, approximately 21 and 20 percent of the TC densities consisted of FC for the second and third five-year period, respectively. TC densities for the first five-year period were low, i.e., only 7 percent
- Significant variations in FC/TC values were observed. The lower FC/TC ratios occurred in the winter and spring due to an increase in TC bacteria, while the higher ratios occurred in the summer and fall because of an increase in FC bacteria.
- To assess the likely source of fecal bacteria, FC/FS ratio values were evaluated. Grouping the bacterial data on the basis of seasons indicated that fecal contamination was derived from human sources in about 30 percent of the samples taken during summer and fall, and from nonhuman sources in 44 and 30 percent of the samples taken in the winter and spring, respectively.
- FC counts in the Illinois River at Peoria were observed to exceed bacterial quality standards most of the time. This is probably due to the nonpoint pollution sources emanating from urban areas.

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Appendix A-1. Bacterial Densities (per 100 mL) of the Illinois River at Peoria, May 1976 to May 1981

Date	*Total coliform*	*Fecal coliform*	*Fecal streptococcus*	*Associated with precipitation*
5/3/76	1,100	42	210	
5/10/76	-	20	55	
5/17/76	5,700	300	130	yes
5/24/76	850	50	43	
6/7/76	630	19	38	
6/14/76	530	20	250	
6/21/76	2,800	250	310	
6/28/76	37,000	3,000	3,000	yes
7/6/76	700	160	180	
7/12/76	970	240	190	
7/19/76	130	20	72	
7/26/91	1,500	-	59	
8/2/76	690	130	50	
8/9/76	1,300	180	110	
8/16/76	1,500	-	120	
8/23/76	330	-	100	
8/30/76	150	-	60	
9/7/76	700	110	55	
9/13/76	870	250	260	
9/20/76	150	50	24	
9/27/76	1,200	130	80	
10/4/76	590	510	70	
10/11/76	480	150	70	
10/18/76	1,600	1,000	-	yes
10/25/76	1,100	750	1,900	yes
11/1/76	1,000	92	40	
11/8/76	720	220	50	
11/15/76	240	70	44	
11/22/76	110	60	44	
11/29/76	390	120	88	
12/6/76	810	110	230	
12/13/76	180	**90**	90	
12/20/76	580	58	100	
12/27/76	740	180	48	
1/3/77	330	54	220	
1/10/77	520	38	55	
1/17/77	150	-	32	
1/24/77	380	320	92	
1/30/77	510	30	74	
2/7/77	260	15	120	
2/14/77	330	24	100	
2/21/77	2,100	400	150	
2/28/77	2,200	120	120	
3/7/77	1,900	330	120	
3/14/77	1,300	600	520	yes
3/21/77	1,300	53	250	

Appendix A-1. Continued.

Date	*Total coliform*	*Fecal coliform*	*Fecal streptococcus*	*Associated with precipitation*
3/28/77	5,000	610	590	yes
4/4/77	3,500	490	110	yes
4/11/77	2,100	96	46	
4/18/77	560	33	9	
4/25/77	380	32	12	
5/2/77	2,000	170	260	
5/9/77	1,700	520	260	
5/16/77	490	68	80	
5/23/77	650	320	140	
5/31/77	4,700	2,200	93	yes
6/6/77	6,700	-	110	
6/13/77	1,100	86	250	
6/20/77	350	61	270	
6/27/77	480	53	140	
7/5/77	11,000	2,300	79	yes
7/11/77	4,200	1,400	98	
7/18/77	1,900	240	100	
7/25/77	700	350	210	
8/1/77	2,800	380	260	
8/8/77	-	-	420	yes
8/15/77	830	290	130	
8/22/77	980	180	180	
8/29/77	7,800	1,000	550	yes
9/6/77	2,400	460	180	
9/12/77	500	47	130	
9/19/77	3,400	470	110	yes
9/26/77	4,100	620	540	
10/3/77	4,700	1,200	170	yes
10/10/77	5,700	450	450	
10/17/77	2,300	590	2,200	no
10/24/77	1,700	760	790	yes
10/31/77	3,500	70	260	yes
11/7/77	3,000	95	320	
11/14/77	2,500	25	1,500	no
11/21/77	2,500	37	230	
11/28/77	2,500	80	260	
12/5/77	2,900	80	180	
12/12/77	6,400	130	33	no
12/19/77	10,000	160	740	yes
12/27/77	11,000	120	380	no
1/3/78	4,500	170	420	
1/9/78	1,600	55	200	
1/16/78	1,200	43	160	
1/23/78	2,100	39	210	
1/30/78	1,300	72	72	

Appendix A-1. Continued.

Date	*Total coliform*	*Fecal coliform*	*Fecal streptococcus*	*Associated with precipitation*
2/2/78	1,200	14	22	
2/13/78	410	48	42	
2/20/78	590	120	82	
2/27/78	300	41	1,400	
3/6/78	250	20	74	
3/13/78	420	160	75	
3/20/78	-	78	340	
3/27/78	2,100	84	240	
4/3/78	6,100	71	470	no
4/10/78	5,700	99	350	yes
4/17/78	3,200	330	720	
4/24/78	5,800	390	220	yes
5/1/78	600	20	160	
5/8/78	2,200	120	610	
5/15/78	1,900	290	-	
5/22/78	6,000	660	-	yes
5/29/78	8,900	550	-	yes
6/5/78	7,600	92	160	
6/12/78	-	92	100	
6/19/78	10,000	1,100	390	no
6/26/78	2,500	280	220	
7/3/78	1,300	410	1,100	no
7/10/78	6,200	550	1,300	yes
7/17/78	1,200	150	330	
7/24/78	1,200	160	66	
7/31/78	1,000	230	150	
8/7/78	1,900	150	290	
8/14/78	3,200	220	240	
8/21/78	1,700	120	30	
8/28/78	3,900	170	110	
9/5/78	430	-	90	
9/11/78	420	-	42	
9/18/78	3,300	450	1,400	yes
9/25/78	1,800	410	300	
10/2/78	1,200	190	65	
10/9/78	830	200	190	
10/16/78	930	230	180	
10/23/78	3,600	2,600	490	yes
10/30/78	1,300	94	110	
11/6/78	-	-	280	
11/13/78	4,100	570	380	no
11/20/78	4,900	340	140	
11/27/78	2,300	73	110	
12/4/78	2,300	180	140	
12/11/78	750	77	64	
12/18/78	530	120	27	
12/26/78	230	4	15	

Appendix A-1. Continued.

Date	*Total coliform*	*Fecal coliform*	*Fecal streptococcus*	*Associated with precipitation*
1/2/79	840	26	72	
1/8/79	200	10	88	
1/16/79	360	23	220	
1/22/79	970	54	-	
1/29/79	520	82	-	
2/5/79	350	68	-	
2/12/79	360	-	17	
2/19/79	380	96	24	
2/26/79	490	38	30	
3/5/79	1,100	210	390	
3/12/79	1,200	310	750	
3/19/79	5,900	620	1,100	yes
3/26/79	6,600	80	420	no
4/2/79	7,800	80	280	yes
4/9/79	3,800	1,200	120	yes
4/16/79	9,300	32	320	no
4/23/79	25,000	1,500	1,500	no
4/30/79	13,000	2,300	1,700	no
5/7/79	22,000	2,100	2,700	no
5/14/79	73,000	1,500	3,500	yes
5/21/79	1,300	33	58	
5/29/79	1,600	340	120	
6/4/79	1,600	73	85	
6/11/79	2,400	320	340	
6/18/79	1,100	200	490	
6/25/79	570	130	140	
7/2/79	1,200	460	200	
7/11/79	490	160	330	
7/16/79	1,300	280	340	
7/23/79	260	130	93	
7/30/79	1,100	530	210	
8/6/79	650	230	270	
8/13/79	1,200	540	280	
8/20/79	2,600	1,200	620	yes
8/27/79	2,800	740	580	no
9/4/79	1,300	430	240	
9/10/79	930	200	120	
9/17/79	590	140	81	
9/24/79	560	180	220	
10/1/79	770	210	120	
10/8/79	800	100	97	
10/15/79	300	76	310	
10/22/79	470	100	490	
10/29/79	-	940	2,000	no
11/5/79	530	93	270	
11/12/79	350	82	18	
11/19/79	220	61	40	

Appendix A-1. Continued.

Date	Total coliform	Fecal coliform	Fecal streptococcus	Associated with precipitation
11/26/79	-	450	240	yes
12/3/79	210	52	75	
12/10/79	560	44	33	
12/17/79	490	87	26	
12/24/79	1,100	150	120	
12/31/79	2,400	190	100	
1/7/80	6,300	82	140	yes
1/14/80	2,900	11	37	
1/21/80	1,100	7	51	
1/28/80	960	98	170	
2/4/80	460	19	8	
2/11/80	460	65	270	
2/18/80	-	43	32	
2/25/80	550	110	960	
3/3/80	320	24	140	
3/10/80	7,900	73	380	no
3/17/80	3,900	310	410	
3/24/80	28,000	2,000	360	yes
3/31/80	1,200	100	140	
4/7/80	7,200	620	130	yes
4/14/80	2,900	490	83	
4/21/80	3,600	590	43	
4/28/80	2,600	450	74	
5/5/80	4,200	94	22	
5/12/80	-	230	30	
5/19/80	2,500	250	31	
5/28/80	3,500	140	60	
6/2/80	-	5,200	510	yes
6/9/80	8,400	900	540	no
6/16/80	4,100	990	410	yes
6/23/80	4,900	2,300	60	yes
6/30/80	4,500	3,900	300	no
7/7/80	2,600	560	120	
7/14/80	1,400	310	90	
7/21/80	8,600	5,900	45	yes
7/28/80	6,700	1,700	150	no
8/4/80	5,300	150	120	yes
8/11/80	13,000	-	270	
8/18/80	3,300	750	180	
8/25/80	1,500	450	140	
9/2/80	6,900	2,400	220	yes
9/8/80	1,900	940	150	
9/15/80	940	800	90	
9/22/80	1,800	780	120	
9/29/80	1,200	460	39	

Appendix A-1. Concluded.

Date	*Total coliform*	*Fecal coliform*	*Fecal streptococcus*	*Associated with precipitation*
10/6/80	1,300	370	10	
10/13/80	-	520	24	
10/20/80	2,200	750	91	
10/27/80	1,300	1,000	47	yes
11/3/80	1,200	280	23	
11/10/80	1,300	190	100	
11/17/90	1,200	470	46	
11/24/80	880	390	15	
12/1/80	690	-	51	
12/8/80	5,100	-	-	yes
12/15/80	3,900	730	57	no
12/22/80	2,200	420	67	
12/29/80	1,500	470	48	
1/5/81	1,000	400	47	
1/12/81	1,500	650	49	
1/19/81	1,400	470	78	
1/26/81	2,100	990	70	no
2/2/81	1,700	1,100	61	yes
2/9/81	1,400	580	73	
2/16/81	2,300	140	160	
2/23/81	3,200	1,600	340	yes
3/2/81	4,100	1,500	150	no
3/9/81	6,400	1,600	72	no
3/16/81	2,500	840	68	
3/23/81	1,600	670	99	
3/30/81	2,500	1,100	380	yes
4/6/81	2,900	1,500	100	no
4/13/81	2,600	1,600	120	yes
4/20/81	3,200	2,000	100	yes
4/27/81	2,800	1,100	67	
5/4/81	960	210	250	
5/11/81	1,400	260	120	
5/18/81	2,900	570	360	yes
5/26/81	5,700	1,800	130	yes

Appendix A-2. Bacterial Densities (per 100 mL) of the Illinois River at Peoria, May 1981 to May 1986

Date	*Total coliform*	*Fecal coliform*	*Fecal streptococcus*	*Associated with precipitation*
5/4/81	960	210	250	
5/11/81	1,400	260	120	
5/18/81	2,900	570	360	
5/26/81	5,700	1,800	130	yes
6/1/81	4,400	940	150	
6/8/81	2,900	680	160	
6/15/81	-	-	-	
6/22/81	3,700	1,100	870	yes
7/6/81	-	-	-	
7/13/81	1,400	870	650	
7/20/81	5,800	3,400	510	yes
7/27/81	7,200	2,000	110	yes
8/3/81	9,800	1,700	500	yes
8/10/81	12,000	730	120	yes
8/17/81	18,000	1,100	300	no
8/24/81	10,000	1,400	400	
8/31/81	1,300	480	110	yes
9/8/81	3,000	420	610	
9/14/81	1,400	620	420	
9/21/81	4,100	120	270	no
9/30/91	8,800	830	220	yes
10/5/81	2,200	660	110	
10/12/81	3,100	600	120	
10/19/81	6,900	560	140	no
10/26/81	2,300	820	150	
11/2/81	20,000	1,600	240	yes
11/9/81	8,300	490	490	
11/16/81	650	-	–	
11/23/81	5,800	730	72	yes
11/30/81	1,600	95	34	
12/7/81	6,500	1,900	130	no
12/14/81	3,700	490	53	
12/21/81	1,400	290	170	
12/28/81	640	220	28	
1/4/82	13,000	1,200	230	yes
1/11/82	6,000	110	100	
1/18/82	5,000	190	1,200	
1/25/82	1,400	230	28	
2/1/82	1,800	230	30	
2/8/82	1,200	220	48	
2/15/82	950	100	42	
2/22/82	6,900	340	640	no
3/1/82	41,000	140	110	no
3/8/82	2,700	80	72	
3/15/82	4,900	180	160	
3/22/82	5,200	420	140	no

Appendix A-2. Continued.

Date	*Total coliform*	*Fecal coliform*	*Fecal streptococcus*	*Associated with precipitation*
3/29/82	2,800	96	32	
4/5/82	2,500	210	130	
4/12/82	3,000	130	32	
4/19/82	4,300	360	58	
4/26/82	4,100	770	110	
5/3/82	3,100	280	100	
5/10/82	3,200	350	97	
5/17/82	3,600	360	150	
5/24/82	2,100	890	95	
6/1/82	3,400	890	86	
6/7/82	1,800	410	490	
6/14/82	1,700	-	-	
6/21/82	1,300	-	-	
6/28/82	1,900	350	150	
7/6/82	2,900	630	150	
7/12/82	7,600	900	210	no
7/19/82	9,300	1,000	350	yes
7/26/82	2,100	990	72	
8/2/82	2,900	420	56	
8/9/82	2,700	1,100	100	no
8/11/82	3,900	560	110	
8/16/82	1,800	420	93	
8/23/82	1,500	80	150	
8/31/82	990	520	120	
9/7/82	990	200	110	
9/13/82	800	450	140	
9/20/82	760	340	120	
9/27/82	600	40	66	
10/4/82	3,100	480	66	no
10/11/82	3,000	320	56	
10/19/82	2,100	230	42	
10/25/82	1,800	210	36	
11/1/82	1,400	160	71	
11/8/82	1,600	390	52	
11/15/82	2,200	430	65	
11/22/82	1,000	200	44	
11/29/82	2,200	320	240	
12/6/82	520	310	200	
12/13/82	350	120	44	
12/20/82	440	160	91	
12/27/82	460	230	130	
1/3/83		130	79	
1/10/83	830	130	48	
1/17/83	2,100	180	98	
1/24/83	1,500	310	67	
1/31/83	2,100	150	62	

Appendix A-2. Continued.

Date	Total coliform	Fecal coliform	Fecal streptococcus	Associated with precipitation
2)7/83	2,800	350	120	
2/14/83	3,800	100	26	
2/21/83	4,900	130	75	
2/28/83	1,500	95	26	
3/7/83	3,100	260	80	
3/14/83	1,900	120	60	
3/21/83	1,200	360	46	
3/28/83	1,800	80	89	
4/4/83	2,100	240	150	
4/11/83	8,800	1,200	120	no
4/18/83	4,800	1,300	65	yes
4/26/83	5,400	2,500	120	no
5/4/83	6,200	760	460	
5/9/83	3,500	350	87	
5/16/83	6,200	840	200	no
5/23/83	1,700	340	66	
5/31/83	2,100	160	46	
6/6/83	1,300	160	46	
6/13/83	550	38	36	
6/20/83	490	330	110	
6/27/83	-	230	49	
7/5/83	2,800	840	370	
7/11/83	2,800	1,100	40	
7/18/83	4,000	3,300	260	no
7/25/83	-	6,500	130	no
8/1/83	-	3,200	250	
8/8/83	-	1,800	100	
8/15/83	-	850	170	
8/23/83	-	1,200	390	
8/29/83	-	500	700	
9/7/83	-	4,000	660	
9/12/83	-	2,900	860	
9/19/83	25,000	16,000	2,700	yes
9/26/83	17,000	3,100	390	no
10/3/83	3,400	900	220	
10/10/83	2,000	950	320	
10/17/83	1,100	420	150	
10/24/83	-	770	120	
10/31/83	-	580	170	
11/7/83	2,400	840	160	
11/14/83	640	260	310	
11/21/83	1,300	160	52	
11/28/83	740	420	160	
12/5/83	-	910	280	yes
12/12/83	1,500	330	160	
12/19/83	2,600	420	530	no
12/27/83	590	15	95	

Appendix A-2. Continued.

Date	*Total coliform*	*Fecal coliform*	*Fecal streptococcus*	*Associated with precipitation*
1/3/84	-	-	-	
1/9/84	-	160	26	
1/16/84	500	210	28	
1/23/84	540	100	18	
1/30/84	190	170	12	
2/6/84	-	290	24	
2/13/84	2,100	690	130	yes
2/20/84	1,600	710	560	
2/27/84	1,600	160	40	
3/5/84	3,700	130	77	
3/12/84	2,200	130	15	
3/19/84	-	580	200	yes
3/26/84	2,900	370	55	
4/2/84	1,700	470	22	
4/9/84	440	410	47	
4/16/84	1,200	220	41	
4/23/84	550	230	54	
4/30/84	160	90	71	
5/7/84	960	160	27	
5/14/84	2,100	210	20	
5/21/84	260	170	' 54	
5/28/84	460	340	95	
6/4/84	1,700	370	110	
6/11/84	2,500	990	36	yes
6/18/84	-	1,400	24	no
6/25/84	-	3,800	27	no
7/2/84	1,700	790	28	
7/9/84	1,800	900	49	
7/16/84	2,000	370	43	
7/23/84	1,500	100	32	
7/30/84	2,600	130	21	
8/6/84	1,500	990	210	
8/13/84	1,100	200	40	
8/20/84	570	260	56	
8/27/84	3,100	600	35	yes
9/4/84	2,600	1,900	55	no
9/10/84	10,000	2,500	150	yes
9/17/84	8,100	240	52	
9/24/84	6,900	700	130	
10/1/84	1,400	140	41	
10/8/84	-	1,300	240	yes
10/15/84	12,000	2,600	250	yes
10/22/84	4,100	450	120	
10/29/84	2,000	180	80	
11/5/84	1,600	620	320	
11/12/84	770	-	520	
11/19/84	850	110	450	
11/26/84	1,400	1,200	150	yes
12/3/84	2,600	220	120	

Appendix A-2. Continued.

Date	Total coliform	Fecal coliform	Fecal streptococcus	Associated with precipitation
12/10/84	1,300	91	60	
12/17/84	1,700	160	64	
12/24/84	2,000	60	140	
1/2/85	3,300	130	240	
1/7/85	1,400	330	670	
1/14/85	2,000	310	130	
1/21/85	3,500	60	64	
1/28/85	3,200	190	12	
2/4/85	1,900	49	5	
2/11/85	500	44	11	
2/18/85	3,000	130	49	
2/25/85	22,000	270	690	yes
3/4/85	78,000	3,000	1,200	yes
3/11/85	27,000	460	520	yes
3/13/85	15,000	1,300	490	yes
3/14/85	8,600	1,500	410	yes
3/18/85	20,000	2,100	340	no
3/25/85	5,400	500	47	
4/2/85	3,900	320	1,500	no
4/9/85	2,600	110	55	
4/15/85	3,200	170	24	
4/22/85	2,400	230	16	
4/29/85	900	63	42	
5/6/85	1,900	310	90	
5/13/85	380	120	1,400	yes
5/20/85	720	180	63	
5/27/85	1,400	640	240	
6/3/85	16,000	2,800	770	yes
6/11/85	-	270	70	
6/17/85	31,000	1,000	240	yes
6/24/85	8,900	2,000	670	yes
7/2/85	4,700	610	630	
7/8/85	4,400	260	70	
7/15/85	26,000	2,300	650	yes
7/22/85	4,500	620	110	
7/30/85	4,000	560	310	
8/5/85	3,700	620	570	
8/13/85	5,200	170	80	
8/19/85	9,300	3,400	1,100	yes
8/26/85	10,000	1,200	80	yes
9/3/85	2,800	260	190	
9/9/85	-	570	81	
9/16/85	1,900	1,300	98	no
9/23/85	1,500	-	1,000	yes
9/30/85	3,000	940	65	yes
10/7/85	1,700	120	41	
10/14/85	1,400	280	160	

Appendix A-2. Concluded.

Date	*Total coliform*	*Fecal coliform*	*Fecal streptococcus*	*Associated with precipitation*
10/21/85	3,800	1,000	180	
10/28/85	2,400	430	22	
11/4/85	3,400	230	140	
11/11/85	4,200	530	150	
11/18/85	4,100	1,100	130	yes
11/25/85	8,100	840	620	no
12/3/85	11,000	530	380	no
12/9/85	37,000	1,800	270	yes
12/16/85	2,900	80	25	
12/23/85	5,600	1,600	1,100	no
12/30/85	6,200	50	280	
1/6/86	3,100	28	43	
1/13/86	410	53	140	
1/21/86	7,300	-	200	no
1/28/86	8,600	180	100	no
2/3/86	1,400	52	72	
2/10/86	5,900	520	750	no
2/17/86	1,900	80	12	
2/25/86	2,700	140	360	
3/3/86	1,100	50	440	
3/10/86	-	2,100	1,600	yes
3/17/86	1,100	60	110	
3/24/86	910	55	45	
3/31/86	1,100	25	17	
4/7/86	3,600	120	120	
4/14/86	540	84	140	
4/21/86	2,600	110	170	
4/28/86	3,100	68	56	
5/5/86	4,200	570	76	yes
5/12/86	1,500	210	50	
5/19/86	3,000	550	700	yes
5/27/86	1,700	71	190	

Appendix B. Daily Precipitation Observed at the Greater Peoria Airport, 1976-1991

Date	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Year- 1976												
1	0.08	0.01	0.04									0.03
2			0.15		0.02							0.04
3			0.53									
4			1.48							0.01	0.01	
5		0.10			0.44			0.94		1.26		
6					1.31			0.28				0.31
7	0.08						0.01					
8									0.05			
9							0.01		0.08	0.09		
10	0.01		0.25									
11			0.13					0.93				
12			0.30					0.09				
13	0.35				0.60			0.05				
14												
15	0.05	0.02		0.37		0.05						
16		1.13			0.56							
17				0.01	0.07			0.01				
18		0.02		0.01		0.13				0.14		
19	0.04			0.02						0.16		
20		0.06	0.40	1.07			0.04					
21		0.73		0.12			0.24					
22							0.88					
23				2.00		0.05			0.02	0.09		
24				0.30		0.28				0.01		
25	0.12			1.33					1.06			
26			0.75				0.18		0.57		0.80	
27			0.12			0.08	0.56					
28					0.10	2.24	0.89					
29		0.49	0.06		1.60	0.14						
30	0.05		0.04									
Total	0.78	2.56	4.25	4.86	5.11	2.92	2.98	2.30	1.78	2.48	0.83	0.38
Year - 1977												
1				0.16	0.03				0.02	0.07	0.91	0.16
2	0.02	0.18	0.06	0.01				0.02			0.03	0.39
3			0.08		0.45						0.01	0.14
4	0.18	0.04	0.02	0.18	1.75			0.15	0.35	0.03		
5				0.02	0.26			0.81		0.02		0.45
6	0.03				0.56			1.62			0.02	
7					0.27	0.24	0.01	1.91	0.13	1.20	0.04	
8						0.03	0.10	0.96		0.43		0.31
9	0.21							0.40			0.04	
10	0.06					0.50		0.02		0.10	0.02	
11			1.42			0.51	0.01	0.85				
12		0.01	0.76						1.15			
13	0.31		0.17						0.33		0.01	
14		0.04		0.13								

Appendix B. Continued.

Date	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Year - 1977												
15	0.04			0.03	0.01		0.07		1.30	0.01		
16							1.36	0.03	0.01			
17			0.30			0.01	0.41		0.22		0.01	
18	0.01								1.44			
19	0.12		0.24	0.10	0.03							0.30
20	0.04		0.01		0.10						0.10	0.21
21			0.23	0.44			0.51	0.02				0.04
22		0.57	0.01	0.02		0.05						
23	0.04								0.61	0.33	0.04	
24							0.11		0.39	0.30		
25										0.94	0.06	
26	0.04	0.05									0.01	
27	0.12	0.06	0.27								0.25	
28			0.84	0.03	0.08	0.11		0.48				
29							0.04					
30						0.61	0.75		0.31		0.22	
31							0.06	0.01		0.57		0.25
Total	1.22	0.95	4.41	1.12	3.54	2.06	3.43	7.28	6.26	4.00	1.77	2.25
Year - 1978												
1	0.05	0.04					0.64					
2			0.26	0.07			0.64	0.02		0.62		0.45
3		0.01	0.01									0.07
4		0.06		0.26	0.94					0.03		
5		0.02		0.85	0.13					0.02		
6				0.34	0.42	0.06					0.51	0.18
7			0.03		1.09	0.06	0.25					0.56
8				0.37								0.02
9				0.53			1.73	0.05		0.01		
10				1.13	0.01			0.05		0.17		
11			0.13		0.88			0.01				
12	0.11				1.20		0.02			0.03	0.02	
13	0.04	0.38	0.23		0.95					0.06	0.10	
14	0.05		0.01		0.23				0.18			
15		0.01				1.14						
16	0.12					0.01			0.08		0.27	
17				0.11		0.31		0.60	0.73		0.67	
18				0.64				0.01	0.31	0.01		0.01
19				0.01				0.06				0.01
20	0.04		0.04	0.03		0.05			0.55			0.04
21				0.02							0.01	
22		0.01		0.03	0.01		0.03			0.15	0.46	
23				0.13	0.30					0.09	0.03	0.06
24	0.10		0.47	0.03				0.25				0.03
25	0.01		0.27	0.14		0.10	0.13	0.17		0.54	0.01	
26			0.07					0.06			0.38	
27											0.04	
28		0.06			1.50	0.17						0.32
29			0.04		0.06		0.03		0.30		0.01	0.55

Appendix B. Continued.

Date	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Year - 1978												
30						0.06			0.17		0.03	0.15
31												1.09
Total	0.52	0.59	1.56	4.69	7.72	1.96	3.47	1.28	2.32	1.73	2.54	3.54
Year - 7979												
1	0.19		0.03	0.23					0.03	0.28		
2				0.02	0.59					0.13		
3			0.85				0.53			0.09		
4	0.03		0.05	0.02								
5	0.07										0.01	
6			0.01			0.02						
7			0.06			0.45					0.11	0.05
8		0.11		0.09		0.53					0.01	
9			0.59								0.11	
10						0.10		0.25				
11	0.10			1.95	0.61							0.20
12	0.02					0.22				0.09		
13	1.11						0.45					
14					0.11		1.15					
15	0.02	0.02										
16										0.27		0.01
17			0.07									
18	0.06	0.07	0.74			0.24		0.37		0.01		
19	0.31		0.42	0.02	0.03					0.16		
20		0.37		0.01				0.12			1.13	
21	0.01	0.10		0.10				0.08			0.30	
22		0.48				0.05		0.03		0.44	0.05	0.66
23	0.14	0.02	0.21	0.02						0.01		0.30
24	0.09		0.23	0.13	0.01		0.62					1.11
25			0.01	1.44			1.81				0.41	
26				0.10	0.45		0.02	0.02			0.42	
27	0.22			0.20							0.14	
28	0.02	0.13	0.45				0.06				0.04	
29			0.56	0.15		0.16	0.09				0.03	
30	0.07		0.14		0.16		0.08					
31	0.02									0.22		
Total	2.48	1.37	4.42	4.48	1.96	1.77	4.81	0.87	0.03	1.70	2.76	2.33
Year - 1980												
1				0.01		2.13		0.03	0.97			0.30
2						4.42		0.01	0.10	0.05		0.02
3				0.16							0.01	
4	0.01		0.02	0.01		0.06		1.02	0.30			
5		0.22	0.03				0.48	0.24	0.15			0.01
6	0.08	0.02		0.28				0.14	0.02			
7	0.01		0.63	0.78				0.29				1.09
8		0.04	0.12	0.56								0.55
9				0.19								0.04
10					0.04		0.01	0.04				0.01

Appendix B. Continued.

Date	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Year - 1980												
11	0.05			0.07				0.73				0.01
12			0.25		0.50				0.10			
13	0.01		0.17			0.18		0.14	0.26		0.05	
14		0.28		0.53		0.75		1.93			0.12	
15	0.04	0.17		0.06		0.74			0.04	0.16		
16	0.10		0.11		0.24		0.04	0.71	2.15	0.54		
17			0.05		0.58			0.16		0.80		
18							0.29					
19	0.08											
20		0.01	0.09					0.01				
21	0.03	0.10					0.51					
22		0.02										
23			0.03		0.42	0.13					0.15	
24	0.03		0.55		0.06					0.52		0.15
25		0.15										
26							0.08					
27	0.01	0.01	0.05							0.35	0.23	
28		0.03	0.10	0.01		0.53				0.02	0.11	0.03
29		0.01		0.12								0.01
30	0.14		0.59		0.21			0.01				
31							0.02	0.70				
Total	0.59	1.06	2.79	2.78	2.05	8.94	1.43	6.16	4.09	2.44	0.67	2.22
Year - 1981												
1	0.03	0.07			0.02				0.01		0.14	
2		0.01						0.83			0.28	
3			0.02	0.23				0.01				0.15
4			0.20		0.15		1.12			0.18	0.16	
5		0.04			0.01	0.38		1.68		0.25		
6	0.17											
7								0.05	0.35			
8	0.15			0.44		0.34						
9		0.02			1.58			0.01		0.08		
10		0.53		0.94	0.89			0.01				
11		0.07		0.22	0.29	0.01						
12				0.32	0.38	0.84						
13				1.36	1.19	0.49	0.03			0.13		
14	0.01					0.01	0.02	1.92		0.39		0.05
15			0.01			0.38	0.08	0.20	0.02	0.01	0.04	
16				0.02							0.12	0.28
17					0.04					0.31		0.05
18					0.60		1.35					
19				0.50		0.25	1.94				0.32	
20						0.41						0.10
21		0.42				1.27						0.06
22		1.01		1.06	0.02							0.19
23		0.22			0.31						0.12	
24						1.71			0.09			
25			0.04		0.07		0.37		0.10			

Appendix B. Continued.

Date	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Year - 1981												
26					0.19		0.32		0.59	0.02	0.16	
27		0.02				0.03	1.80	0.14				0.02
28				0.44			0.05					0.20
29			0.59	0.17	0.03				0.15			
30			0.06	0.01		0.10		0.17			0.30	
31	0.12							0.59			0.04	0.10
Total	0.48	2.41	0.92	5.71	5.77	6.22	7.08	5.61	1.31	1.37	1.68	1.20
Year - 1982												
1									0.17		1.47	
2	0.45		0.31	0.93		0.12	2.77					2.34
3	0.32		0.51	0.02			0.08					0.55
4	0.26	0.04	0.38			0.04		0.05				0.14
5		0.15		0.40	0.18		0.11	0.01	0.02			0.14
6					0.07			0.41	0.25	0.52		
7				0.08		0.15	0.92	0.42				
8		0.07	0.17	0.37		0.12				0.18		0.02
9	0.07	0.02	0.04	0.03		0.14				0.08		
10			0.40	0.02			0.16	0.08				0.28
11			0.07								1.47	
12	0.06		0.17			0.03					0.43	
13	0.05						0.20		0.02	0.01		
14			0.26				0.02		0.15			0.01
15	0.05		0.09	0.46		0.88						0.03
16		0.43	0.65	3.05			0.06					
17	0.02	0.05		0.02					0.63			
18		0.37				0.23	2.96				0.03	
19			1.30	0.02	0.20		0.06			0.65	0.17	
20	0.15		0.01		1.12			0.20				
21					0.02	0.03	0.10				0.19	
22	0.22				0.01	0.09	0.08	0.06			0.24	
23								0.01				
24	0.10		0.02					2.50				1.70
25	0.05					0.17						
26					0.32			0.01			0.09	
27					0.84	0.78	0.01				0.08	0.24
28						0.08				0.03	0.78	
29	0.64				0.15	0.29		0.07				
30	0.35		0.42					0.07				
31	0.09				0.24			0.08				
Total	2.88	1.13	4.80	5.4	3.15	3.15	7.53	3.97	1.24	1.47	4.95	5.45
Year - 1983												
1		0.20		2.48	1.97						0.19	
2		0.54		0.81		0.18					0.61	0.05
3		0.06		0.03	0.07	0.66		0.30				0.42
4				0.20			0.67	0.03				0.03
5		0.05	0.39	0.34		0.06			0.46			0.15
6		0.12	0.20	0.01	0.03				0.12		0.12	0.12

Appendix B. Continued.

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Year - 1983												
7			0.05		0.24						0.01	0.12
8				0.46								
9			0.01	0.48							0.04	
10	0.02		0.05						0.47		0.42	0.26
11	0.02							0.07		0.99		0.64
12				0.13	0.23					0.25		
13				0.76	2.99					0.07	0.07	0.01
14					0.06	0.48						0.26
15					0.01				0.83		0.07	0.03
16		0.02		0.07								
17					0.02							0.02
18			1.13		0.10	0.44		0.16	0.23		0.01	0.06
19			0.05		0.01	0.40			1.66	0.39	0.23	
20			0.46						0.66	0.21	0.40	0.01
21	0.06		0.02		0.24			0.01		0.56		0.23
22	0.28				0.36			0.10		0.32	0.87	
23	0.01						0.03				0.85	0.03
24		0.01										
25					0.07				0.65			
26	0.07		0.16									
27			0.24	0.39	0.05	0.02		0.35			1.42	
28				0.03	0.19	1.68					0.27	0.21
29	0.07			0.79		0.56	1.20					
30			0.07	0.08	0.02		0.09	0.07		0.11		
31			0.01							0.11		
Total	0.53	1.00	2.84	7.06	6.66	4.48	1.99	1.09	5.08	3.01	5.58	2.65
Year - 1984												
1	0.09										1.47	
2		0.02										0.10
3				0.45	0.41		0.15					
4			0.07	0.30	0.04		0.75		0.01			
5		0.03			0.01							0.03
6						0.16	0.25		0.03	0.11		
7			0.08							0.34		
8			0.21	0.38		1.01	0.21		0.75			
9		0.01		0.06		0.52			0.05	0.21	0.53	
10		0.11				0.07	0.69	0.14	0.25		1.18	
11					0.22		0.21			0.19		0.10
12		0.68	0.10	0.44						0.48		0.01
13	0.11			0.06	0.11				0.04	0.02		0.81
14				0.39			0.36		0.20	0.14		0.10
15			0.76	0.43		0.35	0.61			0.06		
16		0.45		0.03						1.33		0.05
17	0.01		0.12					0.18				
18	0.01	0.78		0.01		0.02		0.10		0.58		
19			1.76		0.80							0.17
20			0.04		1.28		0.23			0.13		0.03
21				1.17	0.02	0.60		0.08		0.13		0.72

Appendix B. Continued.

Date	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Year - 1984												
22				0.71	0.56	0.10		0.15	0.34			
23	0.08			0.01					0.62			
24			0.32				0.98			0.11		0.03
25			0.39		0.81		0.16		0.04			
26	0.01		0.03				0.42				0.40	0.08
27		0.17	0.07		0.17	0.07		0.13	0.05	0.14	0.37	
28	0.01	0.03			0.41							
29	0.23			0.74								0.63
30	0.04											
31										1.10		0.96
Total	0.59	2.28	3.95	5.18	4.84	2.90	5.02	0.78	2.38	5.07	3.95	3.82
Year - 1985												
1	0.21		0.25		0.46						0.89	0.98
2						0.25	0.63					
3			1.67									
4		0.07	0.50	0.05		0.56	0.40	0.21	0.03	0.65		
5		0.08		0.60								
6	0.01				0.18			0.62	1.26		0.14	
7			0.06									
8										0.48		
9	0.03	0.05								0.03	0.74	0.12
10	0.10	0.28	0.03			0.03		0.40		0.49	0.55	0.83
11	0.07	0.01	0.58			0.39	0.19			0.06		0.05
12							0.05			0.01	0.37	
13			0.12	0.12	0.18			0.20		0.26	0.15	
14		0.01		0.01	0.66	0.03	0.87	1.33		0.20	0.14	
15						0.42	0.02	0.22			1.04	
16	0.11				0.30	0.02						
17	0.09				0.01	0.05			0.25			0.18
18	0.08					0.21				0.67	2.20	
19	0.01						0.03	0.51		0.10	0.86	0.04
20						0.13			0.09			0.01
21		0.48					0.32				0.03	
22		0.89				0.06			0.90			
23		0.64	0.11	0.30		0.24			0.38	0.35		
24	0.07	0.03		0.01		0.36		0.03		0.12		0.03
25	0.08						0.15	0.06	0.25		0.03	
26		0.08		0.05					0.02		0.11	
27			0.28		0.92	1.63					0.03	
28			1.21			0.56					0.03	
29	0.03		0.25			0.08		0.12	0.20	0.04	0.01	
30	0.10		0.57		0.43	0.09	0.25		0.05		0.30	
31			0.14				0.52			1.15		
Total	0.99	2.62	5.77	1.14	3.14	5.11	3.43	3.70	3.43	4.61	7.62	2.24

Appendix B. Continued.

Date	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Year - 1986												
1							0.21				0.01	1.13
2	0.11			0.05						0.63		0.43
3		0.29								2.03	0.03	
4	0.05	0.39		0.11		0.01				0.02		
5		0.03	0.16		0.31	1.10		0.19				
6		0.08				1.59	2.35	0.21	0.04			0.14
7		0.19				0.01					0.02	0.74
8							0.34			0.01	0.03	0.09
9						0.01	0.37					0.07
10			0.38			1.69	1.22	0.19				
11					0.02	0.02	0.05		0.84	0.03	0.04	
12			0.01	0.05			0.45			0.17		
13					0.09					0.08		
14		0.22		0.21		0.36	0.42					
15				0.01	0.19							
16		0.07										
17			0.01		1.39				0.12			
18			0.27		0.15						0.05	
19									1.88		0.04	
20		0.12		0.02							0.20	
21		0.02										
22									0.56		0.13	
23		0.35							0.04		0.02	
24	0.06				0.46				1.10	0.44		
25		0.03					0.05			0.89	0.32	
26			0.04		0.24			1.15	0.14	0.34	0.43	
27				0.07	0.01	1.26	0.11		0.01			
28					0.09		0.01		0.42			
29				0.86		0.02	0.09		0.28			
30						0.46			0.96			
31							1.33					
Total	0.22	1.79	0.87	1.39	2.95	6.53	7.00	1.74	6.39	4.64	1.32	2.60
Year - 1987												
1	0.18			0.03		0.01						0.02
2	0.02					1.91						
3								0.55				
4												
5		0.07					0.10					
6										0.01		0.08
7									0.18			0.71
8						0.07	0.09	0.26	0.02		0.14	0.11
9	0.50									0.01		
10	0.03			0.07						0.02		
11				0.03	0.06							0.07
12							0.37		0.06			
13				1.26				0.53				
14	0.02		0.24	0.21				0.02	0.16			0.27
15			0.23	0.01			0.39	0.19	0.48			0.77
16									0.07	0.05	0.85	
17	0.31				0.20				0.02		0.01	

Appendix B. Continued.

Date	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Year - 1987												
18	0.01		0.11		0.01							
19	0.29					0.28				0.20		1.15
20					0.04	0.23			0.03			0.05
21				0.06	0.73	0.02		1.10				
22			0.03	0.03						0.02	0.02	
23				0.01								
24			0.41							0.18	0.25	0.16
25			0.05		0.33	0.55		0.97			0.18	
26				0.04				0.37		0.03		
27	0.05	0.01	0.01	0.09	0.11			0.03			0.45	0.57
28		0.76	0.34		0.20		0.05		0.60		0.88	0.19
29	0.06	0.16	0.40				0.30				0.09	
30						0.20					0.01	
31	0.02				0.01		1.60			0.21		
Total	1.49	1.00	1.82	1.84	1.69	3.27	2.90	4.02	1.62	0.73	2.88	4.15
Year - 1988												
1		0.08								0.27		
2				0.11								
3		0.13		0.09					0.03		0.01	
4								0.03	0.09		0.53	
5				0.34							0.01	
6				0.54							0.01	
7												
8			0.13		0.79	0.54		0.34				
9								0.06			0.88	
10		0.33					0.15	0.15				
11		0.05	0.07						0.01			
12									0.03		0.69	0.04
13			0.01					0.07				
14		0.12	0.01									
15					0.05						0.87	
16	0.01								0.32	0.01		
17	0.50		0.02	0.25						0.29		
18	0.01		0.01				0.18	0.26	0.52		0.05	
19	1.01							0.02	0.33		0.41	
20	0.03									0.11	0.02	0.01
21				0.05						0.06		
22	0.01			0.12	0.65	0.05		0.60	0.01	0.08		1.07
23	0.04		0.49		0.19					0.25		
24			0.23									0.03
25	0.08			0.01							0.12	
26				0.08							0.53	0.40
27								0.58	1.33	0.01	0.01	0.68
28			0.86								0.05	
29			0.99			0.01						
30									0.15			
31	0.30		0.01									
Total	1.99	0.71	2.83	1.59	1.68	0.60	0.33	2.44	2.82	1.08	4.19	2.23

Appendix B. Continued.

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Year- 1989												
1					0.08	0.02			0.51			
2		0.02		0.72			0.01					
3		0.01	0.46	0.45		0.21		0.55				
4		0.17	0.01		0.11							
5	0.35	0.10		0.06					0.43	0.42		
6	0.01								0.75		0.01	
7	0.05			0.16							0.05	
8				0.39	0.19							
9					0.58				0.52		0.01	
10									0.08			0.36
11	0.02					0.09						0.02
12						0.35		0.01	0.18			
13		0.34							0.38			0.04
14	0.03		0.09					0.22	0.02		0.60	
15		0.18									0.25	0.01
16										0.50		
17			0.04	0.01						0.20		
18				0.16	0.06		0.28					0.14
19		0.01			0.38		0.78			0.04		0.05
20		0.31	0.05				0.49			0.02		0.07
21		0.03					0.16	0.03				
22				0.61	0.10		0.20	0.01			0.01	
23				1.21		0.28	0.19	1.03				
24					0.11							
25	0.38				0.48							
26				0.36		0.31	0.02	0.03				
27				0.01		0.02						0.01
28	0.10		0.49	0.25	0.01			0.04				
29	0.06						0.09	0.44				0.14
30					0.07					0.39		0.01
31					0.06			0.50				0.02
Total	1.00	1.17	1.14	4.39	2.23	1.28	2.22	2.86	2.36	1.57	0.93	0.87
Year - 1990												
1		0.89		0.09								
2		0.01										0.54
3	0.19				0.23			0.16	0.13	0.53	0.02	0.81
4	0.09				0.77			0.77			1.87	
5			0.24		0.31	0.01					0.57	
6		0.13	0.01									
7			0.01			0.68			0.05	0.16		
8			0.99							0.59		
9	0.08			0.28	1.15		1.26			0.52	0.02	
10			1.59	0.05			0.31			0.70		
11							0.74					
12					0.71			0.11				
13				0.51	0.01	0.29	0.24	0.01				

Appendix B. Concluded.

Date	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Year - 1990												
14		1.18	0.49	0.01	0.01	0.42						0.38
15		0.11	0.06		0.11		0.26					0.01
16	0.10			0.10	0.43		0.15					
17	0.13					0.41				0.62		0.12
18									0.34			
19				0.01	0.34	1.24	0.04	0.76	0.01			
20	0.07			0.12		0.84	1.43	2.27				
21							1.65	0.13	0.24	0.01	0.39	0.28
22		1.06	0.23			0.55	1.09		0.03			0.01
23	0.02	0.11		0.22	0.45					0.04		
24	0.03				0.15							
25	1.02			0.43	1.52			0.39				
26											0.06	0.05
27				0.22			0.05				4.26	0.59
28			0.05	0.28			0.88	0.01	0.20			0.72
29			0.27			3.47	1.08	0.70	0.03			0.19
30						0.08						
31			0.01									
Total	1.73	3.49	3.95	2.32	6.19	7.99	9.18	5.31	1.03	3.17	7.19	3.70
Year - 1991												
1			0.48		0.12						0.49	
2			0.07				0.05			1.09	0.21	0.49
3					0.31			0.02	0.26	0.87		
4	0.06	0.01		0.28	0.03				1.37	2.68	0.21	0.07
5	0.64				0.99			0.22		0.01		
6								0.77			0.01	
7				0.05				0.62			0.22	
8	0.01							0.16	0.11			
9							0.06		0.41			0.25
10	0.10						0.01					
11	0.17		0.01				0.12		0.03			
12	0.02		1.14	0.07							0.01	0.17
13			0.58	0.21						0.04		0.47
14		0.05		0.91	0.01					0.09		
15	0.02			0.36	0.13	0.57			1.07		0.78	
16	0.04			0.01	1.11				0.04		0.02	
17			0.46		0.82			0.62				
18		0.47		0.07	0.28				0.10	0.10	0.02	
19				0.27								
20	0.01										0.19	
21			0.30		0.30	0.17			0.01		0.03	
22			0.02			0.05	0.01		0.19			
23			0.06	0.02			0.01			0.46	0.08	
24					0.24		0.01			0.25	0.15	
25	0.08				1.03					0.17	0.08	
26			0.44							0.43		
27		0.04	0.10	0.39							0.07	
28										0.17	0.14	
29	0.04			0.01	0.41		0.08	0.62		0.21	0.18	
30				0.32	0.06	0.71		0.38		0.67	0.49	
31			0.01		0.10					0.07		
Total	1.19	0.57	3.67	2.97	5.94	1.50	0.70	3.41	3.59	7.31	3.38	1.45