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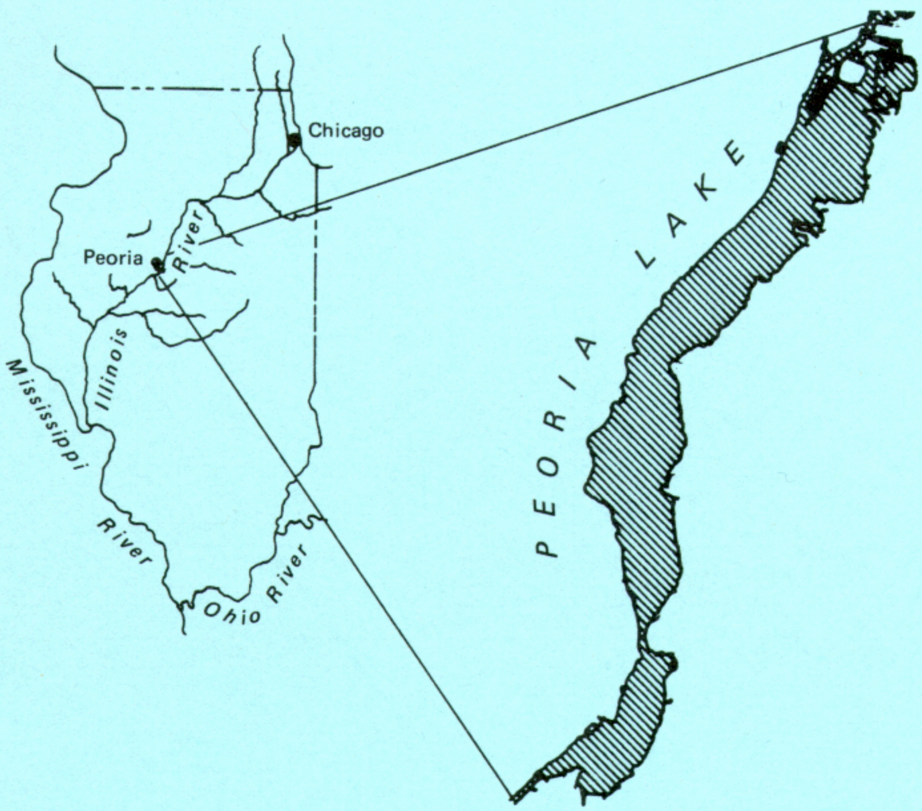
PEORIA LAKE SEDIMENT INVESTIGATION

by Misganaw Demissie and Nani G. Bhowmik



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INTRODUCTION

Peoria Lake is one of the most important water resources in central Illinois. It provides many benefits to the citizens of Illinois such as opportunities for recreation, fishing, and boating, and a channel for navigation. Most of the benefits were taken for granted for many years. However, continuous sedimentation over the years is threatening the existence of the lake. At the present time the lake has lost 68 percent of its original volume. The situation is even worse when the navigation channel, defined as that part of the lake which is 9 feet or deeper, is excluded from the lake volume. Outside of the navigation channel, Peoria Lake has lost 77 percent of its original volume. The average depth of the lake is only 2.6 feet, and the average depth of Upper Peoria Lake is only about 2 feet.

Excessive sedimentation not only reduces the lake volume and depth but also impacts water quality, aquatic habitat, navigation, recreation, real estate values, and tourism. Thus it can be said that sedimentation poses a very serious problem to Peoria Lake since it negatively impacts all of the beneficial uses of the lake.

Realizing the importance of Peoria Lake and the seriousness of the sedimentation problem of the lake, the Illinois State Water Survey initiated the Peoria Lake Sediment Investigation under the sponsorship of the U.S. Army Corps of Engineers, Rock Island District.

The main objectives of the study were to:

- Determine the sedimentation rate of the lake
- Identify the sources of sediment to the lake and their relative quantities
- Develop a sediment budget
- Investigate the quality of the sediment in the lake
- Investigate a range of alternative solutions to the sedimentation problem of the lake and make recommendations

As can be inferred from the objectives listed above, the goal of this project is different from that of most of the previous studies on Peoria Lake. This project will address alternative solutions to the problem of sedimentation in Peoria Lake. There has never been a scientific study on Peoria Lake conducted to remedy the problem or to evaluate the effectiveness of numerous suggestions and ideas forwarded by various groups or individuals. For example, one of the ideas proposed to solve the problem is to dredge the lake. No study has been conducted to determine where to dredge, where to dispose of the sediment, what impacts dredging will have on water quality, or how effective dredging will be for Peoria Lake. These types of questions must be addressed before any solution can be implemented.

Because of its limited scope, this study will not answer all the questions about sedimentation and its solutions in Peoria Lake. However, it does provide the facts and information needed by the U.S. Army Corps of Engineers in evaluating any remedial action that might be taken.

Acknowledgments

This project was conducted under the administrative guidance of Richard J. Schicht, Acting Chief, and Michael L. Terstriep, Head, Surface Water Section, Illinois State Water Survey. Financial support was provided by the Rock Island District, U.S. Army Corps of Engineers, under contract DACW25-85-C-0013, and by the National Science Foundation, LTER program. Dan Johnson, Shirley Johnson, and Mark Shroeder of the Rock Island District, U.S. Army Corps of Engineers, provided liaison and direction for the project.

The following staff members from the Illinois State Water Survey, Geological Survey, and Natural History Survey assisted in field data collection, analyses, and preparation of the report: Rodger Adams, Al Bonini, Bill Bogner, Cheri Chenoweth, Frank Dillon, Bill Fitzpatrick, Thomas Hill, Barbara Miller, and Vassilios Tsihrintzis from the Illinois State Water Survey; Richard Cahill from the Illinois State Geological Survey; and Jack Grubaugh from the Illinois Natural History Survey. Illustrations were prepared by John Brother and Linda Riggin. Kathleen Brown and Becky Howard prepared the draft and camera ready copy of the report, and Gail Taylor edited the report.

BACKGROUND

Peoria Lake is the largest and deepest bottomland lake in the Illinois River Valley. It is located between River Miles 162 and 182 on the Illinois River. River miles on the Illinois River are measured starting from Grafton, Illinois, where the Illinois River joins the Mississippi River. The bottomland lakes are remnants of a much larger glacial river system that occupied the Illinois River Valley. This larger river carried much greater flow than the present Illinois River and occupied much of the Valley. Reduction in drainage area and changes in the flow regime of the old Illinois River resulted in the present Illinois River, which is smaller and more sluggish than the old river. The present Illinois River could not transport the sediment delivered by tributary streams, which resulted in the formation of alluvial fans and deltas near the mouths of the tributary streams. These fans and deltas created narrow and shallow segments in the river valley, which held back water in the deeper channels to form the bottomland lakes.

Peoria Lake was created in a fashion similar to this, as shown in Fig. 1. The alluvial fan from Farm Creek created the constricted stretch of the Illinsois River just downstream of Farm Creek, forming Peoria Lake (Willman, 1973; Horberg et al., 1950). Further upstream at River Mile 166.5, another alluvial fan deposited by Tenmile Creek (Fig. 1) divides the lake into two segments: Lower Peoria Lake and Upper Peoria Lake. This constricted segment of the Illinois River is referred to as the Narrows.

Prior to the late 1800s, the Illinois River and thus Peoria Lake were not impacted significantly by man. The river and the lakes in the river valley were under near-natural conditions and had very few problems resulting from human activities. The major changes on the Illinois River started on January 1, 1900, when a significant amount of water started to be diverted

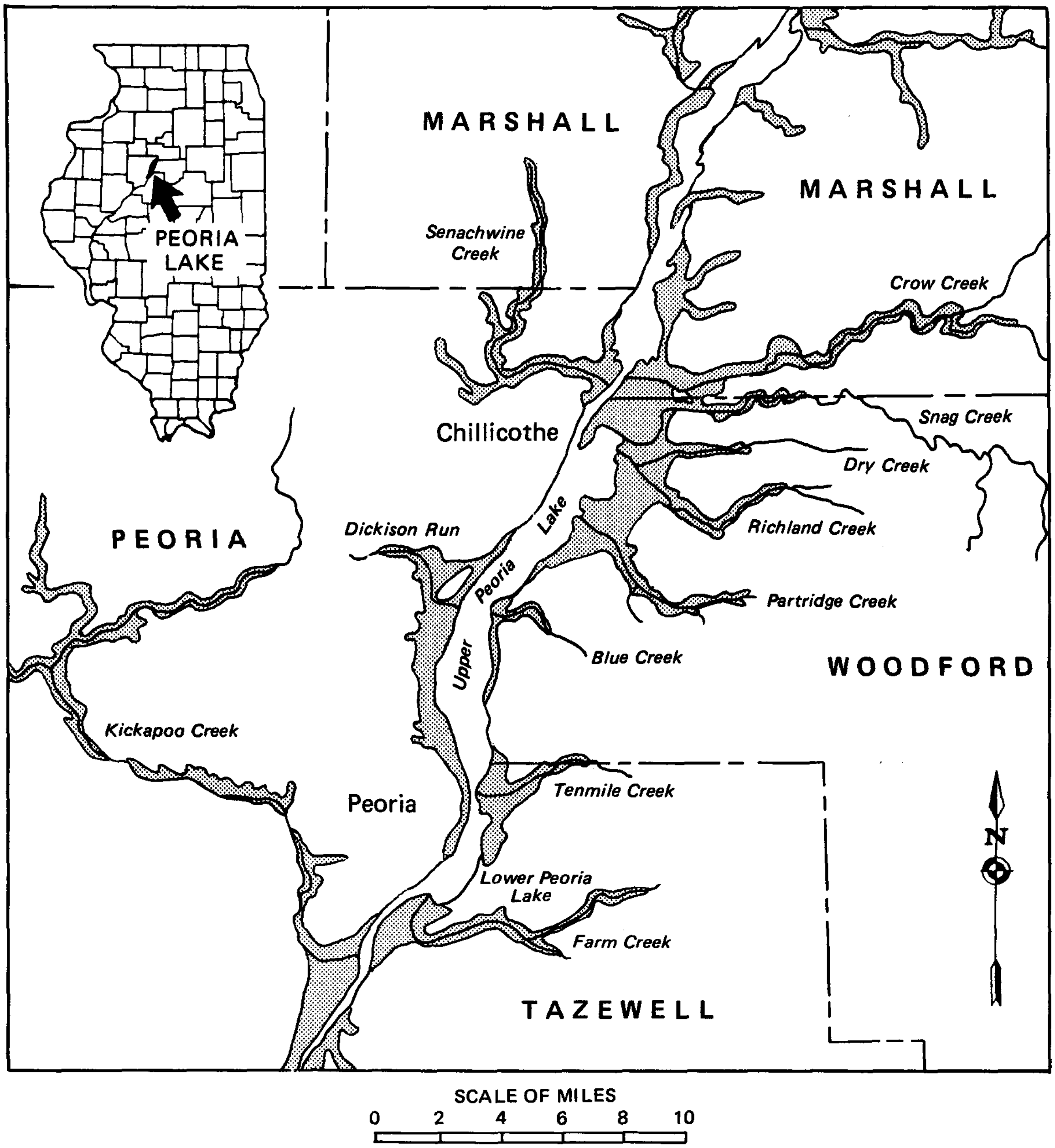

Fig. 1. Sediment deposits at the mouths of tributary streams in the Illinois River Valley in the Peoria Lake area (adapted from Lineback, 1979)

from Lake Michigan to the Illinois River through the Chicago Sanitary and Ship Canal. This allowed the City of Chicago to flush untreated domestic sewage and industrial wastes away from Lake Michigan, which was the city's source of water supply, and into the Illinois River. From 1900 through 1938, the average amount of diversion into the Illinois River was approximately 7200 cubic feet per second (cfs). Starting in 1939, the amount of diversion was reduced to an average of 3200 cfs. The influence of the diversion on the Illinois River discharge is shown in Fig. 2 for the Marseilles gaging station. As can be seen, the mean flow since 1939 is 3448 cfs less than in the prior period. Since the early 1970s, the quality of water diverted into the Illinois River has been improved as a result of more stringent water quality standards.

The diversion of water, combined with the discharge of domestic and industrial waste into the Illinois River, significantly changed the nature of the Illinois River and the bottomland lakes along its valley. Low water levels were increased, water quality degraded rapidly, and as a result fish and other aquatic organisms were either eliminated or reduced significantly in numbers.

Another major event which permanently changed the nature and character of the Illinois River and its bottomland lakes was the construction of navigation dams. Initially four low dams were built on the Illinois River to provide a 7-foot navigation channel for large steamboats from the Mississippi River to LaSalle, Illinois. The dams were built at Henry in 1872, Copperas Creek in 1877, LaGrange in 1883, and Kampsville in 1893. In 1919 construction started on the Illinois Waterway, a project designed to provide a navigation channel with a minimum depth of 9 feet and a minimum width of 300 feet from the Mississippi River to Lake Michigan. This project required

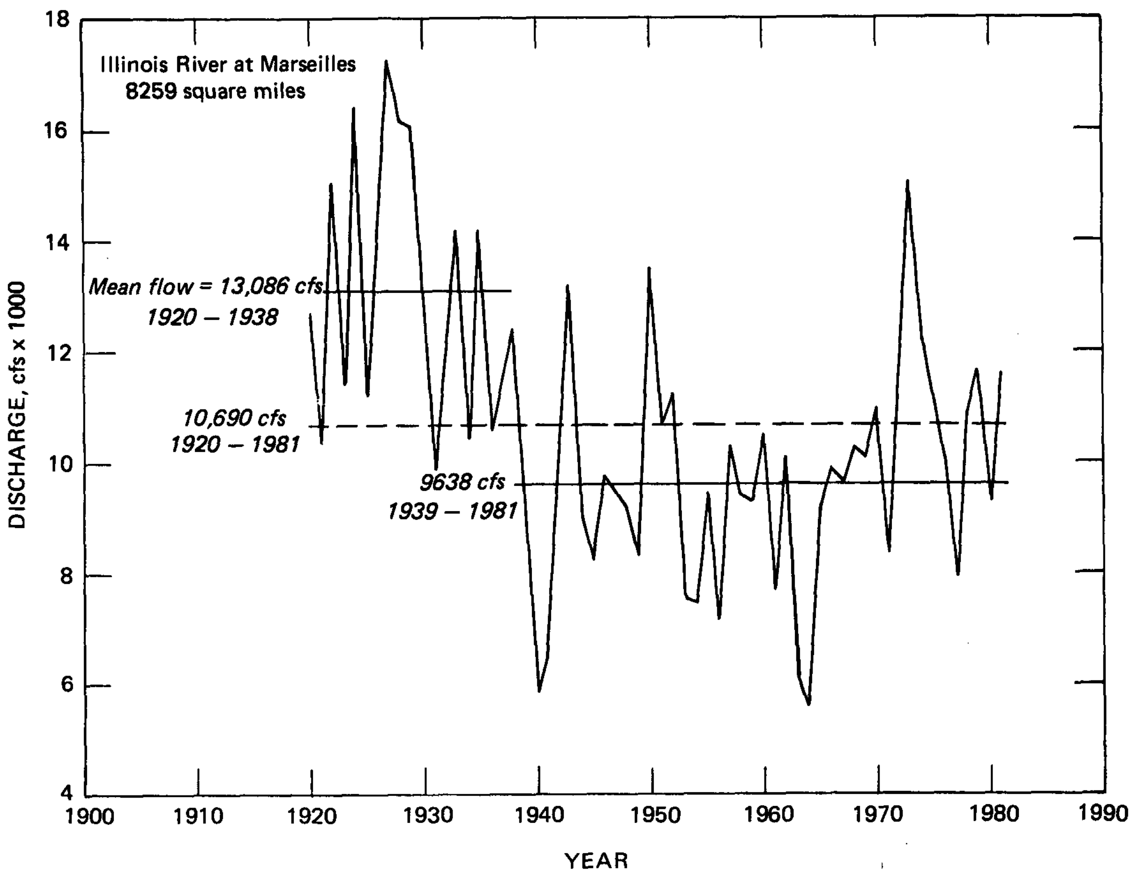

Fig. 2. Influence of Lake Michigan diversion on the Illinois River flow

the construction of five major locks and dams along the Illinois River in the 1930s.

The navigation lock and dam system on the Illinois River includes the Dresden Island Lock and Dam, the Marseilles Lock and Dam, the Starved Rock Lock and Dam, the Peoria Lock and Dam, and the LaGrange Lock and Dam. The height of the dams ranged from 10 feet for the LaGrange Lock and Dam to 24 feet for the Marseilles Lock and Dam (the Peoria Lock and Dam is 11 feet high). The Alton Lock and Dam on the Mississippi River provides a navigation pool in the lower part of the Illinois River. The profile of the Illinois Waterway created by these and upstream locks and dams on the Des Plaines River is shown in Fig. 3. The Illinois River ceased to be a natural river all the way from its starting point at the junction of the Des Plaines and Kankakee Rivers to its mouth at the Mississippi River. It now consists of a series of six navigation pools with five locks and dams used to facilitate navigation. Under these conditions, the low flow hydraulics of the river changed significantly, resulting in increased low water levels (Peoria Pool is maintained at 440 ft msl), decreased velocities, and thus increased sedimentation rates. During high flows, the dams at Peoria and LaGrange are lowered to the river bottom and thus do not have any impact on the river flow at those times.

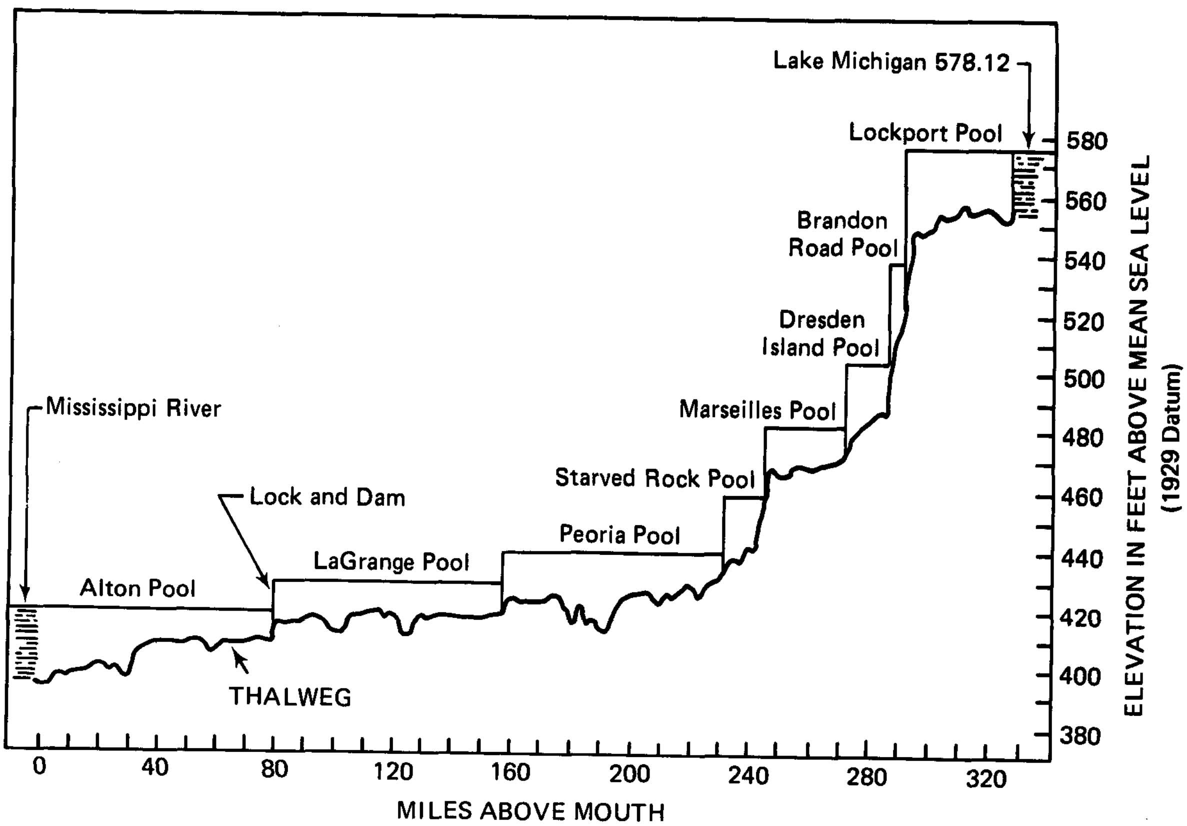

Fig. 3. Profile of Illinois Waterway

METHOD OF ANALYSIS

The results of the Peoria Lake investigation and the recommendations thereof are based on new data collected in 1985 and on a review and reanalysis of existing data and literature. The details of the work and all the information collected and analyzed will be presented in a technical report to be published in the near future. A summary of the work is presented in the following sections.

Mapping of Peoria Lake and Tributary Watersheds

Data on Peoria Lake and the watersheds of the tributary streams which drain directly into Peoria Lake, obtained from eleven 7-1/2-minute quadrangle maps of the U.S. Geological Survey, were digitized. The digitized data were for an area that starts from the Peoria Lock and Dam (R.M. 158) and ends at the Route 17 bridge (R.M. 186) at Lacon. Data on the locations of highways, railroads, and cities and towns were also digitized. The digitization was performed using the GIS (Geographic Information System). The GIS makes it possible to produce maps of different sizes and scales, and to compute the area of the lake, the length of the shoreline, the drainage areas of tributary streams, stream length, and other relevant information. It is also possible to overlay selected features of the area and to develop display maps. Such a map, which shows the important features in the Peoria Lake area, is shown in Fig. 4.

The information stored on the computer is useful not only for this study but also for other long-term studies on the Illinois River and Peoria Lake. If any changes were to be implemented in the area, those changes could easily be incorporated into the data base and then analyzed and interpreted. For example, areas of excessive erosion in the bluff watersheds could be

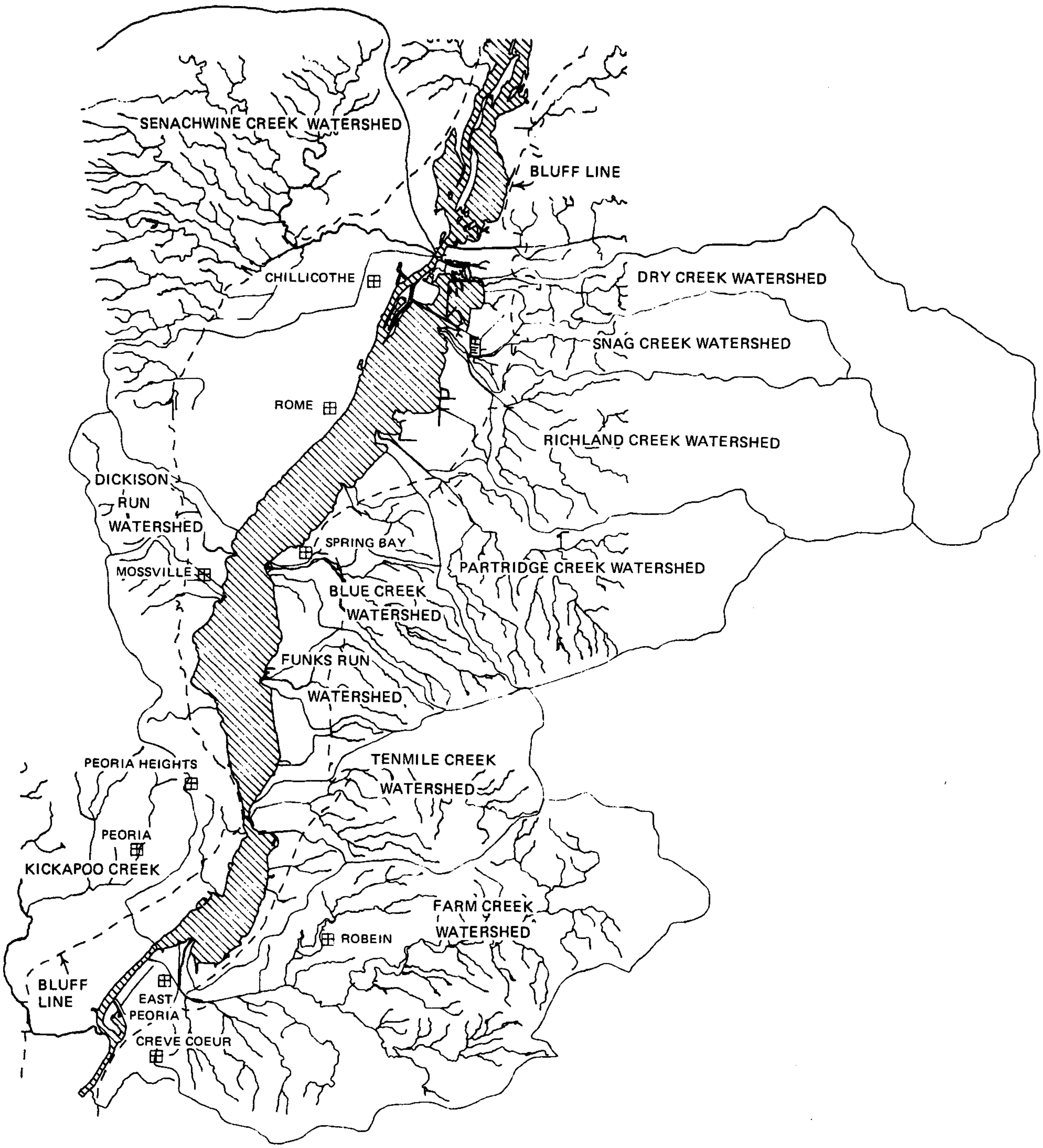

Fig. 4. Map of Peoria Lake area developed by using the Geographic Information System

identified and added to the data base to determine which areas should be given the highest priority for erosion control measures. Thus the data which have been compiled so far will be a very useful tool in the implementation and management of future programs for the Peoria Lake area.

Review of Previous Data and Literature

Before this report was prepared, existing data and literature on the Illinois River and Peoria Lake which were not available from the Illinois State Water Survey files and library were obtained from the University of Illinois, Illinois State Geological Survey, Illinois Natural History Survey, U.S. Army Corps of Engineers, and other organizations. All the data and information were carefully reviewed and analyzed in preparing this report. Some of the important sources of information include previous lake surveys, sediment and water quality studies, flow records along the Illinois River, and aquatic habitat studies. The bibliography lists the important reference materials used in preparing this report.

Field Data Collection and Analysis

The Illinois State Water Survey, in cooperation with the Illinois Natural History Survey and State Geological Survey, conducted an intensive field data collection from February to May 1985. This was an important component of the study because it provided the information needed to evaluate the current conditions of the lake. This data collection also produced valuable information because the third highest flood on the Illinois River occurred during the data collection period.

The field data collection program included the following components:

1) Velocity and discharge measurements

2) Suspended sediment concentration, bed load, and particle size sampling and analysis

3) Lake bed material and sediment core sampling and analysis

4) Bathymetric profiling of the lake bed

A brief discussion of the different types of data collected in 1985 is presented in the following pages.

Velocity and Discharge Measurements

Velocity and discharge are important parameters used to define the hydraulic characteristics of rivers and lakes. They are used to calculate the amount of sediment that a river is transporting or that it can transport. They are also used to identify areas of a lake where excessive sedimentation can be expected.

Velocity and discharge measurements were made at seven locations in Peoria Lake, beginning at the Franklin Street Bridge near downtown Peoria and ending at Chillicothe. The locations of the transects where velocity and discharge measurements were taken are shown in Fig. 5. Velocities were measured across the stream channel and the lake at all locations at least two times. At the Franklin Street Bridge velocities were measured nine times.

The velocity distributions during one of the field measurements at cross section 8 at the Franklin Street Bridge, at cross section 7 in Lower Peoria Lake, at cross section 6 at the Narrows, and at cross section 4 in Upper Peoria Lake are shown in Figs. 6, 7, 8, and 9, respectively. Except at the Narrows and the Franklin Street Bridge, the velocities are extremely low. Velocities at the Franklin Street Bridge reached as high as 4 feet per

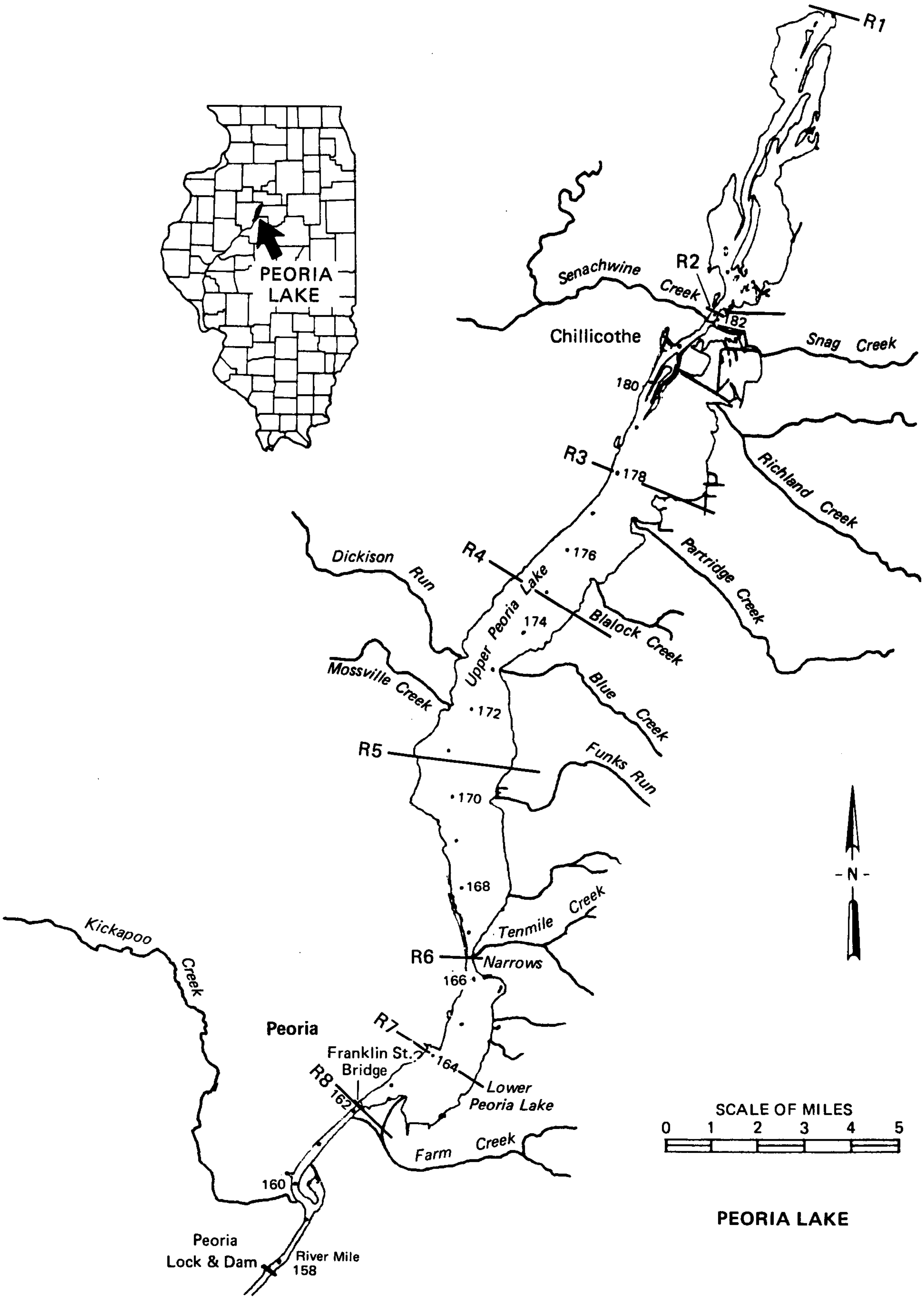

Fig. 5. Location of data collection cross sections

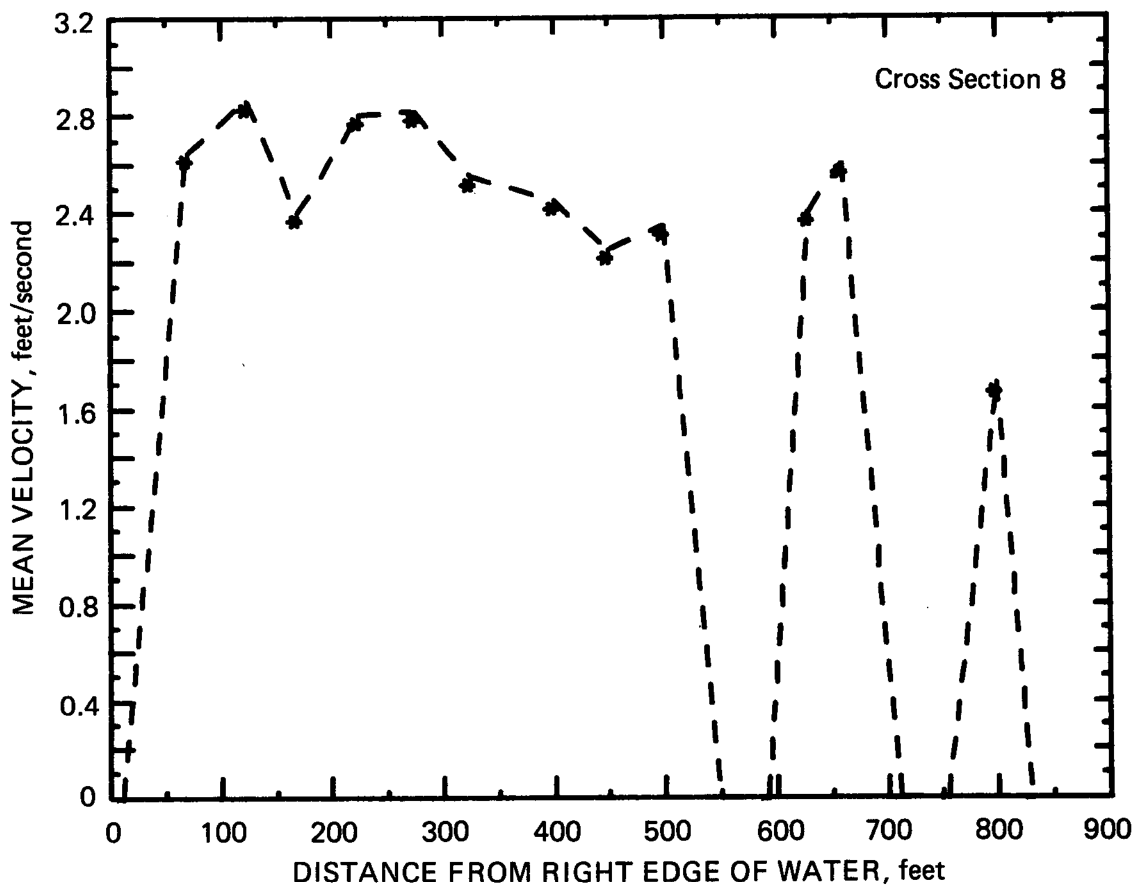

Fig. 6. Velocity distribution at cross section 8 at Franklin Street Bridge, April 24, 1985

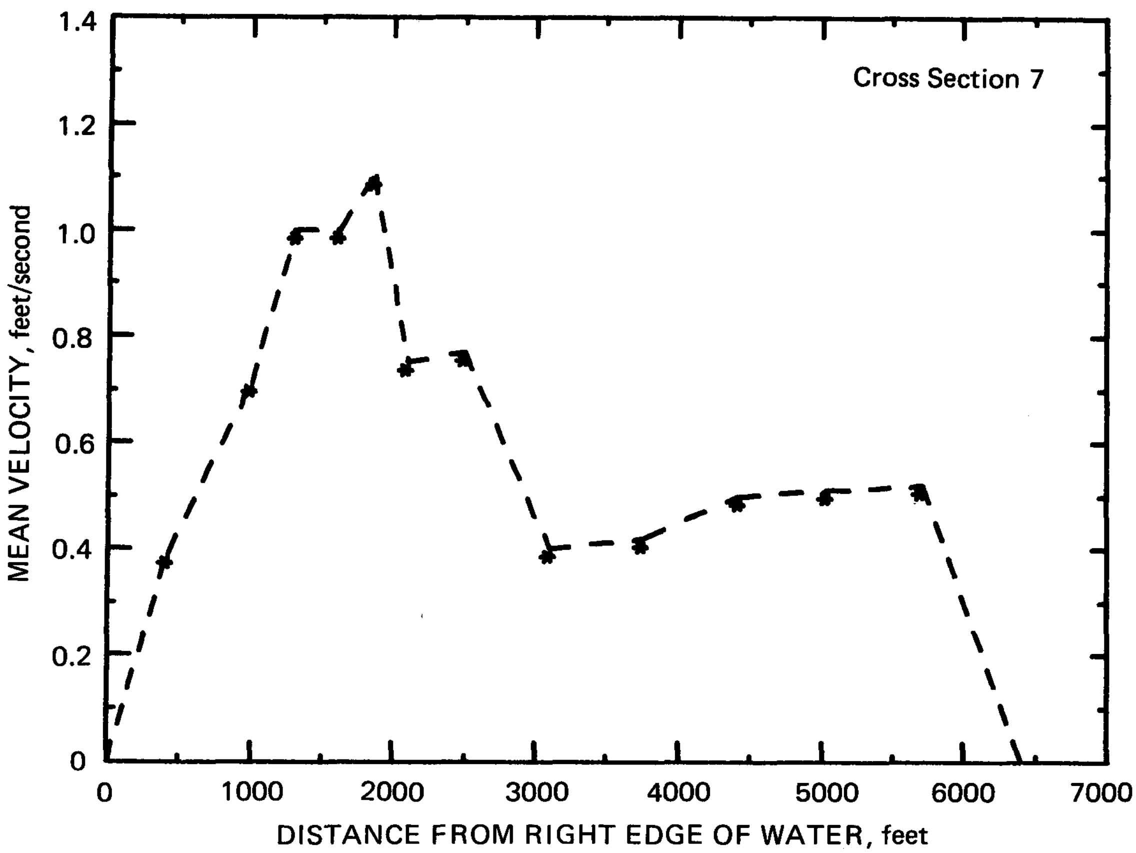

Fig. 7. Velocity distribution at cross section 7 in Lower Peoria Lake, April 24, 1985

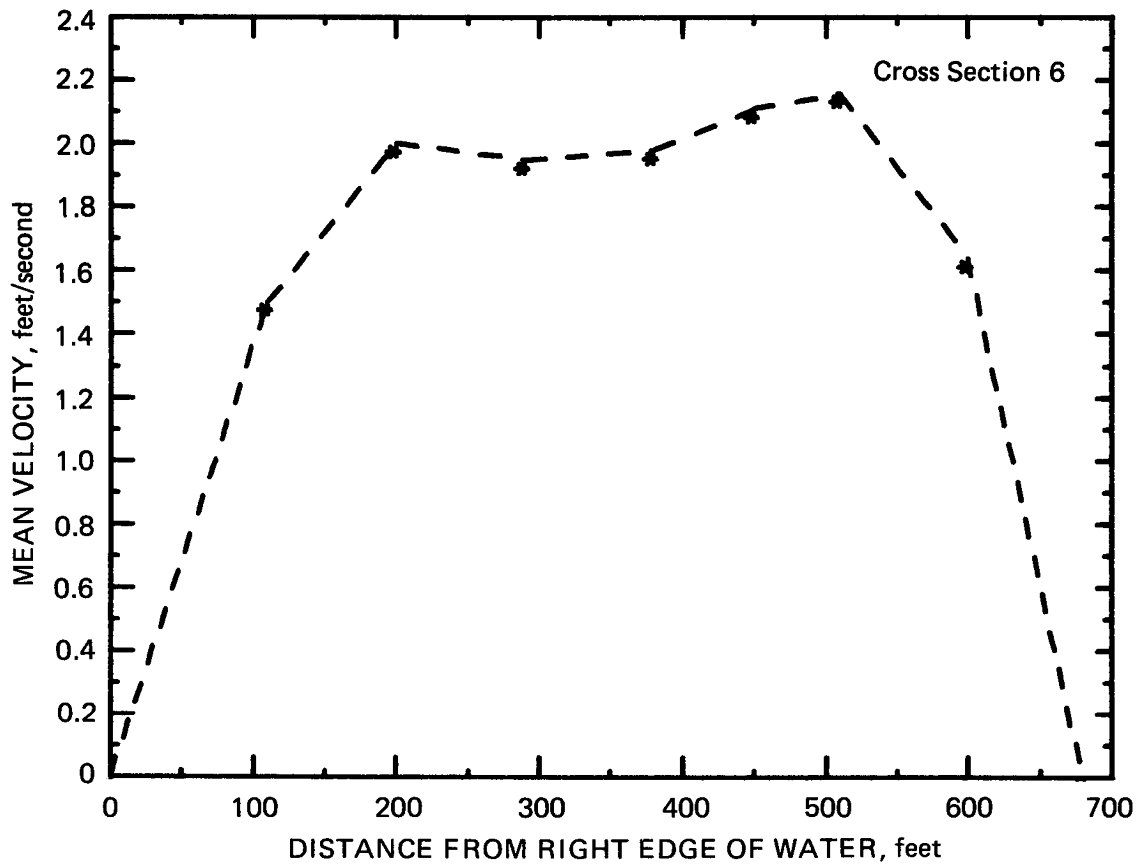

Fig. 8. Velocity distribution at cross section 6 at the Narrows, April 25, 1985

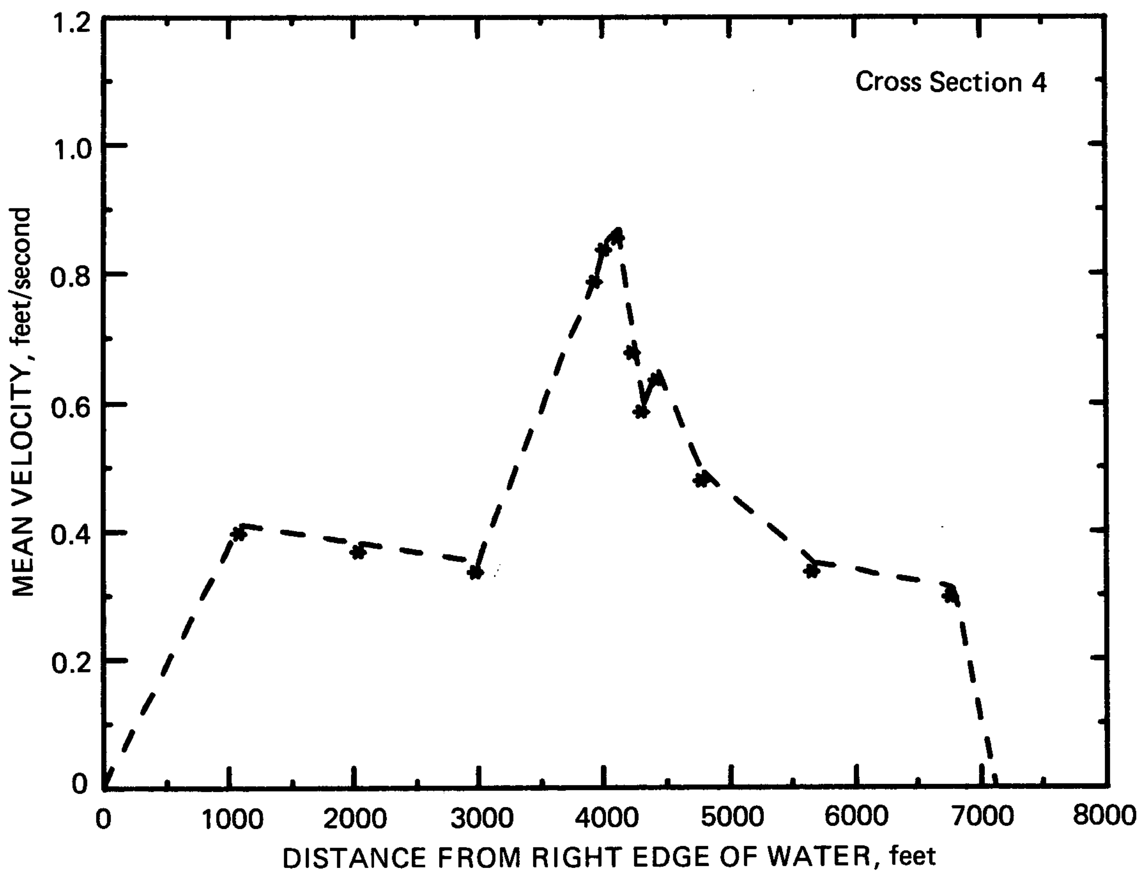

Fig. 9. Velocity distribution at cross section 4 in Upper Peoria Lake, April 25, 1985

second, and at the Narrows velocities reached over 2 feet per second. For most of the lake, however, velocities are generally less than 1 foot per second except in the navigation channel, which has slightly higher velocities.

The water discharge in the Illinois River from February to May 1985 was calculated by using the velocity measurements at the Franklin Street Bridge. The flood hydrograph of the Illinois River generated from those measurements is shown in Fig. 10a. The maximum discharge measured was 80,800 cfs on March 8, 1985.

Suspended Sediment Concentration, Bed Load, and Particle Size Sampling

To understand the sedimentation process in Peoria Lake, it is necessary to gather field data on sediment transport. Sediment in a river is transported either in suspension or on or near the stream bed as bed load. The total sediment load of a stream is the sum of the suspended load and the bed load. Measurements of the two components of the total sediment load are different. Suspended sediment load is calculated by multiplying the concentration of the suspended sediment by the measured water discharge. The suspended sediment concentration is measured by following the standard procedures outlined by the U.S. Geological Survey.

Bed load is measured by collecting bed load samples during a known period of time with a bed load sampler. Bed load is calculated on the basis of the duration of the bed load sample collection, the width of the bed load sampler, and the width of the channel. The bed load sample collected is first converted to bed load discharge per unit time and width by dividing the sample weight by the sampling period and width of the sampler. Then total bed load is calculated by multiplying the bed load per unit width by the

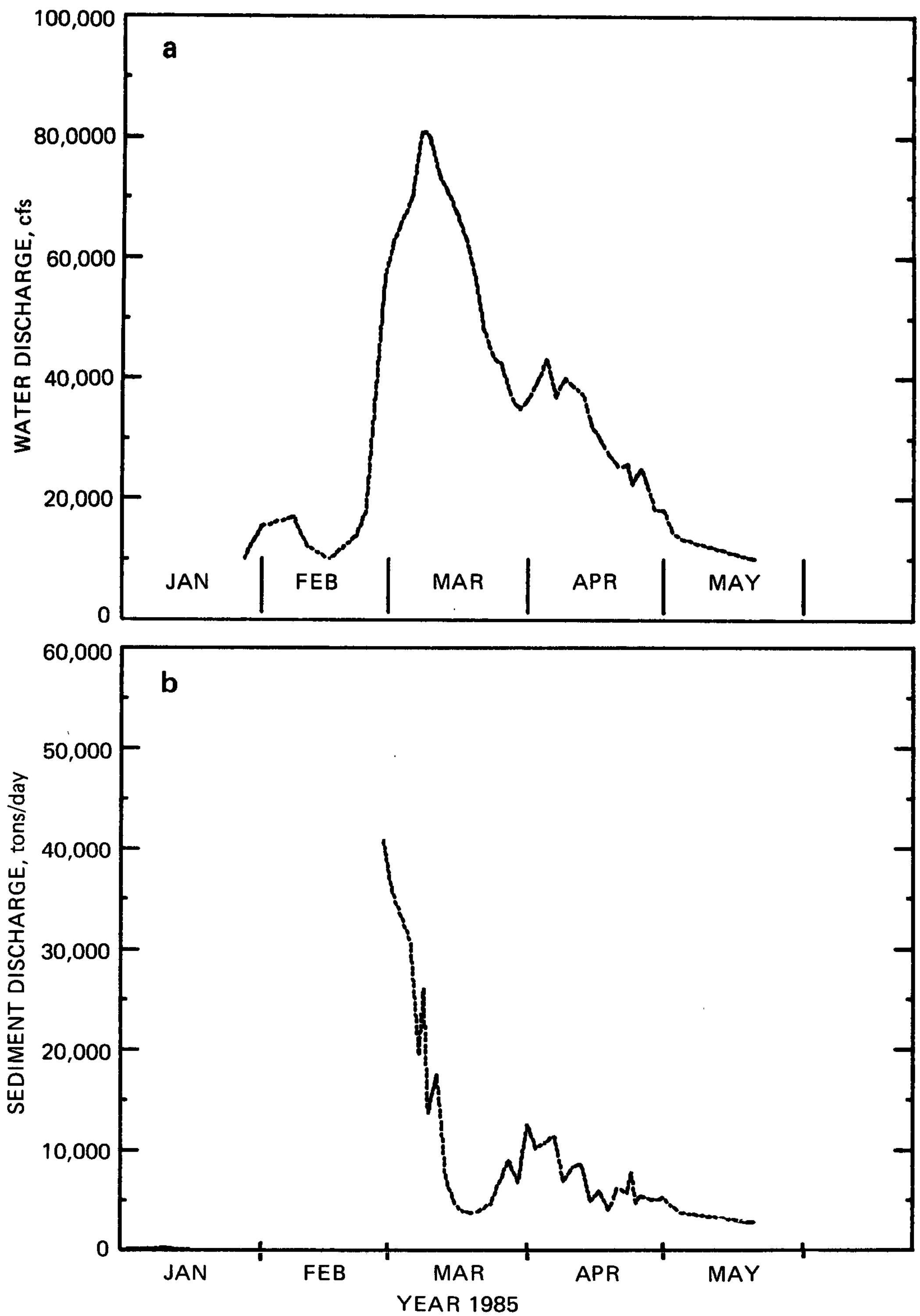

Fig. 10. Illinois River water discharge and sediment load from February 26 to May 20, 1985 at the Franklin Street Bridge, Peoria

width of the channel. It is assumed that the bed load is transported at a uniform rate across the width of the channel.

For this project, a total of 256 suspended sediment concentration samples were collected from February 26 to May 20, 1985. Most of the samples were collected at the same locations shown in Fig. 5 at which velocity measurements were made. Additional samples were collected at the Route 17 Bridge at Lacon, at Farm Creek, and at Tenmile Creek. It is not possible to generalize about the sediment loads of Farm Creek and Tenmile Creek on the basis of the sediment data for those two creeks because the limited duration and scope of the project precluded intensive sampling during storm events, at which time small creeks transport most of the annual sediment load.

Suspended sediment concentrations measured at cross section 8 at the Franklin Street Bridge, at cross section 7 in Lower Peoria Lake, at cross section 6 at the Narrows, and at cross section 4 in Upper Peoria Lake are shown in Figs. 11, 12, 13, and 14, respectively. The sediment concentrations at the Franklin Street Bridge are nearly uniform across the channel, which makes it an ideal site for sediment load measurements. Similarly, the concentrations are fairly uniform at the Narrows. Cross sections 4 and 7 show slightly higher concentrations in the channel than in the lake areas, but not by very much.

The sediment load in the Illinois River from February 26 to May 20, 1985 was shown in Fig. 10b along with the water discharge data. The maximum sediment load measured during the period was approximately 40,800 tons per day on February 27, 1985. Twenty-five suspended sediment samples were also analyzed for particle size distribution to determine the sediment characteristics. In all the samples from the Illinois River, it was observed that over 95 percent of the suspended sediment is silt and clay.

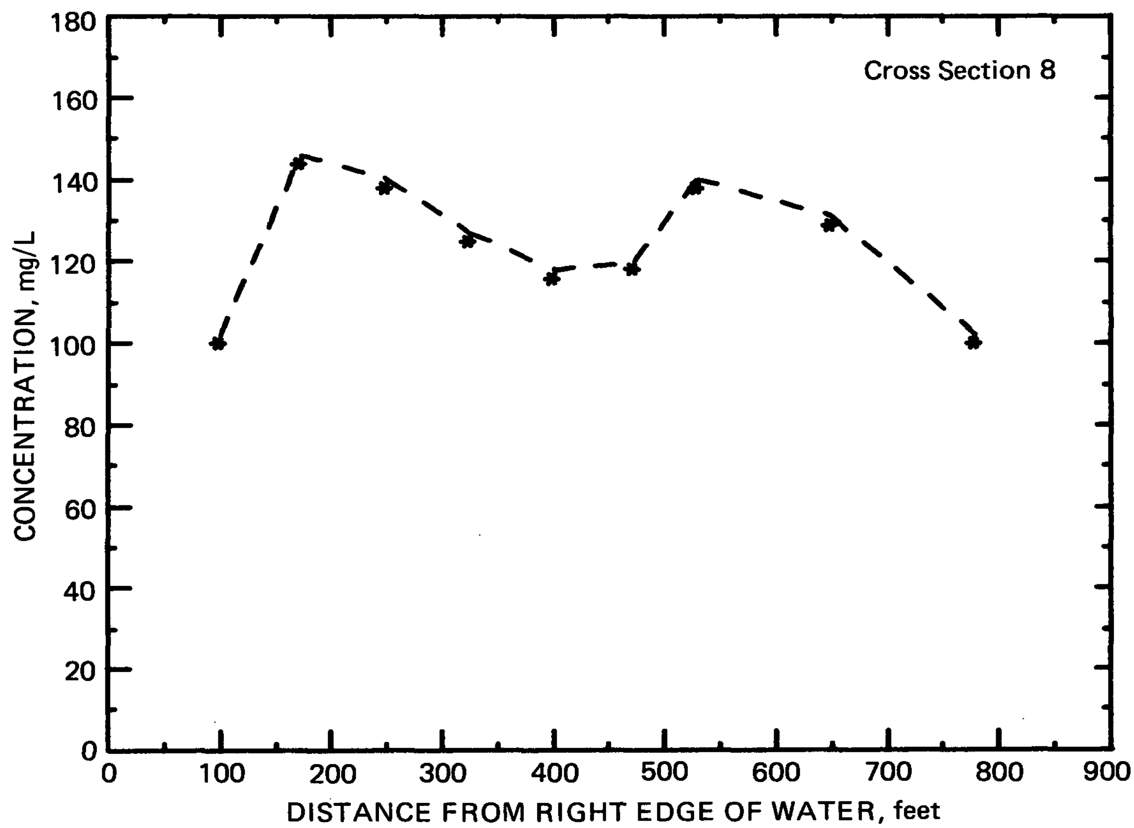

Fig. 11. Suspended sediment concentration at cross section 8 at Franklin Street Bridge, April 24, 1985

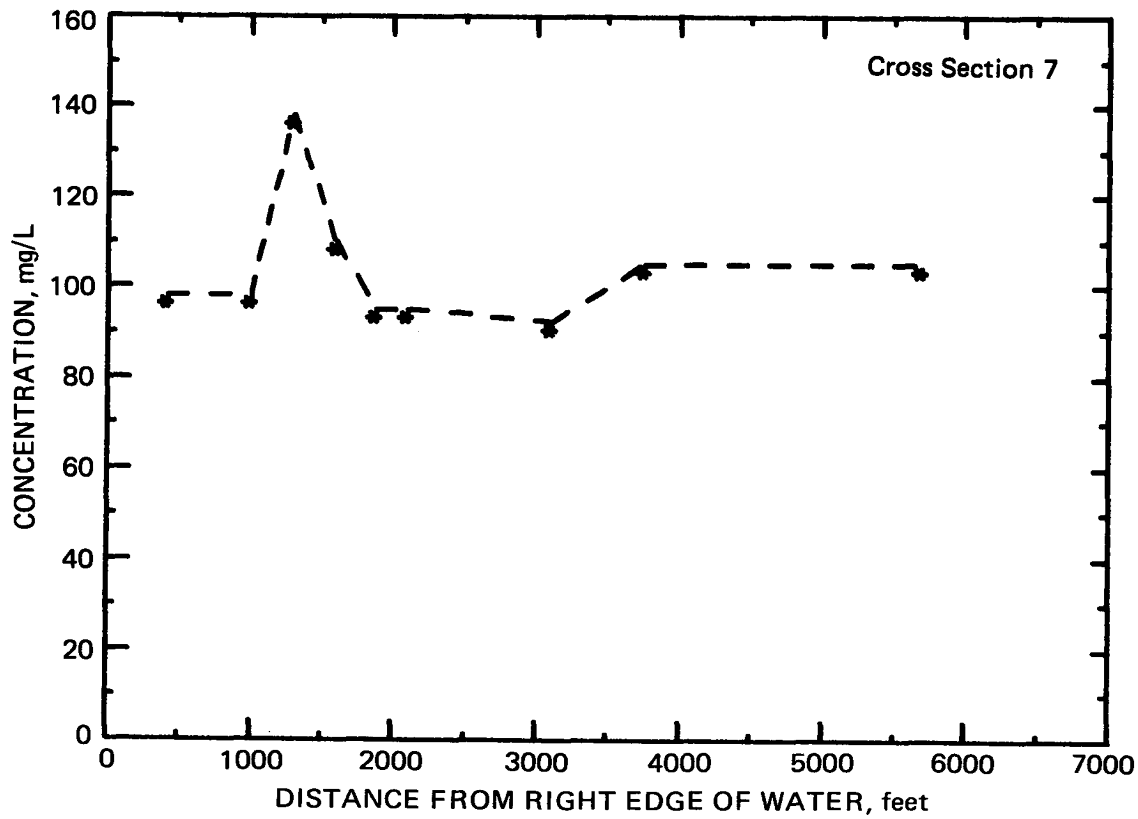

Fig. 12. Suspended sediment concentration at cross section 7 in Lower Peoria Lake, April 24, 1985

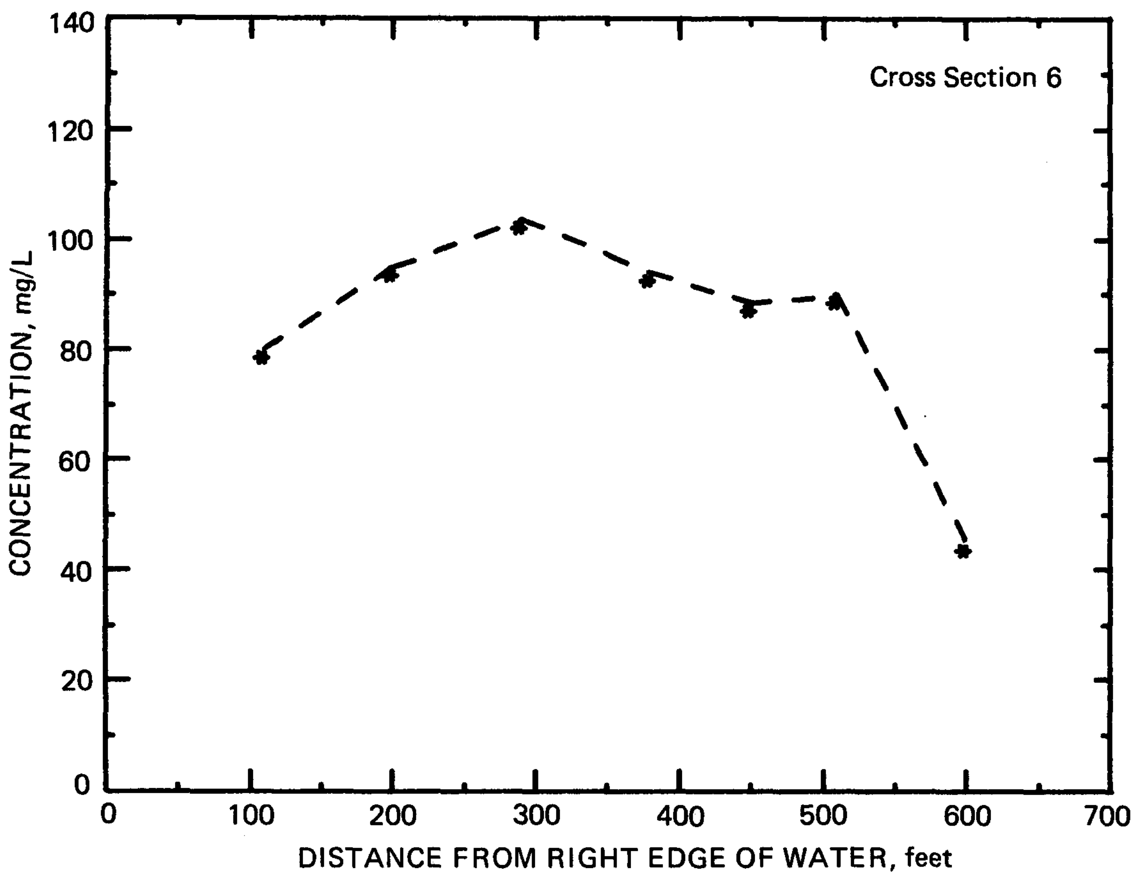

Fig. 13. Suspended sediment concentration at cross section 6 at the Narrows, April 25, 1985

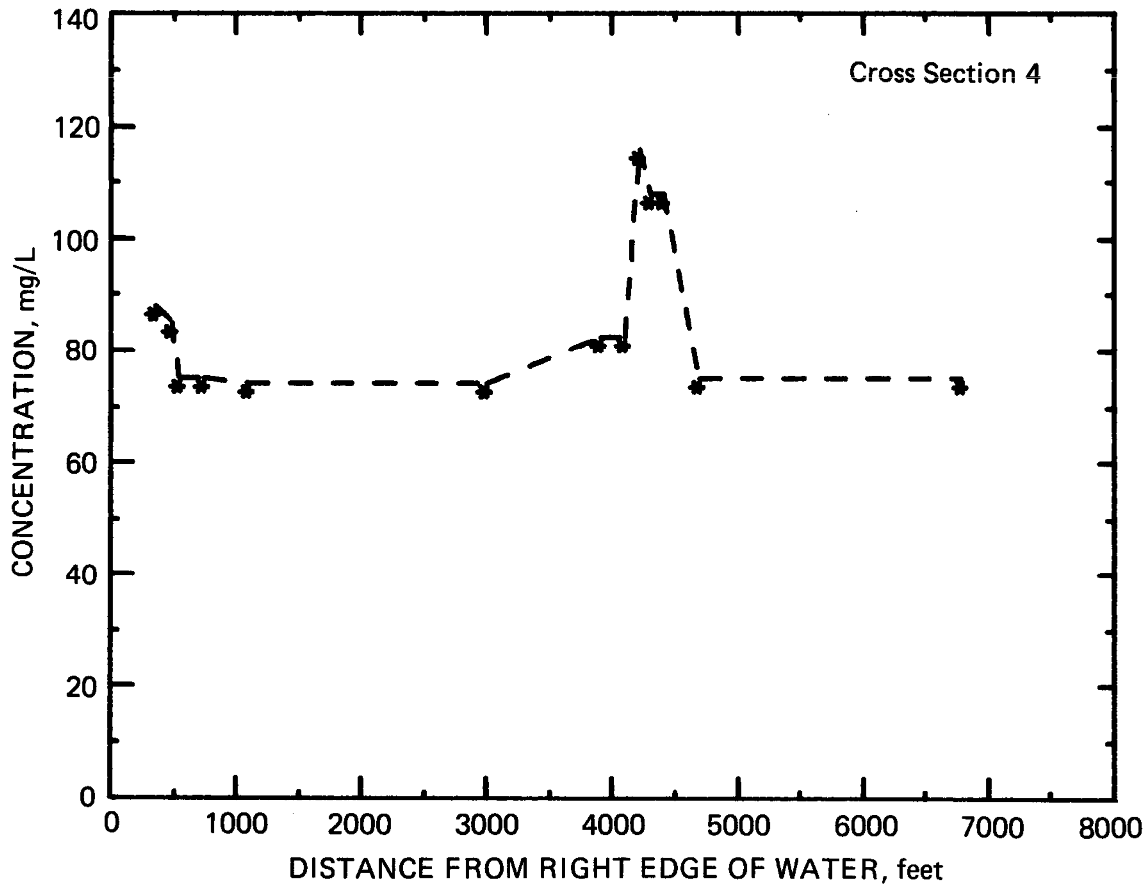

Fig. 14. Suspended sediment concentration at cross section 4 in Upper Peoria Lake, April 25, 1985

Thirty-one attempts were made to collect bed load samples. Fourteen of the attempts were at the Franklin Street Bridge during different flow conditions. Out of the 14 attempts, only once was a measurable amount of bed load sample collected. This particular sample consisted mainly of organic material such as shells and broken twigs. However, six bed load samples were collected in the main channel in both Upper and Lower Peoria Lake during boat sampling. These samples were also very high in organic content.

On the basis of the attempts made to measure bed load in the Illinois River, it can be assumed that the bed load in the river consists of fine sediment and organic material and not coarse sediment such as sand or gravel. The fine sediment moving as bed load cannot be sampled using the Helley Smith sampler, which is the only bed load sampler available at the present time.

Three bed load samples were collected at Farm Creek during low flow conditions. These scant data showed that the bed load in Farm Creek is very significant and could be a major part of the total sediment load. However, because of the limited data and sampling period, accurate calculations of the sediment load in Farm Creek and other tributary streams can not be made at the present time.

Lake Bed Material and Sediment Core Sampling

Twenty-five bed material samples and 14 sediment core samples were collected in Peoria Lake for particle size, unit weight, and chemical analyses. The bed material samples were collected using a ponar sampler, while the core samples were collected using a 3-foot-long thin-wall stainless steel 2-inch-diameter core sampler. The locations of the sampling points are shown in Fig. 15. The physical characteristics of the sediment samples were analyzed in the Inter-Survey Geotechnical Laboratory. The results of the

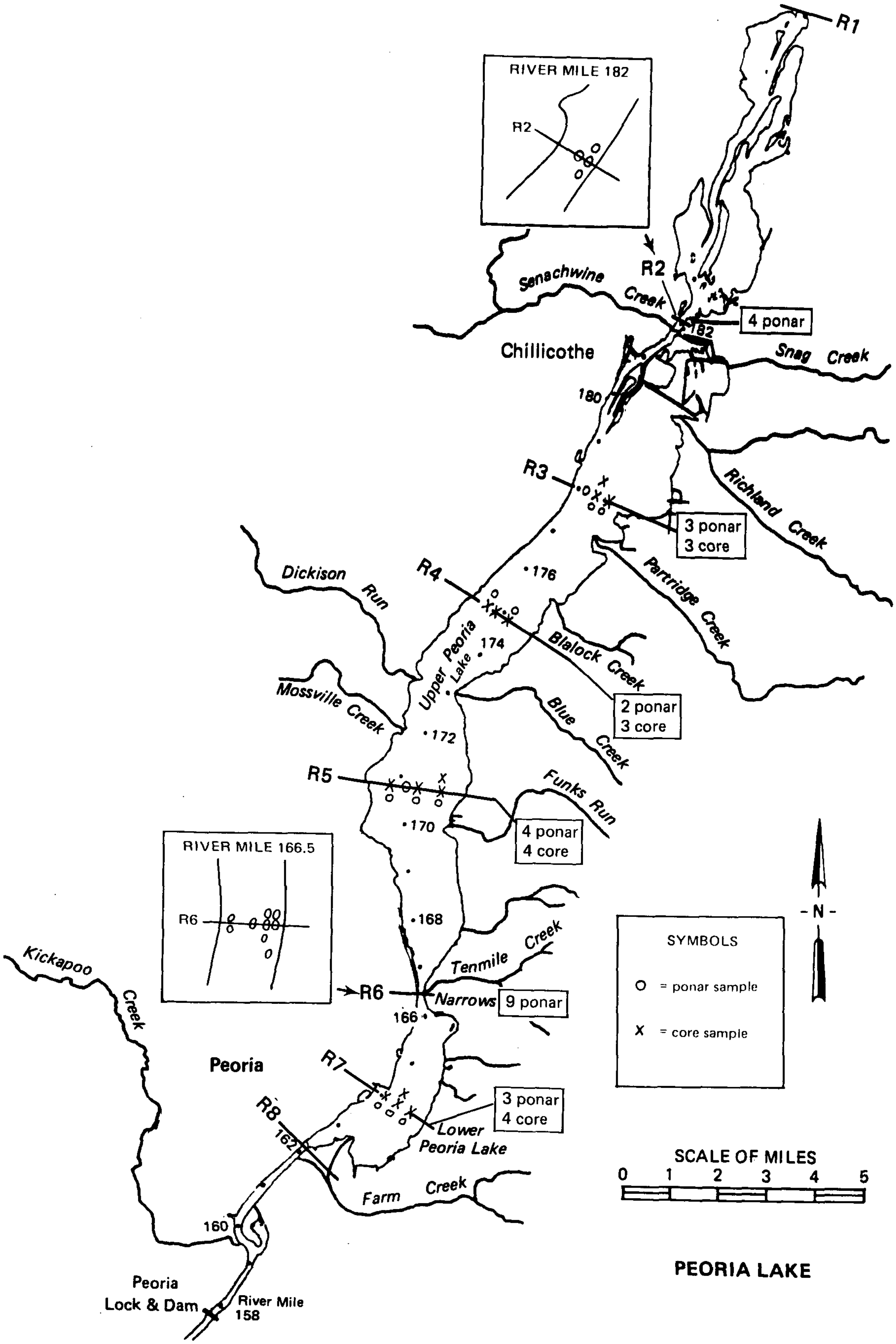

Fig. 15. Locations of bed material and sediment core samples

analyses are summarized in Fig. 16 for one of the core samples collected from cross section 5 at River Mile 170.8. On the basis of the type of information in Fig. 16, it is possible to describe the sediment characteristics and to determine the weight of the sediment in the lake bottom.

The results of chemical analyses for nine dredge samples from the top of the lake bottom in Peoria Lake are summarized in Table 1. Analyses were performed for seven heavy metals, moisture content, volatile solids, oil and grease, Total Kjeldahl nitrogen (TKN), orthophosphate-P (PO_4-P), and ammonia-nitrogen (NH_3-N). The chemical analyses for the samples were performed at the laboratory of the Illinois State Water Survey, Water Quality Section, in Peoria. Samples 1, 2, and 3 were collected at cross section 7 in Lower Peoria Lake, and samples 4 through 9 were collected in Upper Peoria Lake at cross sections 5 and 3. The locations of the sample collections are shown in Fig. 15. There is no clear trend in the chemical properties of the sediment samples collected at the different locations, with the exception of sample 8, which has consistently lower concentrations than the other samples for all the elements analyzed. Sample 1 from cross section 7 in Lower Peoria Lake has slightly higher concentrations of chromium and lead than the other samples. However, the difference is not significant and the other samples at the same cross section are consistent with all the other samples.

Bathymetric Profiles

In 1903 a survey of Peoria Lake was performed by J.W. Woermann of the U.S. Army Corps of Engineers. Since 1903, there have been only two detailed lake profile surveys performed for Peoria Lake: one in 1965 and another in 1976, both conducted by the U.S. Army Corps of Engineers. These three

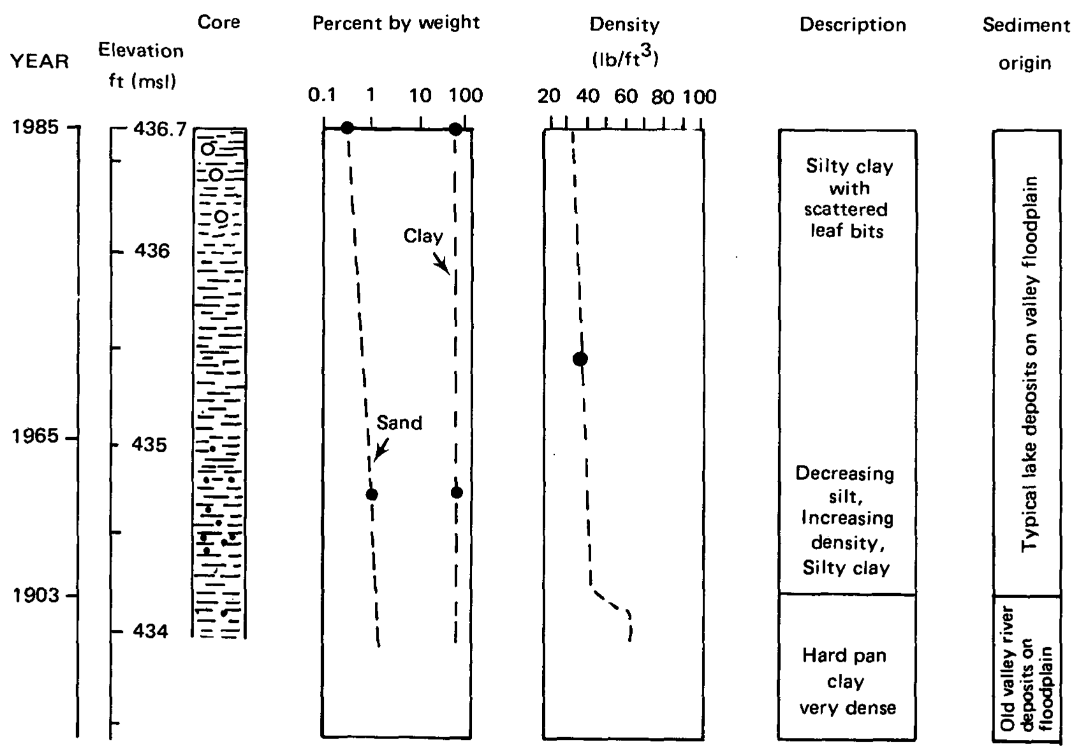

Fig. 16. Physical characterization of a sediment core sample

Table 1. Peoria Lake Sediment Sample Analyses

Parameters	Samples 1	2	3	4	5	6	7	8	9
Moisture content (%)	49.5	61.2	56.5	54.5	52.1	54.4	55.5	28.1	51.0
Volatile solids (%)	6.8	7.7	7.4	7.0	6.9	6.8	7.6	3.4	6.2
Oil & grease (% dry solids)	0.15	0.12	0.10	0.10	0.11	0.10	0.10	0.05	0.10
TKN (mg/kg)	2377	2835	2555	2453	2497	2448	2589	868	2303
Total PO_4-P (mgs/kg)	1907	1815	1614	1721	1654	1470	1819	785	1224
NH_3-N (mg/kg)	399	341	374	295	290	315	222	76	318
Cadmium (mg/kg)	3.20	1.83	1.83	1.83	1.83	1.83	1.55	None found	1.83
Chromium (mg/kg)	60.6	39.9	47.7	39.2	44.9	47.7	41.3	10.7	36.4
Copper (mg/kg)	45.9	46.3	50.4	43.8	48.7	48.9	40.6	10.7	41.7
Iron (mg/kg)	28,700	34,400	26,000	32,000	26,000	26,000	28,000	11,900	26,000
Lead (mg/kg)	66.6	44.0	57.1	46.2	57.1	46.2	52.7	16.9	46.4
Manganese (mg/kg)	807	922	725	746	651	703	821	459	692
Zinc (mg/kg)	264	277	258	232	277	255	248	89	233

Note: Samples 1, 2, and 3 were collected at cross section 7 in Lower Peoria Lake.
Samples 4, 5, 6, and 7 were collected at cross section 5 in Upper Peoria Lake.
Samples 8 and 9 were collected at cross section 3 in Upper Peoria Lake.

previous lake surveys were very useful in determining the sedimentation rates during different periods but were not felt to be adequate for evaluating the present status of the lake.

The present project did not have enough funding for a detailed lake sedimentation survey. However, without some type of lake profile data on the present conditions of the lake, it was impossible to evaluate the conditions of the lake, let alone make recommendations as to the best alternatives. Therefore, it was decided to perform a limited bathymetric survey of the lake to estimate the current capacity of the lake and the areal distribution of sediment in the lake. A total of 18 cross-sectional profiles were measured from the Franklin Street Bridge (R.M. 162.3) to Chillicothe (R.M. 182). These lake profiles were felt to be adequate for the present study, even though a detailed lake sedimentation survey should be conducted when funding permits.

Comparisons of the present data with the 1903, 1965, and 1976 data are shown for four cross sections in Figs. 17 to 20. Fig. 17 is for River Mile 164, which is in Lower Peoria Lake. As can be seen in the figure, there has been up to 14 feet of sediment accumulation in some areas of the lake since 1903. However, the navigation channel has been kept relatively deep, around 16 feet, at normal pool level (440 msl). Fig. 18 compares the data from the different surveys at River Mile 168, which is in Upper Peoria Lake and about 1-1/2 miles upstream of the Narrows. Here again, only the navigation channel is deep, while the rest of the lake bed has gradually been raised by sediment accumulation.

Fig. 19 shows the cross-sectional profile at River Mile 175, which is in the upper lake just north of Spring Bay. In this area, most of the lake has filled in with the exception of the navigation channel. As a matter of fact, the current navigation channel is deeper than the 1903 channel bed. The

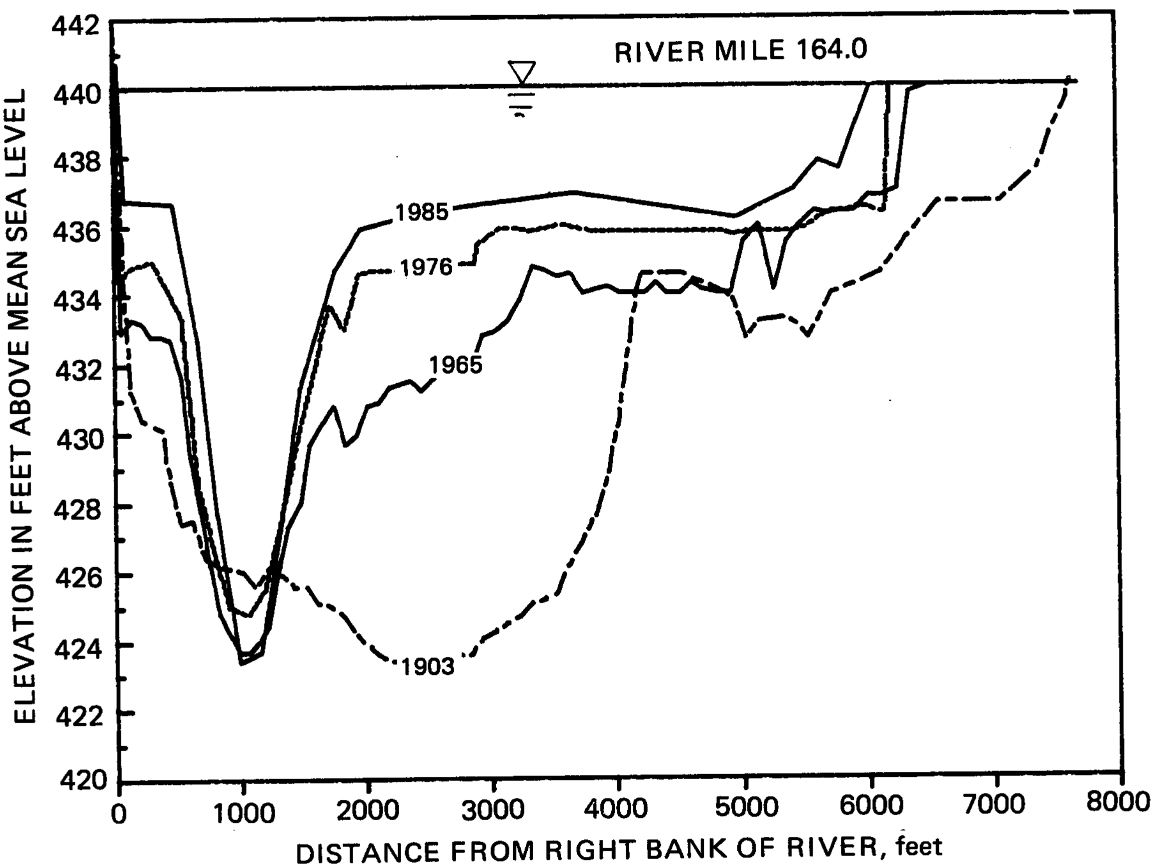

Fig. 17. Cross-sectional profile of Peoria Lake at River Mile 164

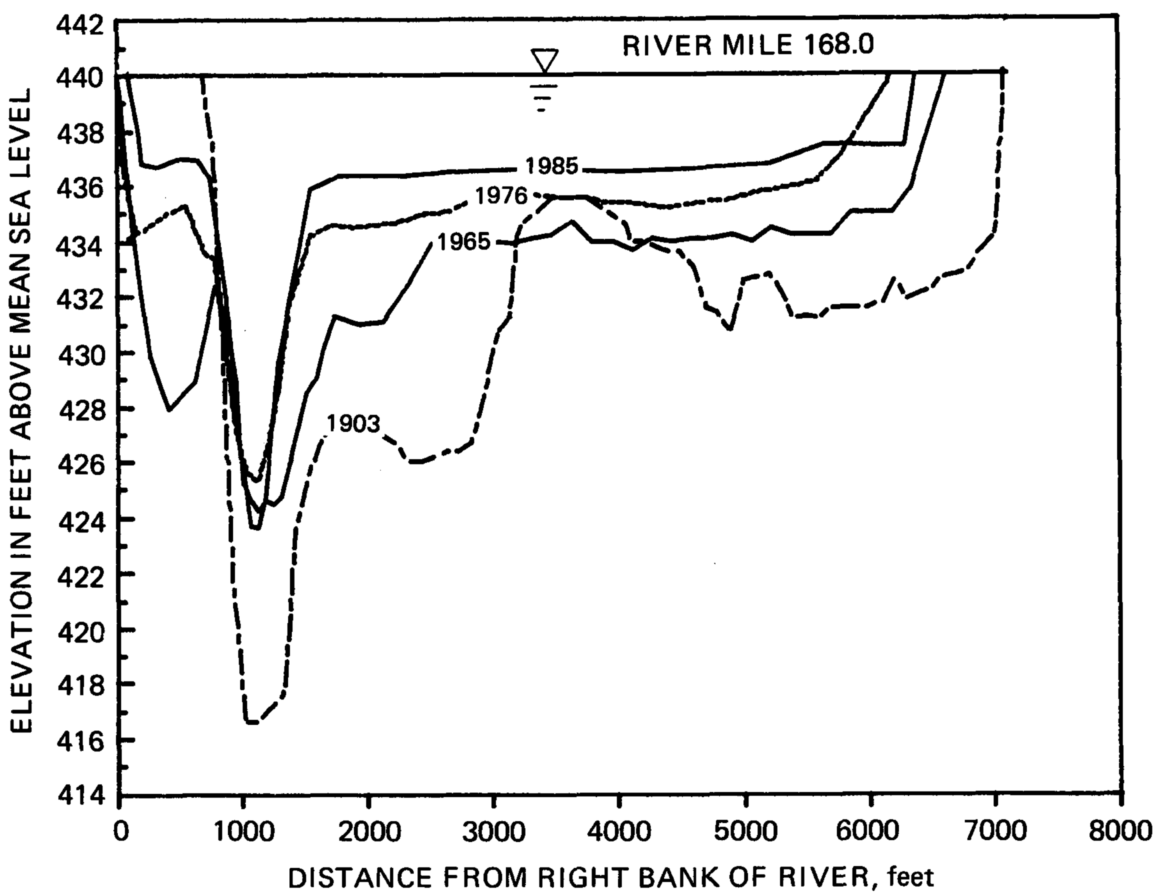

Fig. 18. Cross-sectional profile of Peoria Lake at River Mile 168

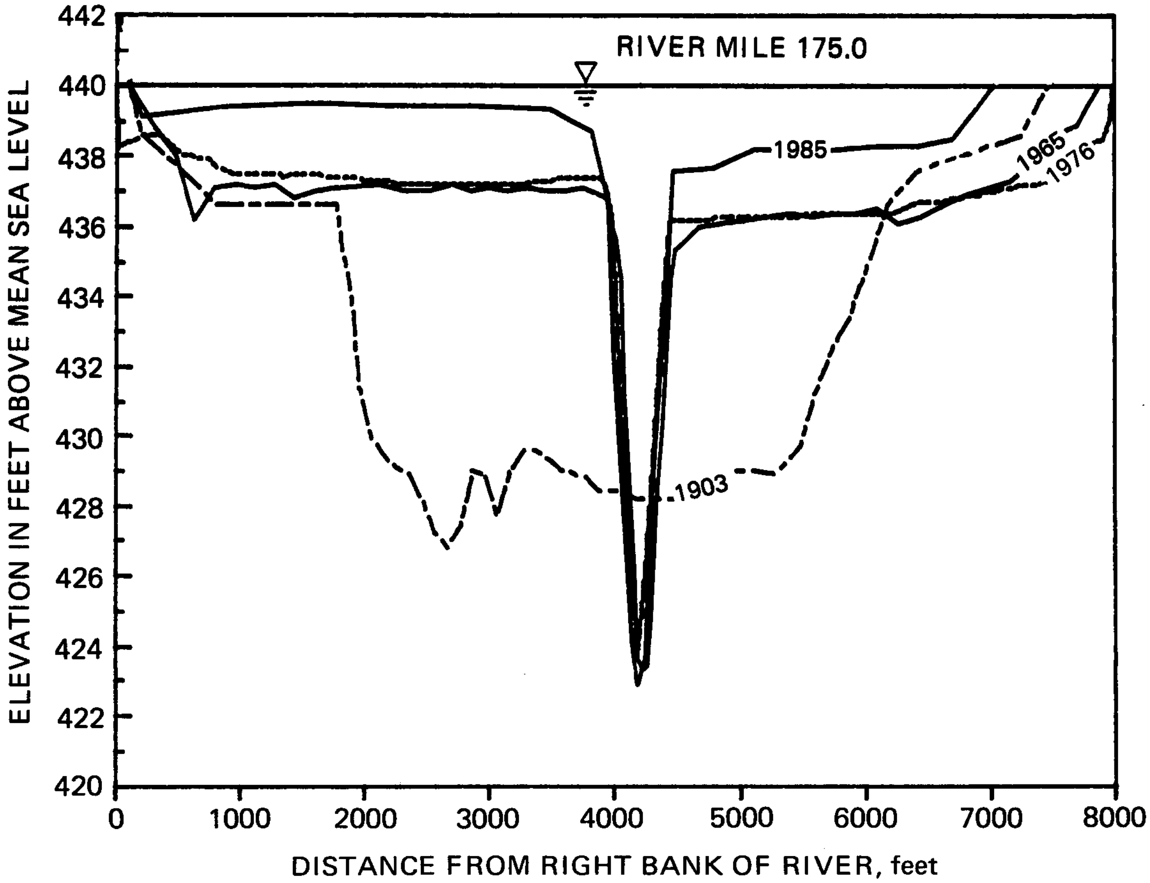

Fig. 19. Cross-sectional profile of Peoria Lake at River Mile 175

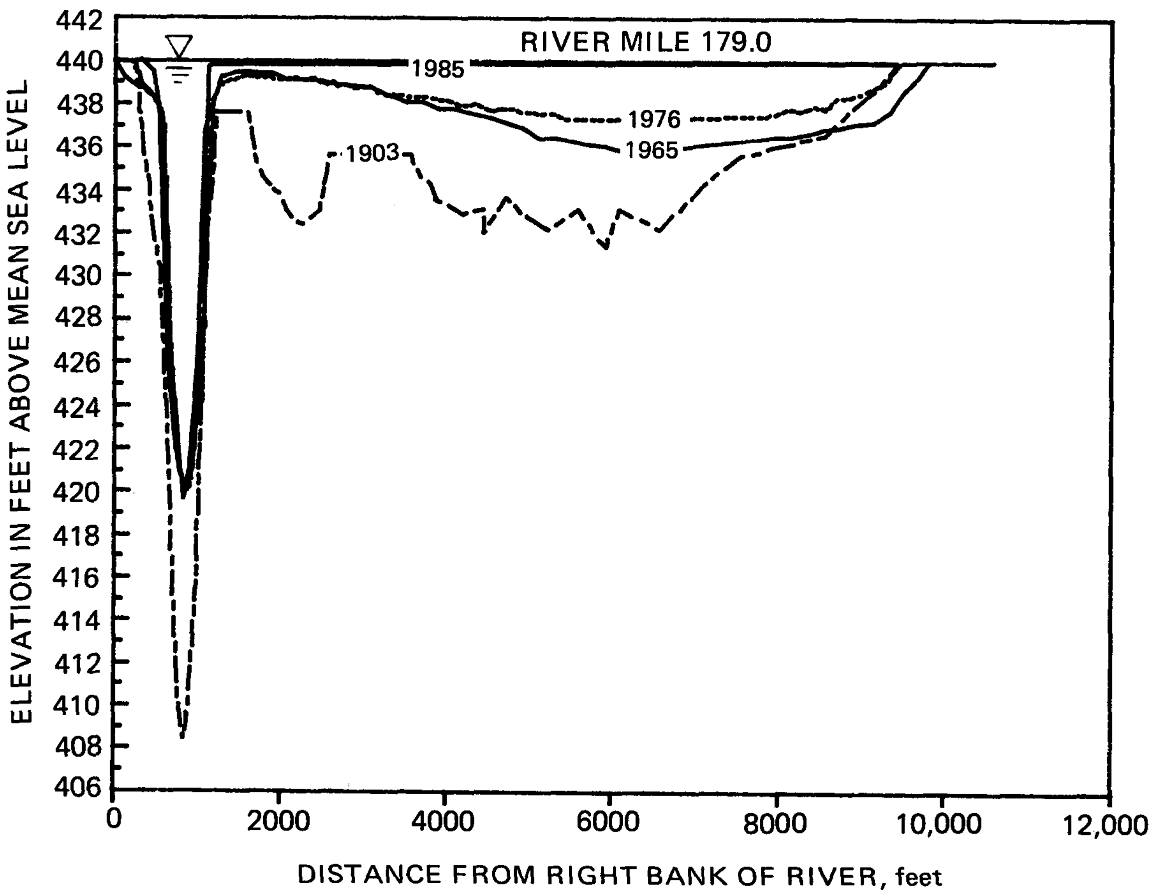

Fig. 20. Cross-sectional profile of Peoria Lake at River Mile 179

average depth of the lake in this area is about 2 feet at normal pool (440 msl). Fig. 20 shows the lake profile at River Mile 179, at the upstream end of Upper Peoria Lake. In this area the average depth of the lake is about 1 foot at normal pool and it can be assumed that the lake has totally filled up in some places.

The profiles show the sedimentation pattern and the changing character of the lake. The deeper parts of the lake are shrinking, the lake bed is becoming very flat and uniform, and at present there are no areas which are very deep outside of the navigation channel.

SEDIMENTATION

Sedimentation is the process by which soil particles eroded from upstream watersheds and stream channels are deposited in stream channels or lakes and reservoirs located downstream of the source. Erosion and sedimentation are natural processes that can neither be stopped nor completely eliminated. However, human activities such as agricultural practices, modification of stream channels, and construction of roads, highways, buildings, and reservoirs can drastically increase the rates of erosion and sedimentation to dangerous levels. Sedimentation in the Illinois River Valley has a long history. Even under natural conditions, there was a long period of sedimentation in the valley. The deltas and fans deposited by tributary streams are clearly identified along the Illinois River Valley.

The impacts of human activities in the Illinois River Basin are reflected by the conditions of the streams, rivers, and lakes in the basin. The tremendous development in agriculture, transportation, industry, and urbanization which has taken place in the basin has increased the rates of erosion and sedimentation significantly. Most of the lakes in the Illinois River Valley are so filled with sediment that it is difficult to refer to them as lakes any more.

As of 1985, Peoria Lake has lost two-thirds of its 1903 volume. The average depth of the lake at normal pool elevation (440 ft msl) has been reduced from 8 feet in 1903 to less than 3 feet in 1985, and thus most of the lake cannot be used for recreation such as swimming, boating, or fishing. The bottom sediment is so soft and soggy that it cannot provide proper habitat for fish and other aquatic organisms. Because the lake is very shallow and the bottom sediment is so soft, wave action causes resuspension of the sediment, leading to turbidity of the lake water.

The volume of Peoria Lake at different times is shown in Table 2 and Fig. 21. The corresponding average depths of the lake are given in Table 3 and Fig. 22. In 1903, the lake volume below 440 ft msl was calculated from the Woermann maps to be 120,000 acre-feet. For all practical purposes the 1903 volume can be assumed to be the original volume of the lake, even through the original volume of the lake would actually have been somewhat greater than the 1903 volume. Elevation 440 ft msl is used in calculating the lake volumes at different times because it provides a consistent reference point for all computations. It should be noted, however, that the low water lake level prior to 1939 was about 436.7 ft msl, which is 3.3 feet below the current mean pool level. The low water volume of Peoria Lake prior to 1939 was estimated to be 58,200 acre-feet based on the 1965 survey and assuming a uniform sedimentation rate from 1903 to 1965.

The completion of the Peoria Lock and Dam in December 1938 increased the low water lake capacity by 34,900 acre-feet. The increased lake capacity, combined with the reduction in the diversion of water into the Illinois River at that time, increased the trap efficiency of Peoria Lake. Trap efficiency is a factor used to determine how much of the sediment carried by a stream or river is retained by a lake or reservoir. The trap efficiency of Peoria Lake changed from 40 percent to 45 percent in 1939 because of the completion of the lock and dam and the reduction in Lake Michigan water diversion.

In 1965, the lake volume was 72,900 acre-feet. Thus in 62 years the lake had lost slightly less than half of its volume. By 1976 the lake volume was further reduced by 16,300 acre-feet to a total volume of 56,600 acre-feet. This is an average loss of 1400 acre-feet of lake volume per year. In the 11 years from 1965 through 1976, the lake lost 14 percent of its original volume or 22 percent of its 1965 volume due to sediment accumulation.

Table 2. Volume of Peoria Lake at Different Times at 440 feet msl

Year	Volume in acre-feet		
	Upper Peoria Lake	Lower Peoria Lake	Peoria Lake (Upper plus Lower)
1903	96,000	24,000	120,000
1965	55,200	17,700	72,900
1976	42,200	14,400	56,600
1985	26,500	11,800	38,300

Table 3. Average Depth of Peoria Lake at Different Times at 440 feet msl

Year	Average depth (feet)		
	Upper Peoria Lake	Lower Peoria Lake	Peoria Lake (Upper plus Lower)
1903	7.6	9.8	8.0
1965	4.4	7.2	4.8
1976	3.4	5.9	3.8
1985	2.0	5.3	2.6

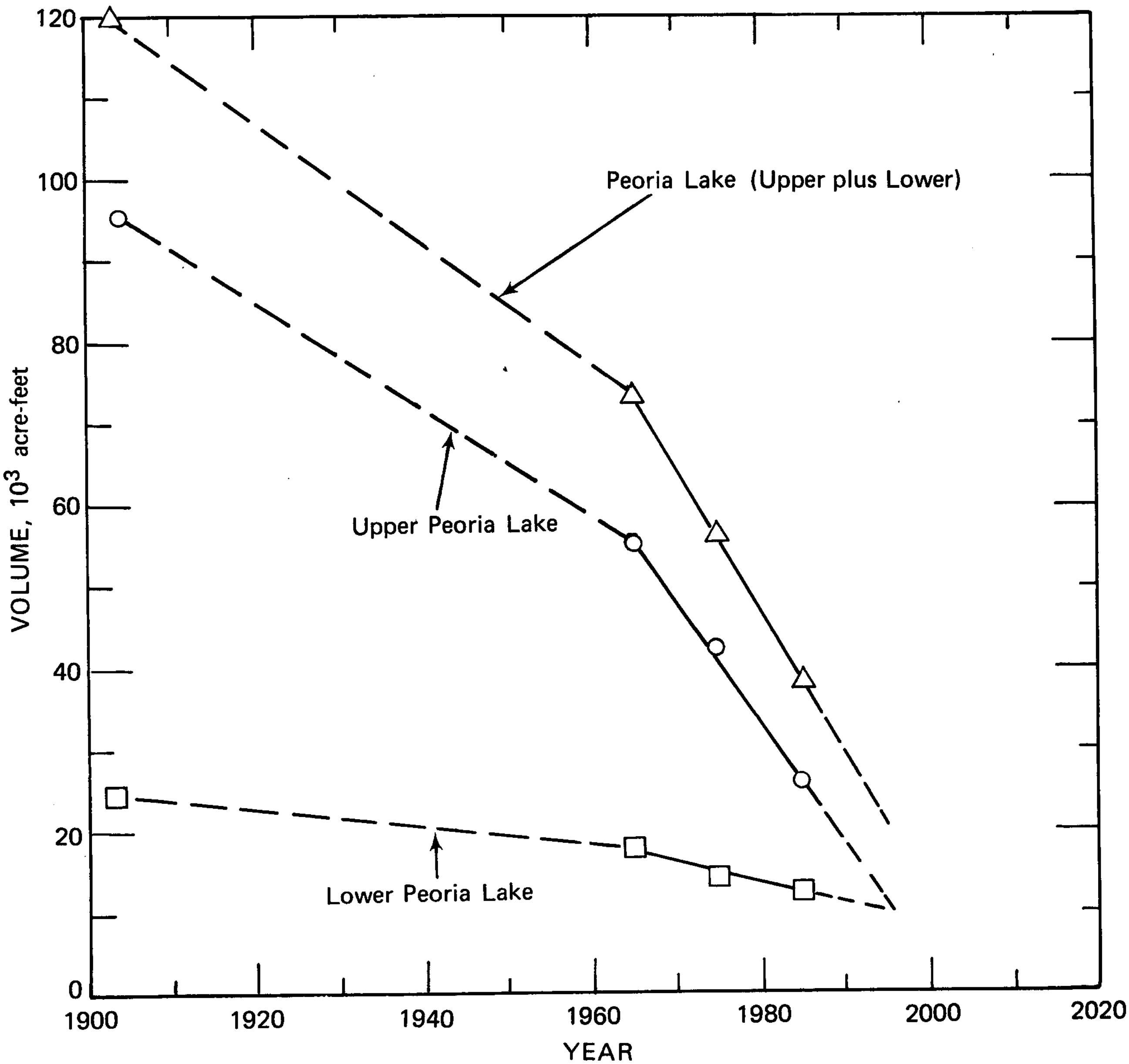

Fig. 21. Volume of Peoria Lake at different times

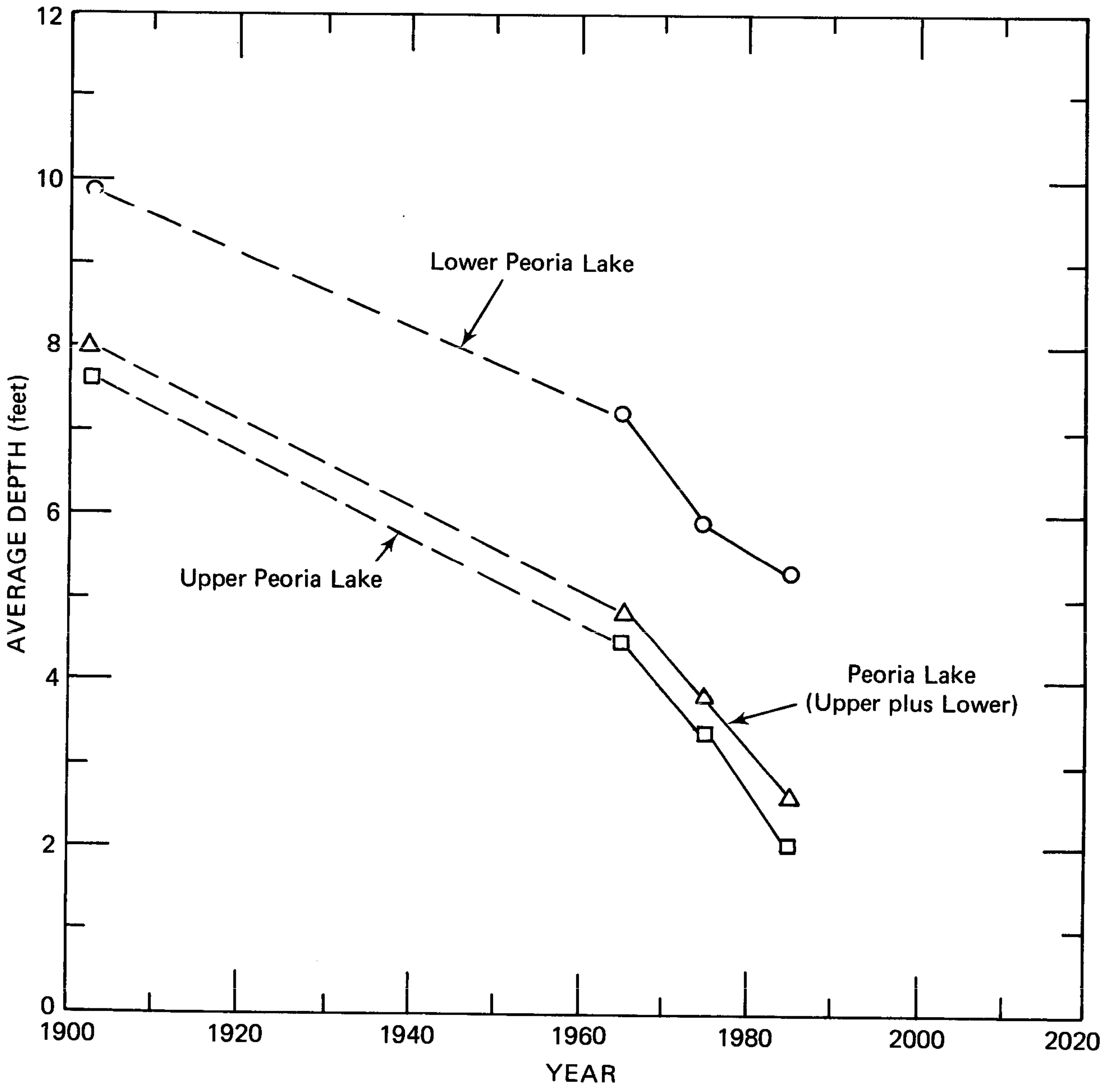

Fig. 22. Average depth of Peoria Lake at different times

In 1985 the lake volume is estimated to be only 38,300 acre-feet, which is about one-third of the 1903 volume. The lake volume lost in the last 9 years, from 1976 through 1985, is about 15 percent of the original volume, which is almost the same as that lost in the preceding 11 years. However, the loss amounts to 32 percent of the 1976 volume.

The annual rate of lake capacity loss due to sedimentation in Peoria Lake is compared with the rates for other major reservoirs in Illinois in Table 4. The capacity loss rate in Peoria Lake is shown for two different periods (1903-1965 and 1965-1985) because of the significant change in the sedimentation rate during the two periods. The capacity loss rate between 1903 and 1965 was 0.63 percent per year, which is within the range of capacity loss rates for the other reservoirs. The capacity loss rate from 1965 to the present, however, is 1.44 percent per year, which is more than twice the capacity loss rate from 1903 to 1965 and much greater than the capacity loss rates of the other reservoirs.

Sediment Distribution

The distribution of sediment in Peoria Lake is uneven in some respects and very uniform in other respects. For example, the sedimentation rate in Upper Peoria Lake is nearly 1-1/2 times that of Lower Peoria Lake. The upper lake has lost about 73 percent of its 1903 volume while the lower lake has lost 51 percent of its 1903 volume. The difference in volume loss between Upper and Lower Peoria Lake is shown in Fig. 21. The slope of the curves for the two segments of the lake indicates the difference in sedimentation rates. The steeper the slope, the higher the sedimentation rate. Further illustration of the difference in the sedimentation rates of the two segments is shown in Fig. 22, where the change in the average depth from 1903 to 1985

Table 4. Sedimentation Rates for Large Reservoirs in Illinois

Reservoir	Initial Volume (acre-feet)	Drainage Area (sq mi)	Sedimentation Period	Volume Loss (Percent/Year)
Keokuk Pool	479,600	119,000	1913-1979	0.83
Lake Carlyle	280,600	2,680	1967-1976	0.53
Lake Shelbyville	207,800	1,054	1969-1980	0.37
Rend Lake	184,700	488	1970-1980	0.41
Peoria Lake	120,000	14,165	1903-1965	0.63
Peoria Lake	120,000	14,165	1965-1985	1.44
Crab Orchard Lake	70,700	196	1940-1951	0.44
Lake Springfield	59,900	265	1934-1984	0.26
Lake Decatur	27,900	925	1921-1983	0.53

is shown. Upper Peoria Lake, with an average depth of 2 feet, is much shallower than Lower Peoria Lake, which has an average depth of 5.3 feet.

The 1903 and 1985 average lake bed elevations are compared in Fig. 23, where the difference between the two bed profiles represents the accumulation of sediment. The figure shows how the lake gets shallower in the upstream direction and also shows the relatively deep section of the lake around the narrows between Upper and Lower Peoria Lake.

The change in the depth of the lake is illustrated by comparing the lake bottom at different times at River Miles 164, 168, 175, and 179, as shown in Figs. 17-20. There are several observations which can be made from these figures. The first one is of course the dramatic decrease in depth over much of the lake. The second observation is the shrinking of the deeper portions of the lake. The navigation channel, which is maintained for navigation at a minimum depth of 9 feet and a minimum width of 300 feet, is the main part of the lake which has depth equal to or greater than 9 feet. Outside the navigation channel the lake is generally very shallow.

The reduction of the channel capacity is shown in Fig. 24 along with the changes in lake volume outside the channel and the changes in the total lake volume. The channel is defined here as that part of the lake which is 9 feet or deeper. As shown in the figure, the channel capacity is being reduced at a higher rate than the capacity of the lake outside the channel. The lake capacity is approaching a dynamic equilibrium, while the channel capacity does not show any reduction in rate of capacity loss. This implies that the channel will keep decreasing in capacity at the same rate as before for some time to come and that eventually dredging will have to be performed much more frequently than at the present time to keep the navigation channel open.

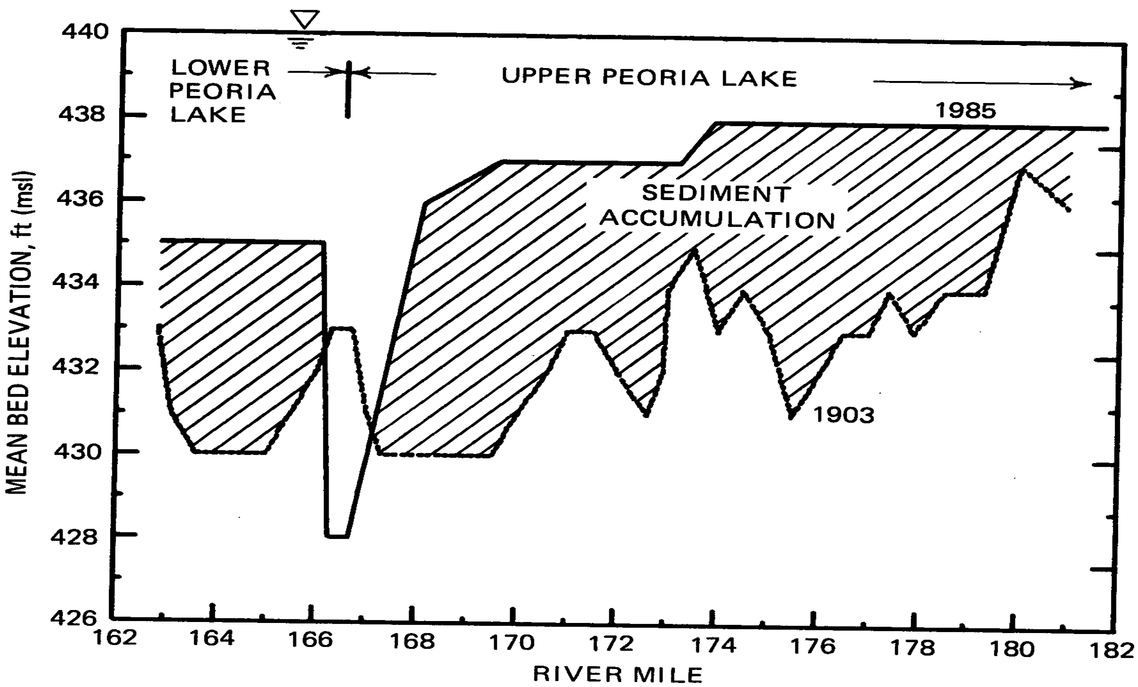

Fig. 23. Changes in average bed elevations along Peoria Lake from 1903 to 1985

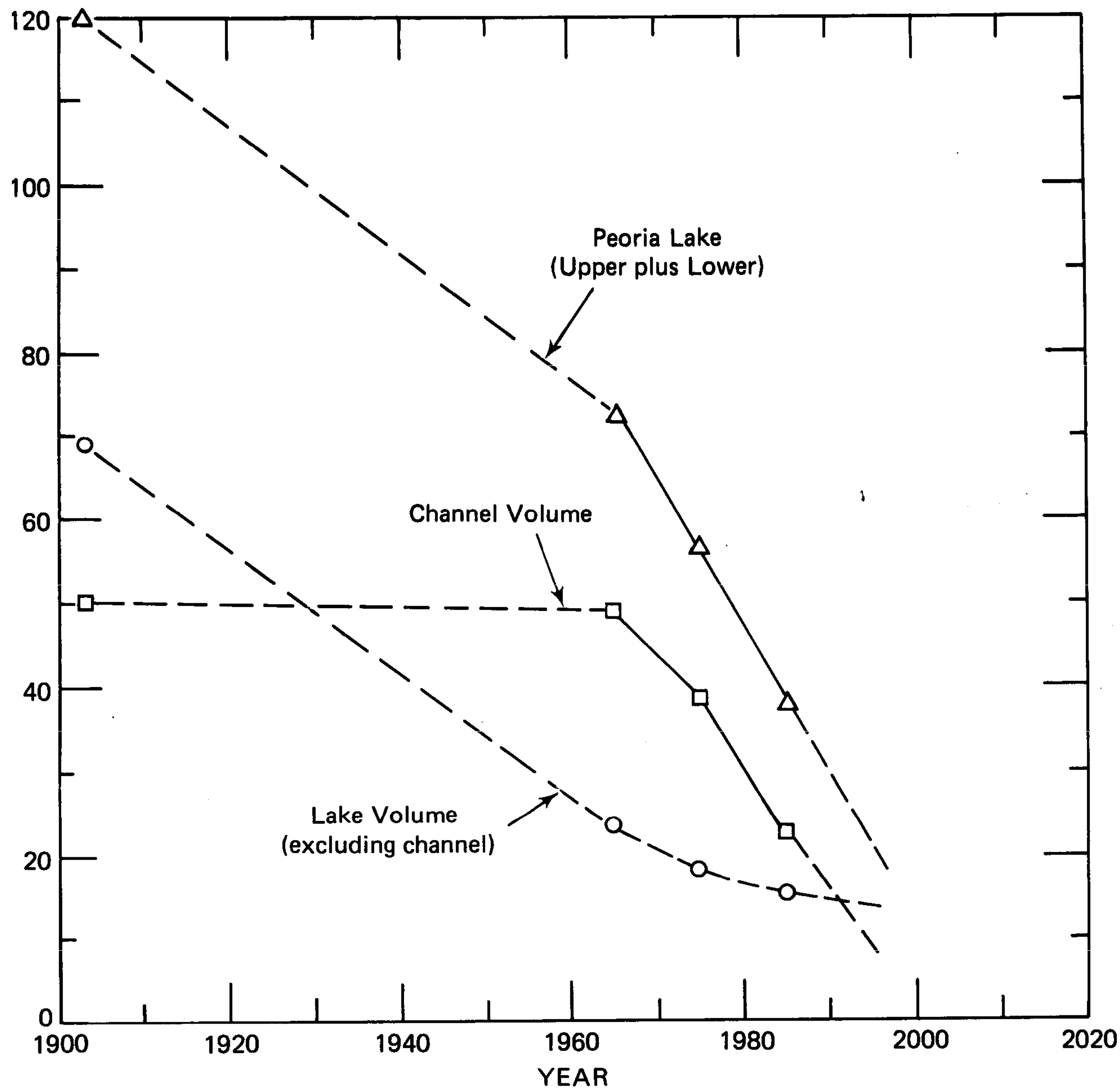

Fig. 24. Volume loss of Peoria Lake, channel, and lake outside channel

The shrinking of the channel and the loss of the deeper parts of the lake are further illustrated very clearly in Fig. 25, in which the 5-foot depth contours for 1903 and 1985 are compared. The 1903 contour shows that much of the lake was deeper than 5 feet, while the 1985 contour indicates a narrow channel that migrates from shore to shore in Upper Peoria Lake and stays closer to the western shore in Lower Peoria Lake. The narrow channel is all that is left of the original lake with a depth of 5 feet or more. If sedimentation continues at the same rate as before and no dredging is performed in the lake, the 1985 contour might be the indication of the future of Peoria Lake: a narrow stream channel in the middle of the lake with extensive mud flats and marsh areas on both sides of the channel. The dynamic equilibrium conditions expected for the Illinois River within the Peoria Lake segment of the Illinois River Valley will be totally different than its original shape, planform, and character.

Sediment Sources

The primary sources of sediment to Peoria Lake are:

1. The upper Illinois River watershed
2. The watersheds of tributary streams which drain directly into Peoria Lake
3. Shoreline erosion

The Illinois River watershed, shown in Fig. 26, contributes the largest amount of sediment to the lake. This watershed is the single largest watershed in Illinois and has a drainage area of 28,906 square miles. Except for about 4000 square miles of area in Indiana and Wisconsin, the watershed is located in Illinois. The total watershed located upstream of Peoria Lake is 14,165 square miles. The watershed contains the drainage basins of the

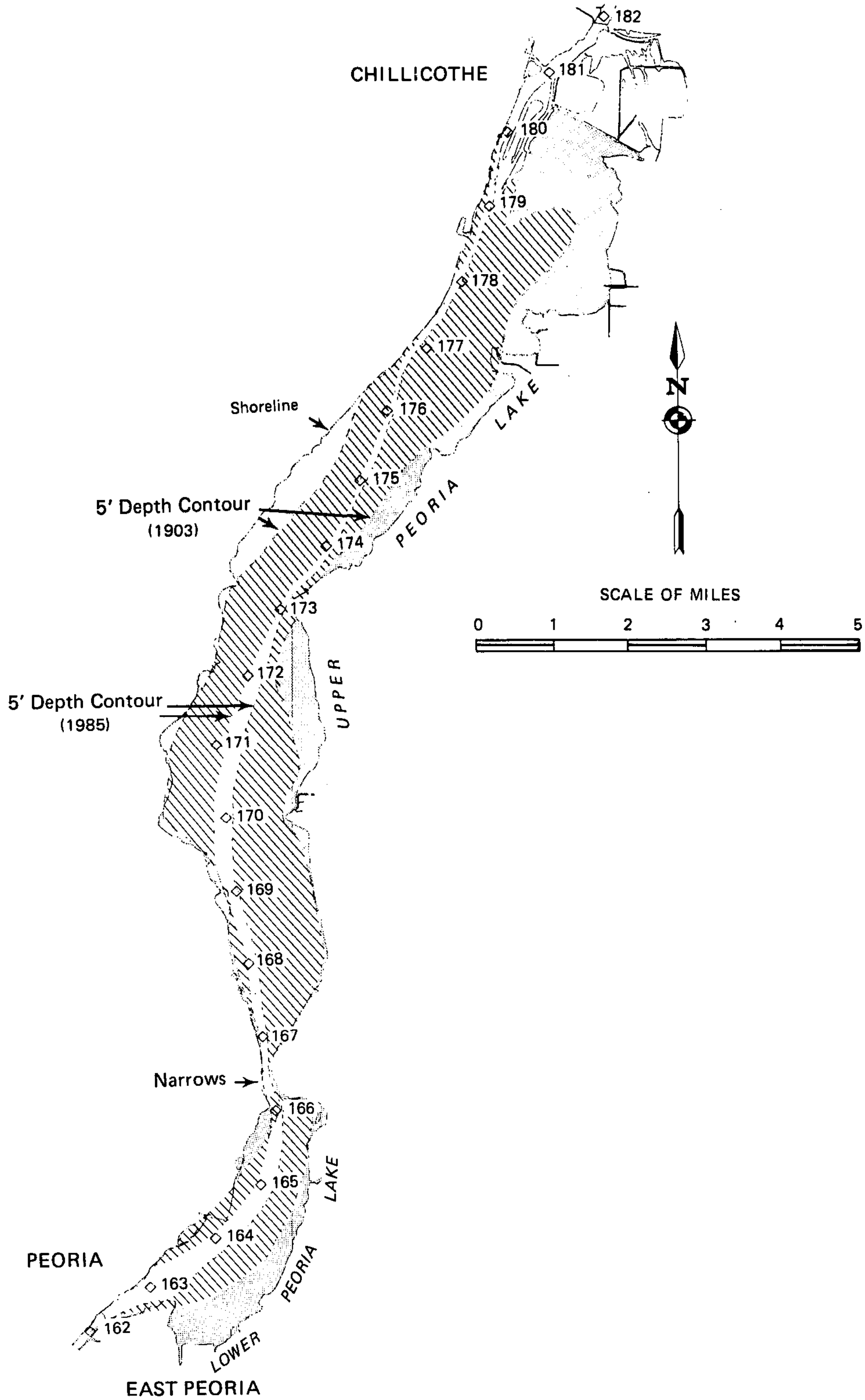

Fig. 25. Change from 1903 to 1985 in the amount of lake area with depth greater than 5 feet

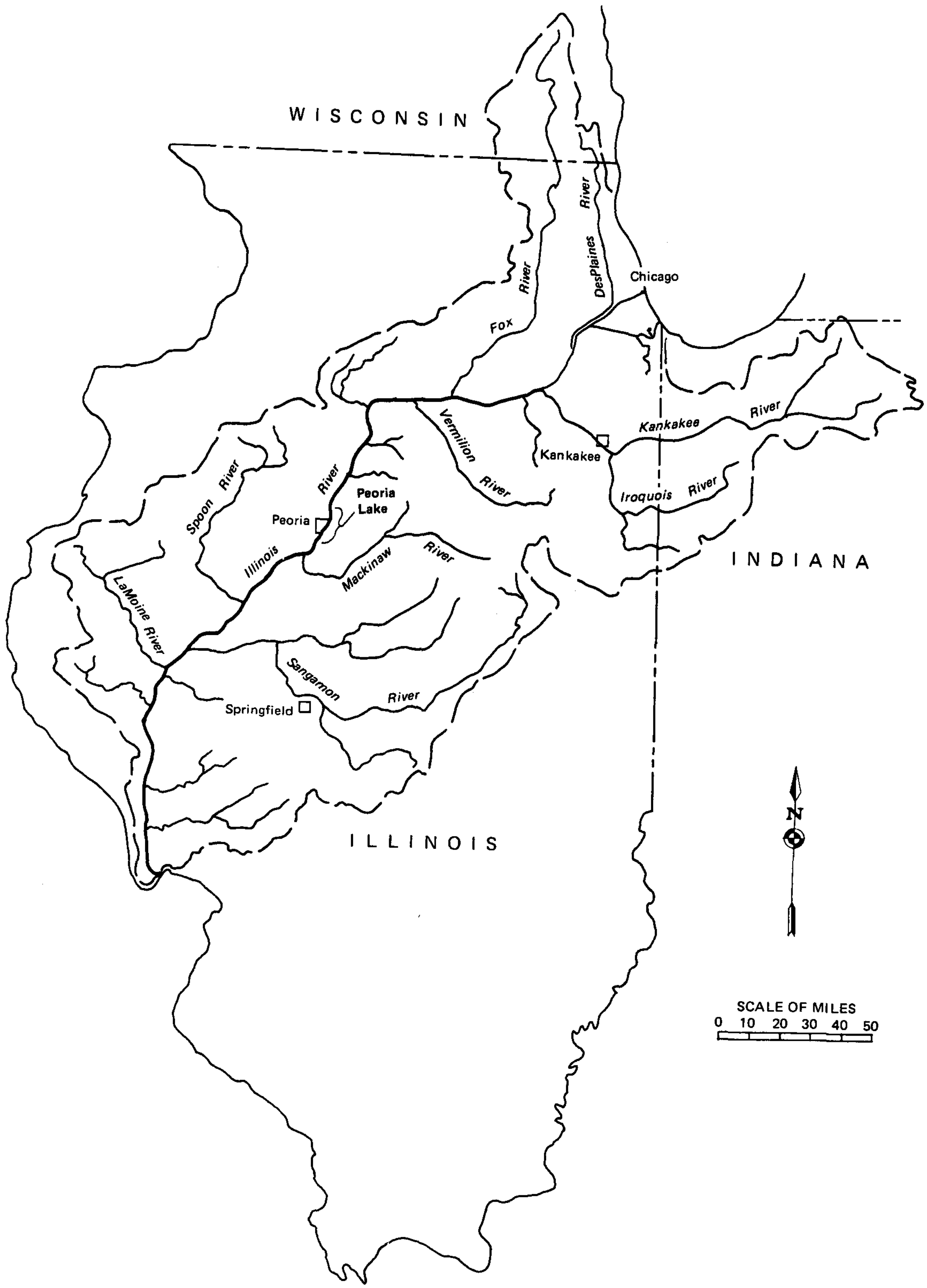

Fig. 26. Drainage map of the Illinois River

Vermilion, Kankakee, Fox, and Des Plaines Rivers in addition to many smaller tributary streams. All of the tributary streams contribute to the sediment load in the Illinois River. Since the Illinois River passes through Peoria Lake, a percentage of the sediment carried, by the river is trapped in the lake. The amount of sediment carried by the Illinois River varies from year to year depending on precipitation, runoff, land use, and other factors. There are no long-term data to assess the variation in sediment load of the Illinois River through time other than the changes in sedimentation rates in the bottomland lakes along the Illinois River Valley.

The other major sources of sediment to Peoria Lake are the small tributary streams which drain directly into the lake. The names of the streams and the sizes of their drainage areas are given in Table 5. All the streams enter Peoria Lake downstream of Chillicothe and upstream of Peoria. Most of the area in the watersheds of these streams is agricultural, with Some urban area primarily in the Farm Creek watershed where East Peoria is located.

Because of their steep slopes and close proximity to the lake, the tributary streams which drain directly into the lake contribute a significant amount of sediment to the lake. Factors which contribute to the sediment loads of these streams include watershed erosion, stream bank erosion, and gully erosion. Stream bank and gully erosion are significant along the bluff which surrounds the lake.

The contribution of tributary streams to the sedimentation problem is partially shown by the growth of deltas at the mouth of the streams. For example, Fig. 27 illustrates the growth of the Partridge Creek delta from 1939 to 1969. The surface area of the delta increased by 94 acres in 30 years and the total amount of sediment accumulated was estimated to be 900

Table 5. Tributary Streams which Drain Directly into Peoria Lake

Name of Stream	Drainage Area (sq mi)
Senachwine Creek	85.0
Crow Creek	78.7
Farm Creek	60.0
Richland Creek	47.0
Snag Creek	32.0
Partridge Creek	28.0
Tenmile Creek	17.6
Blue Creek	10.5
Dickison Run	7.9
Funks Run	5.4
Blalock Creek	2.8
Unnamed Tributaries	57.8

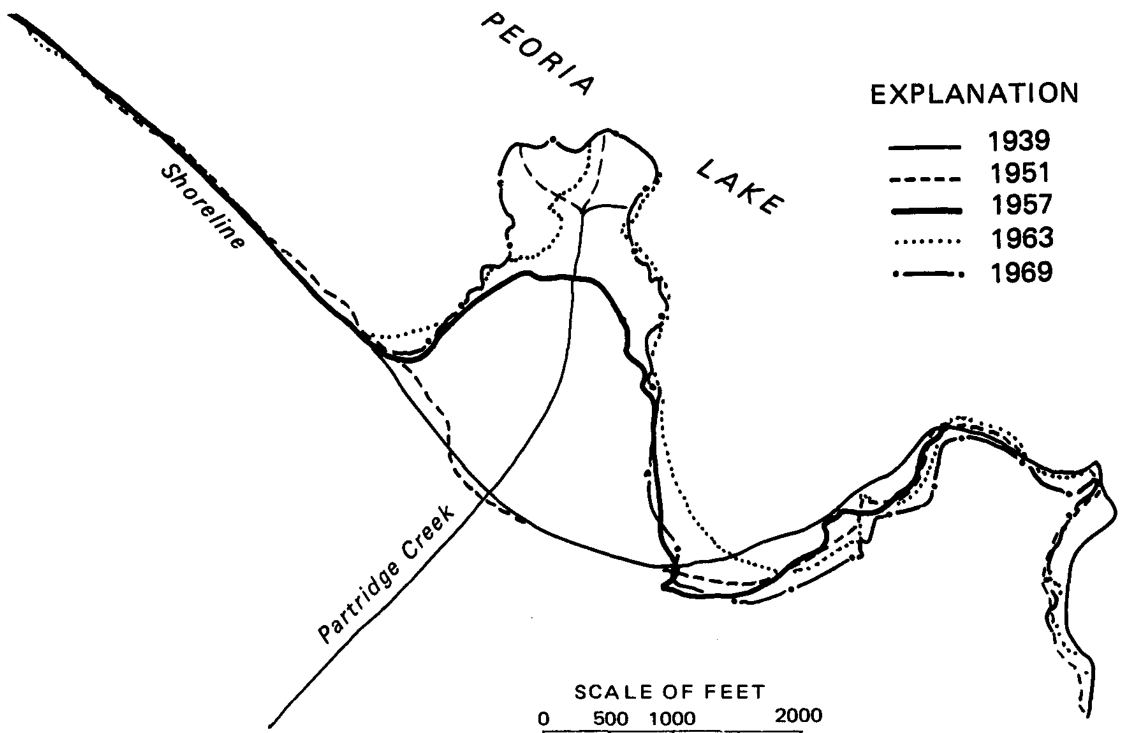

Fig. 27. Growth of Partridge Creek Delta from 1939 to 1969

acre-feet. It should also be noted that the sediment accumulating at the deltas is only a fraction of the total sediment input from the tributary streams since a large percentage of the sediment is carried further into the lake.

Peoria Lake has approximately 80 miles of shoreline and there is some localized erosion along the shoreline, which can be significant in some areas. In terms of being a sediment source to the lake, the contribution of shoreline erosion is estimated to be very small as compared to the contributions of the Illinois River and the tributary streams. Shoreline erosion is estimated to contribute no more than 2 to 3 percent of the total sediment input into the lake. However, this does not mean that shoreline erosion is not a problem. As a matter of fact it could be a major source of sediment for localized areas, but when the sediment input into the whole lake is considered, shoreline erosion is the least contributor of sediment to the lake.

Sediment Budget

From 1976 to 1985, Peoria Lake has accumulated 2033 acre-feet of sediment per year on the average. Assuming that the unit weight of the recent sediment is 45 pounds per cubic foot, the sedimentation rate is 2.0 million tons per year. On the basis of the analysis of the sedimentation rates since 1965, there is no indication that the sedimentation rate will change significantly in the coming years even though the trap efficiency of the lake will gradually decrease as the capacity of the lake is reduced due to sedimentation.

The relative contributions of the different sources of sediment are estimated as follows. The Illinois River annual sediment load is estimated to be 4.2 million tons based on the assumption that the sediment yield from the Illinois River watershed upstream of Peoria Lake is 300 tons per square mile. The sediment yield was estimated on the basis of sediment load measurement of the Illinois River at Valley City. The average sediment load of the Illinois River for three years (from 1981 to 1983) was calculated to be 283 tons per square mile. The sediment yield per unit area generally increases as the drainage area decreases. The drainage area of the Illinois River at Valley City is 26,564 square miles as compared to 14,165 square miles for the Illinois River upstream of Peoria. Thus a slightly higher sediment yield estimate of 300 tons per square mile is used for the Illinois River upstream of Peoria Lake.

The contribution of the Illinois River to the sediment in the lake is computed by determining the trap efficiency of the lake at different times. The trap efficiency of Peoria Lake was calculated from the historical lake level and flow records in the Illinois River. The results of the computations are shown in Table 6. The trap efficiency was calculated for four different periods from 1903 to 1985. The average lake levels for the different periods were utilized to compute the mean lake capacity of the lake for each period, and the mean inflow was calculated for the same period from flow records for the Illinois River at Marseilles, Kingston Mines, and Meredosia. The trap efficiencies were then determined from Brune’s curves using the capacity-inflow ratios. For the period from 1976 to 1985 the trap efficiency of Peoria Lake is estimated to be 28 percent. Therefore, on the average 28 percent of the Illinois River sediment load is trapped in the lake. This amounts to 1.2 million tons of sediment per year, which is about 60 percent of the mean annual sediment accumulation in the lake.

Table 6. Trap Efficiency of Peoria Lake during Different Periods from 1903 to 1985

Period	Mean lake level (ft, msl)	Average capacity (acre-ft)	Mean inflow (cfs)	C/I ratio	Trap efficiency percent)
1903-1939	441.0	121,800	19,300	0.0087	40
1939-1965	441.0	98,300	12,800	0.011	45
1965-1976	441.9	95,800	16,300	0.0081	39
1976-1985	440.9	61,800	16,000	0.0053	28

The contributions of sediment from the tributary streams listed in Table 5 were computed using the sediment yield equations from Adams et al. (1984). On the basis of the equation developed for Sediment Yield Area I, the total annual sediment yield from tributary streams is estimated to be 0.8 million tons, which is 40 percent of the mean annual sediment accumulation in the lake.

Sediment Quality

In general there has been improvement in the quality of sediment in Peoria Lake in recent years. The sediment layer accumulated since the late 1970s is generally of better quality than the sediment layers deposited in the 1950s or 1960s. This is illustrated in Fig. 28, in which the concentrations of zinc and lead in the sediment are plotted against the depth of sediment. The period of sedimentation, based on the assumption of a uniform rate of sedimentation, is also indicated in Fig. 28. The peak concentration for lead was in the late 1960s, while that for zinc was in the early 1950s. The concentrations of the two heavy metals have been decreasing since those periods. Since the mid-1970s there has been a significant decrease in the concentrations of zinc and lead in the sediment.

In general the concentrations of many chemical elements have been decreasing since the 1950s. Table 7 summarizes the general chemical characteristics of Peoria Lake sediments for three time periods. The 1976-1985 period represents the most recent sediment layer, while the 1903-1939 period represents the old sediment layer. The 1953-1965 period represents the middle sediment layer, which has the worst chemical contamination. The older sediment is much cleaner than the sediment

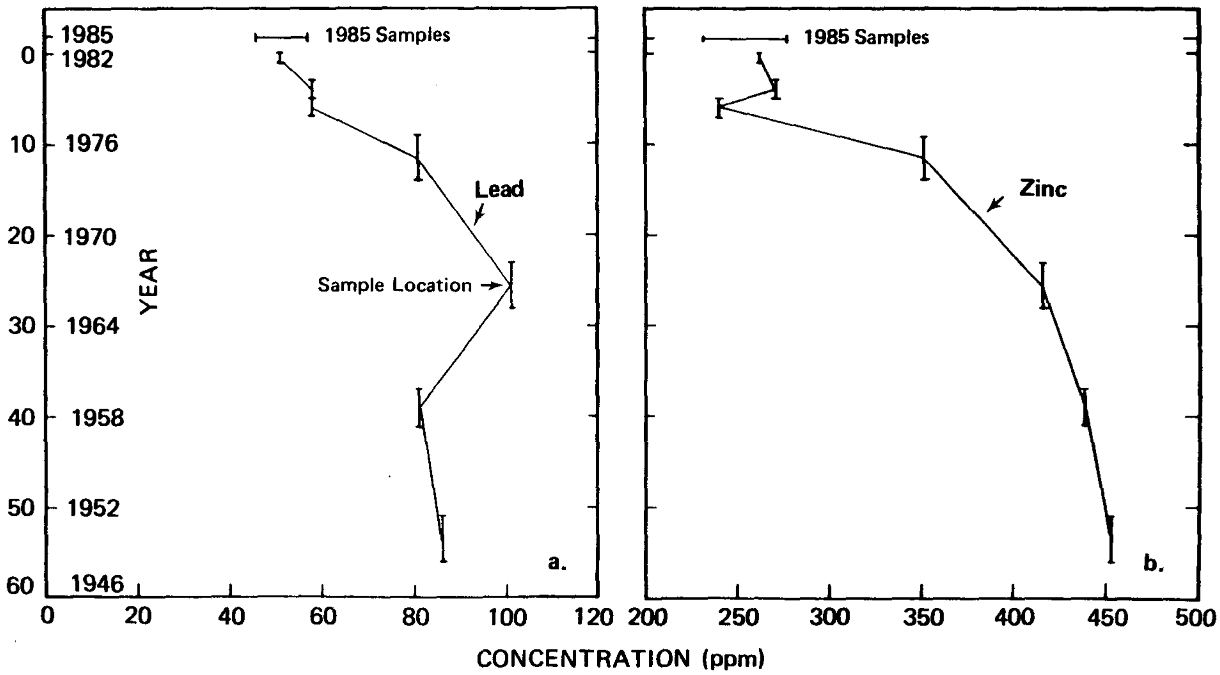

Fig. 28. Change in the concentrations of lead and zinc with depth in Peoria Lake sediment

Table 7. Summary of Chemical Characteristics of Peoria Lake Sediment

Period	As (ppm)	Cd (ppm)	Cr (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	P205 (percent)
1976-1985	11.2	2.2	134	66	57	258	.34
1953-1965	14.6	7.3	182	78	89	436	.57
1903-1939	6.4	<0.9	105	25	10	99	.20

deposited in the later periods. The most recent sediment is, however, much cleaner than the sediment deposited from 1953 to 1965.

The improvement in sediment quality is a direct result of stricter environmental regulations which have limited the discharge of untreated domestic and industrial wastes into the Illinois River and its tributaries.

ALTERNATIVE SOLUTIONS FOR PEORIA LAKE SEDIMENTATION PROBLEMS

Sedimentation in Peoria Lake is not a new problem. In fact, it has existed since the creation of the lake. However, the sedimentation problem has been significantly accelerated by a number of human-induced changes in the Illinois River and its watershed. Even though a small segment of conservationists and residents in the area recognized the problems of sedimentation in Peoria Lake very early, the problem was ignored until recently. If sedimentation in Peoria Lake continues at the present rate, it is estimated that in 10 to 15 years the river and the lake will reach dynamic equilibrium and the net accumulation of sediment in the lake will be zero. There will be sediment accumulation in some areas, especially the channel and the delta of tributary streams, but an equal amount of sediment will be transported out of the lake from other areas within the lake.

With the conditions allowed to reach the level they have, any of the solutions to regenerate Peoria Lake will cost a significant amount of money and will take a long time to fully implement. All possible alternative solutions to the sedimentation problem in Peoria Lake will be discussed briefly in the following pages. Because of the limited scope of the project, the cost of each alternative has not been analyzed. Thus some of the alternatives may be financially infeasible, but they are included in this report so their technical feasibility may be evaluated. The alternative solutions are grouped into the following four main categories:

I. Control Sediment Input

II. Manage In-Lake Sediment

III. Hydraulically Manipulate the Illinois River through Peoria Lake

IV. Do Nothing -- Let the River Establish Its Own Dynamic Equilibrium

I. Control Sediment Input

The alternative solutions in the sediment input control category are those solutions which are intended to reduce the input of sediment from different sources. It should be mentioned that these alternative solutions do not deal with the existing sediment in the lake. However, they should be incorporated along with the best in-lake sediment control measures for a meaningful long-term solution of the sedimentation problem in Peoria Lake. This group includes the following specific solutions:

I.a. Control sediment input from tributary streams which drain directly to the lake by implementing some or all of the following programs deemed necessary

1. Implement Best Management Practices in the watersheds to reduce soil erosion.
2. Implement appropriate measures to reduce stream bank erosion and gully formation in the watersheds.
3. Build sedimentation basins on the tributary streams to trap sediment before it reaches the lake.
4. Increase the dredging of sand and gravel at tributary stream channels.
5. Re-divert Farm Creek from its present course to its original course to stop sediment input from Farm Creek to Lower Peoria Lake.

I.b. Implement Best Management Practices (BMPs) on the Illinois River watershed to reduce erosion

This alternative solution should be viewed as part of the long-term solution to the sedimentation problem in the Illinois River Valley lakes. Because of the size of the area (14,165-sq-mi watershed upstream of Peoria) and the problems with land management, it is doubtful that this alternative will have any significant impact on the sedimentation problem in Peoria Lake in the immediate future. However, without any progress in the control of soil erosion in the Illinois River watershed, the sedimentation problem will not be reduced to an acceptable level.

Priorities for implementation of Best Management Practices have to be set on the basis of the best available data on soil erosion, land use, physiography, proximity to the lake, and other factors. The highest priority should be assigned to the marginal lands with steep slopes, construction sites, and excessive stream bank erosion areas. These are the areas where the best results in reducing soil erosion could be attained for the least amount of effort and money. Fur thermore, it should be realized that reducing soil erosion in the areas with close proximity to the lake will result in the greatest reduction of sediment delivery to the lake.

It should be pointed out that excessive soil erosion is not unique to the Illinois River watershed. It is a global problem which everybody should be concerned about. Any meaningful program to control soil erosion will have to include the participation of local property owners and local, state, and federal governments and agencies. Certain government programs could be used effectively to reduce the erosion problem nationwide.

I.c. Implement shoreline protection program for Peoria Lake

The shoreline of Peoria Lake, which is approximately 80 miles long, is subject to erosion due to waves generated by wind and river traffic. The amount of shoreline erosion in Peoria Lake is not very well documented; however, it could be one of the sources of sediment in the lake. Reducing the amount of shoreline erosion will help in the overall reduction of sediment input into the lake. However, shoreline erosion control by itself will not solve the sedimentation problem in Peoria Lake.

I.d. Establish marshy areas to prevent bank erosion and resuspension of bottom sediment

This alternative will establish marshy areas (wetlands) by planting the proper vegetation along the shoreline of the lake to prevent bank erosion and resuspension of bottom sediment. In addition to controlling bank erosion, the marshy areas will provide improved aquatic and wetland habitats and might improve the quality of water in the lake. This alternative will not significantly reduce the sediment input into the lake, but it will provide a means of reducing the negative impacts of the sediment already in the lake. This alternative should be incorporated into a comprehensive sediment management plan for the lake. Selected areas of the lake could be designated as marshy areas and if managed properly could promote an increased diversity and abundance of aquatic life.

I.e. Construct a dam upstream of Peoria Lake

This alternative will reduce the amount of sediment coming into the lake by trapping much of the sediment from the Illinois River. However, the lake created by this dam will experience excessive sedimentation and might require dredging regularly to function as an effective sediment trap. Furthermore, the people around the upper reaches of Peoria Pool might not allow the construction of such a dam.

Overall, this alternative is not very attractive since it simply transports the problem to another part of the river.

I.f. Provide upstream storage for high flows

This alternative will reduce the amount of sediment coming into the lake by trapping some of the sediment carried by the Illinois River during high flows. A high percentage of the annual sediment load of a stream or river is transported during flood events which occur in relatively short periods of time out of the year. By trapping the sediment during flood events upstream of the lake, the annual sediment accumulation in the lake will be reduced. This alternative is better than alternative I.e because the flood storage does not have to be on the river. Also, this alternative will have the added benefit of reducing flood levels in the Peoria area.

The amount of upstream storage needed to effectively reduce the sediment input to Peoria Lake is not known. It is also not known if there are appropriate locations for construction of the needed upstream storage. A significant amount of land would be required, and relocation and construction costs would be high.

II. Manage In-Lake Sediment

The alternative solutions grouped under in-lake sediment control generally involve some form of dredging. Since most of the lake is essentially filled up with sediment, the only way to gain additional lake capacity is either to dredge the sediment out of some areas of the lake or to raise the elevation of the dam. Raising the dam will be discussed later. The dredging options are presented in this section.

It should be pointed out that before any of the dredging alternatives can be implemented, the standard environmental impact evaluations have to be performed to satisfy federal and state regulations. The environmental impact studies will include evaluation of the impacts of dredging and dredge disposal on water quality, aquatic organisms and habitats, and any beneficial uses of the lake and the river. They will identify the specific areas that will be dredged, the amount of dredge material, the dredging and disposal techniques, and specific dredge disposal sites. The environmental impact studies will identify and quantify the long-term and short-term impacts of the whole dredging operation. If conventional dredging and disposal practices do not meet federal and state regulations, special procedures will be established to reduce the negative impacts of the dredging operation.

II.a. Dredge selected areas of the lake

The total amount of sediment in Peoria Lake is estimated to be 89 million tons. The volume of sediment is approximately 81,000 acre-feet. This means that if the sediment in Peoria Lake is spread over 81,000 acres of land, the depth of sediment will be 1 foot. If it is piled over an acre of land, it will rise 81,000 feet (or 15 miles) into the sky. Since it would no doubt be impossible to find a proper place outside the lake to put all this sediment if the whole lake were dredged, the most reasonable option is to dredge the lake in selected areas. The choice of the areas to be dredged will depend on several factors. The first criterion is of course the relative importance of the area for recreation, fishing, and other beneficial uses.

The second criterion is the expected sedimentation rate after dredging. Some areas of the lake will fill up quickly with sediment while some could remain deep for longer periods of time. The rate of sedimentation for different areas depends on their locations within the lake and the flow conditions at the sites. For example, much of the area in Lower Peoria Lake will have a better chance of staying deep than most of the upper lake once it is dredged. However, if the area around the mouth of Farm Creek in Lower Peoria Lake were to be dredged, it could fill up with sediment quickly.

The third criterion is the availability of sites for dredge disposal. Since one of the major problems with dredging is the lack of suitable places to dispose of the sediment, this criterion is important in selecting areas to be dredged.

II.b. Lower the lake level to compact sediment by drying

This alternative involves lowering the lake level below the lake bottom to dry the sediment. When the sediment is dried it becomes compacted and loses some of its volume. Theoretically, it is possible to reduce the volume of saturated lake sediment by half through the processes of drying and compaction. However, there are no reliable data which will guarantee such a reduction in volume of sediment under field conditions. Since much of the sediment in Peoria Lake consists of clay and silt, it is possible for the dry sediment to expand in volume when it is again submerged under water. Thus it is not clear how much of Peoria Lake's volume could be reclaimed by drying the sediment. Furthermore, the time required to dry much of the sediment will be greater than one year, which will be impossible to attain because of the annual flooding cycle in the Illinois River. During the flooding season, when the dam has no effect on the level of water in the lake, the whole lake is under several feet of water, which will saturate the sediment with water every year.

It is therefore almost impossible to dry and compact much of the sediment in Peoria Lake. Even if it were possible to lower the lake and dry the sediment, the impacts on navigation, recreation, and aquatic life of lowering the lake level for the extended time required for drying must be assessed very thoroughly. Overall lowering of the lake level to compact the sediment by drying does not seem to be a promising alternative for Peoria Lake.

II.c. Lower the lake level for dry dredging

This alternative will involve lowering the lake level below the lake bottom to dry the sediment, and then dredging the dry sediment. As was pointed out before, it will be almost impossible to dredge the whole lake. Thus even this alternative involves only selected dredging. The choice between dry or wet dredging depends primarily on the cost of dredging. At this time it will be difficult to select either type of dredging because the extent and location of dredging are not well defined and thus no cost analysis can be performed. This alternative would have significant impacts on navigation, recreation, and aquatic life because of the lowering of the lake level for an extended period of time (time required for drying and dredging).

II.d. Dike part of the lake for dry dredging

This alternative involves building dikes in the lake to isolate selected areas for dry dredging. The dikes will prevent river water from entering into the dredge site during the periods of drying and dredging. They will also help contain any negative impacts that might be associated with the dredging operation within the dredging site.

In general, this alternative is one of the possible ways to perform dredging in Peoria Lake. However, further analysis is needed regarding the feasibility of building dikes within the lake to withstand the annual floods in the Illinois River, as well as the costs associated with such an operation.

II.e. Create artificial islands in the lake to form braided side channels, increase flow velocities, and reduce wave action

This alternative goes along with any of the dredging alternatives discussed earlier. This is a creative technique for locating dredge disposal sites while at the same time providing long-term solutions and improved aquatic environment. The implicit assumption on which this alternative is based is that the lake is too large for the flow conditions in the river. By reducing the flow area, greater velocities are generated in the different channels and side channels between the islands, preventing the channels from filling up with sediment. The channels will be relatively deep and can be utilized for recreation and fishing.

The islands will also serve as windbreaks and thus will reduce the generation of waves by wind. This will prevent the resuspension of bottom sediments by wind waves and will result in less turbid water in most areas. The less turbid the water, the better the water quality, resulting in improved aquatic habitats for fish and other organisms.

There are several engineering and environmental issues which need to be investigated before this alternative can be implemented. The engineering issues include the location, size, and building material selected for the islands. The islands have to be designed to minimize sedimentation and provide windbreak action for a large area of the lake. Thus a detailed hydraulic study will be required to determine the optimum sizes and locations of the islands. Even though the sediment in the lake could provide the bulk of the material needed to build the islands, additional material from outside of the lake might be needed to stabilize the islands. Proper vegetation selection and planting will also be required to help stabilize the islands and provide enhanced aquatic and riparian environment. The environmental issues are related primarily to the dredging operation that will be performed during the building of the islands. A full environmental impact study will definitely be required before and during the implementation of this alternative.

II.f. Experiment with thalweg disposal of dredged sediment

This alternative is a means of disposing of dredged sediment. It involves placing dredged sediment in the deepest part of the main channel so it can be transported downstream by the higher currents present in the channel. This has been found to work effectively in sand bed channels but has not been tried for silt and clay materials. If it is found to work effectively it might provide one of the cheapest means of disposing of dredged materials.

One of the major questions that needs to be answered regarding this technique concerns the final fate of the disposed material. Where does the dredged material end up? Is it flushed out of the system during periods of high flow or is it just spread out further downstream within the lake?

III. Hydraulically Manipulate the Illinois River through Peoria Lake

The alternative solutions under this category involve changing the flow conditions of the Illinois River through Peoria Lake to achieve an increase in lake volume and depth. Some of them are short-term solutions while others could be incorporated into a comprehensive long-term solution scheme.

III.a. Raise the Peoria Dam

This is an alternative which will provide additional lake volume and depth temporarily. How much the lake level can be raised will be determined by surveying the lakeshore properties and the impact that a higher low-flow lake level will have on those properties. Raising the dam during low flows will not affect the flood elevations during the flooding season.

The pool elevation cannot be raised more than 12 to 18 inches by using the present lock and dam because of the nature of the dam, which is a navigable wicket dam. The dam is lowered to the channel floor during high flows and raised during low flows. The support system for the wickets is at fixed locations, which makes it impossible to raise the pool elevation significantly without major modifications. If the pool elevations were raised by 3 to 4 feet, a new lock and dam might be required.

However, it should be recognized that this is a temporary solution. If the lake volume is increased, the trap efficiency of the lake will increase from the present condition and sediment accumulation in the lake will increase accordingly depending on how much the dam is raised.

III.b. Build in-lake dike (levee) to confine Illinois River flow

This alternative will route the Illinois River flow through a confined channel past Peoria Lake. A dike will be built to separate the river from the lake so that the sediment carried by the Illinois River will bypass the lake. During extreme high flows, the part of the lake isolated from the river could be operated as a floodway to reduce flood stages.

This alternative might reduce future sedimentation, but will not address the present problem unless most of the material for building the dike is dredged from the lake. Furthermore, isolating most of the lake from the Illinois River might create water quality problems in the lake because of stagnation and possible eutrophication. Access channels from the river to the lake would need to be constructed and maintained.

III.c. Redirect the main flow of the Illinois River to the shallow parts of the lake

Redirected main flow will have some scouring action on the fine deposited sediment within the lake, resulting in increased depth along the areas where the main flow is redirected. The scouring action of the main flow of the Illinois River in Peoria Lake can be observed from the cross-sectional profiles (see Figs. 17-20), which show that the depth in the main channel is much greater than in the channel border areas. If the main flow is redirected repeatedly at various locations, it will be possible to increase the depth of water over large areas. However, some of the sediment scoured by the river might settle out at other places in the lake, and thus there might not be much gain in the total lake capacity. Also, this alternative might be impractical to implement.

III.d. Relocate sailing line periodically

This alternative is similar to the previous one but will have the added factors of making use of barge traffic and maintenance dredging. Barge traffic will resuspend the fine sediment and move it either laterally or downstream. Areas of deep water will be increased as old sailing channels are abandoned and new ones added. Some of the sediment removed from the newer sailing channels will settle out in the other parts of the lake and some of it will move downstream out of the lake. How effectively and by how much the lake depth could be increased is very difficult to estimate at this time.

III.e. Widen and deepen the Narrows

This alternative might help reduce the sedimentation rates in Upper Peoria Lake by reducing the backwater effect of the Narrows and by increasing the flow out of Upper Peoria Lake. However, this most probably would result in increased sedimentation in Lower Peoria Lake and therefore is not a very good alternative.

III.f. Build a check dam at the Narrows

This alternative involves building a check dam at the Narrows to impound more water in Upper Peoria Lake. Sediment from Upper Peoria Lake could be flushed out by lowering the check dam occasionally. This could accomplish two purposes: it might reduce the sedimentation rate in Lower Peoria Lake by generating higher velocities during the flushing period of Upper Peoria Lake, and it might provide a mechanism to flush some of the sediment out of Upper Peoria Lake.

The major problem with this alternative is the navigation requirements. Either a lock has to be built at the Narrows for continuous navigation, or navigation has to be suspended during the flushing operation.

IV. Do Nothing -- Let the River Establish Its Own Dynamic Equilibrium

To choose this alternative is to accept that the life of Peoria Lake is over or will be over very soon. As shown in Fig. 25, at dynamic equilibrium the Illinois River will consist of a relatively narrow channel meandering through the lake. Much of the area outside the channel will be either a mud flat or a marshy wetland area depending on the ability of vegetation to grow over the lake sediment. During the flood season, however, most of this area and beyond will be inundated by water.

RECOMMENDATIONS

The solution to the sedimentation problem in Peoria Lake has to include two major components: 1) in-lake sediment control, and 2) sediment input control. Applying just one of these types of measures to the present conditions will not solve the problem. Most of the lake has essentially filled up with sediment. Thus if we apply only sediment input control measures, which will take a long time to result in any significant impacts, neither the volume nor the depth of Peoria Lake will increase. On the other hand, if we dredge the whole lake to 1903 conditions or raise the dam but do not implement any sediment input control measures, it will be just a matter of time before the lake again fills up with sediment. Therefore, a sound and beneficial management plan to solve the sedimentation problem in Peoria Lake must include either removing some of the sediment in the lake or raising the dam, along with implementation of sediment input control measures to reduce the sedimentation rate.

In-Lake Sediment Control

The first major component of a comprehensive plan is the management of the sediment in the lake. Raising the Peoria Dam might be considered as a partial and temporary alternative to dredging. How much higher the dam can be raised without affecting property on the shore during low flow periods needs to be investigated further. Raising of the dam during low flows will not increase flood heights during the flood season if the dam is operated properly. It should be stressed, however, that raising the dam is a temporary solution. As a matter of fact, it could increase the sedimentation rate temporarily by increasing the trap efficiency of the lake; and the additional volume gained by raising the dam could be lost in a relatively short period of time if sediment input is not controlled.

Selective dredging is one of the best alternatives and should be incorporated in a comprehensive sediment management plan for the lake. The best location for selective dredging is Lower Peoria Lake. This is primarily because the sedimentation rate in Lower Peoria Lake is lower than that in Upper Peoria Lake. Any dredged area in Lower Peoria Lake will have a longer life expectancy than an area in the upper lake. The approximate area in Lower Peoria Lake that needs dredging, as determined by the 1985 bathymetric survey, is shown in Fig. 29.

The area that needs dredging is identified as that part of the lake that had a depth of 5 feet or more in 1903 and that presently is less than 5 feet deep. It is not necessary to dredge the whole area shown in Fig. 29 nor to dredge it to 1903 conditions. Further analyses including determinations of dredging locations, depth requirements for recreation, and costs of dredging are needed before deciding which areas and to what depth to dredge.

Since only three bed profile surveys were taken in Lower Peoria Lake in 1985, it is difficult to be much more specific about the dredge area. However, areas in Lower Peoria Lake which could have sedimentation problems after dredging include the Detweiller Marina area, the Farm Creek mouth area, and the area just downstream of the Narrows (Fig. 30). The Farm Creek mouth area is not a very good site to dredge because it could be filled up with sand from Farm Creek very quickly. The Detweiller Marina area and the area just downstream of the Narrows are located in dead zones, where the currents are not expected to be high enough to keep the sediment moving downstream. There might even be eddies around those areas which would tend to increase the sedimentation rates.

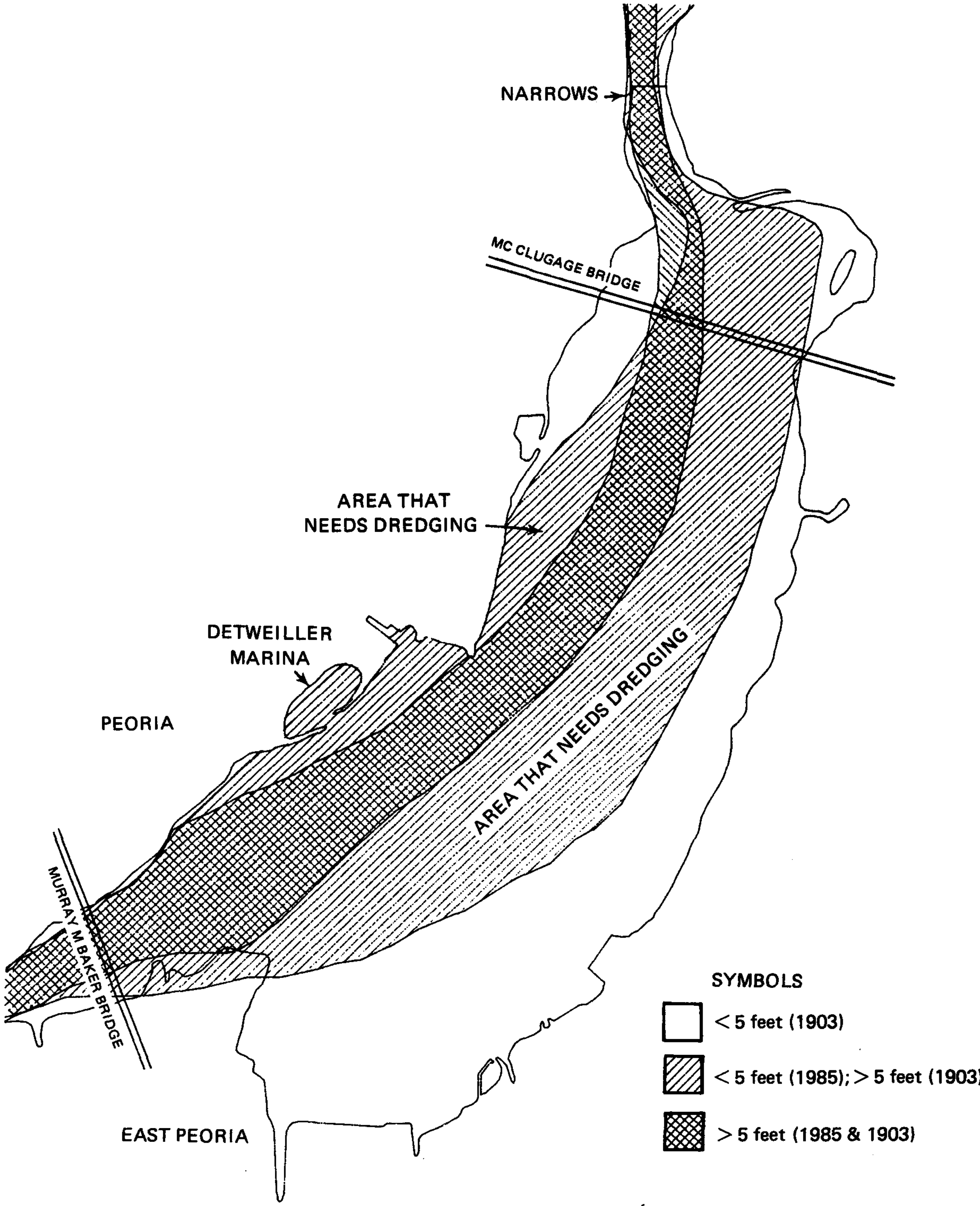

Fig. 29. Areas in Lower Peoria Lake that need dredging (areas with depths greater than 5 feet in 1903 and less than 5 feet in 1985)

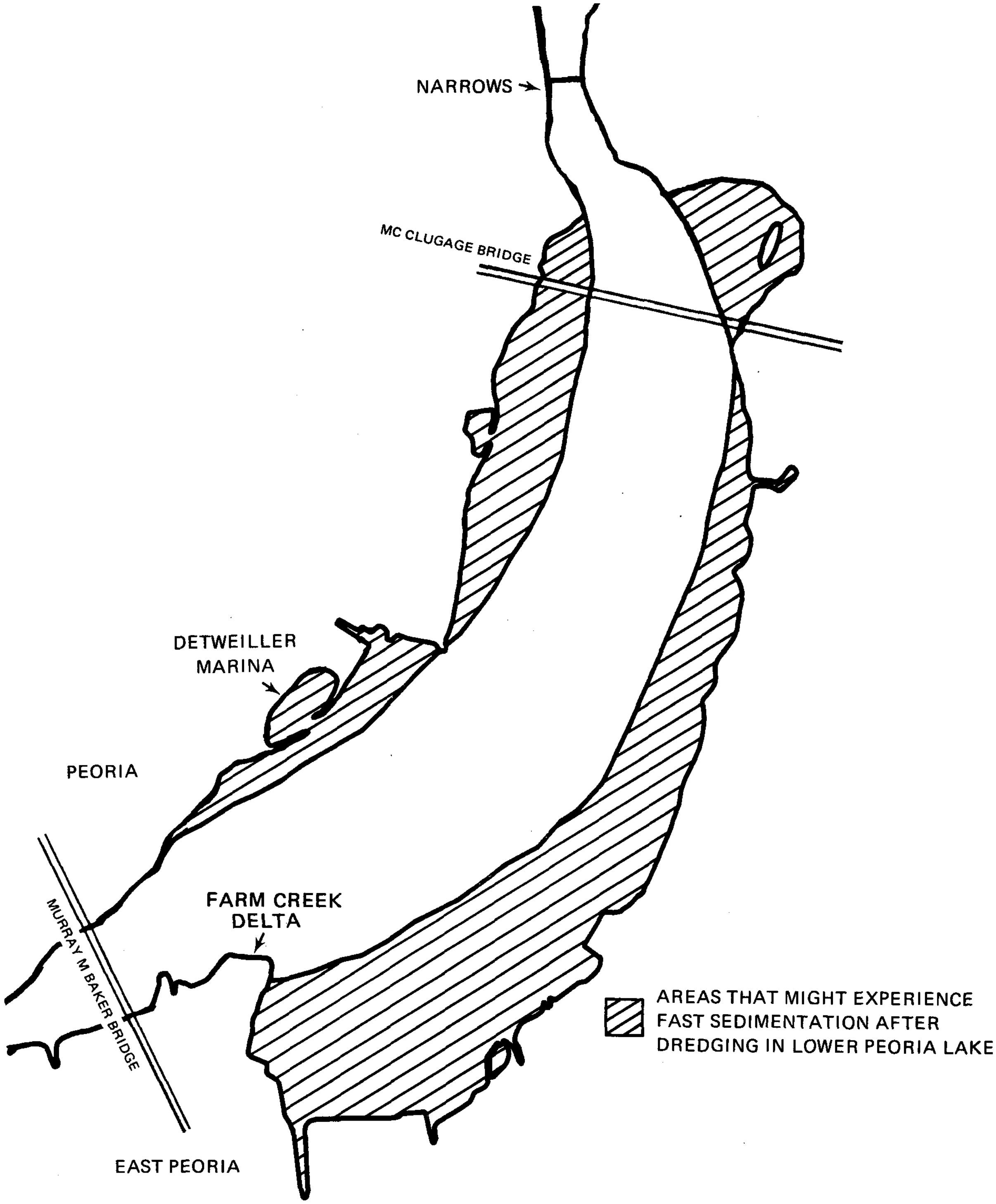

Fig. 30. Areas in Lower Peoria Lake that might experience sedimentation problems after dredging

On the basis of the past sedimentation rates in Lower Peoria Lake, if the lake is dredged to its 1903 capacity of 24,000 acre-feet and the sediment input to the lake remains as before, it is estimated that in 40 years it will fill back to its present capacity of approximately 12,000 acre-feet. The total amount of sediment that needs to be dredged in Lower Peoria Lake to bring it back to its 1903 capacity is estimated to be 13 million tons. However, as previously mentioned, the lake need not be dredged to 1903 conditions.

Dredge disposal sites were not throughly investigated in this project. However, the best disposal sites for Lower Peoria Lake might be the Farm Creek and Tenmile Creek deltas.

All the above assessments are based on this reconnaissance study. If dredging is selected as the best alternative, more detailed surveys and studies on the extent of dredging, environmental impacts, and sedimentation after dredging will be needed.

In Upper Peoria Lake selective dredging of isolated areas does not seem to be advisable, unless it is part of an overall solution that requires hydraulic manipulation of the Illinois River. The best alternative at present appears to be creation of artificial islands with dredge material along with some enhancement programs such as creation of marshy areas along selected locations in the lake. However, there are many technical questions which need to be answered in order to implement such a plan. The first question is what kind of islands and how many islands will be needed to keep the rest of the lake from filling up with sediment. The second question is how to build the islands with the type of sediment present in Peoria Lake, which is mostly silt and clay. Another question concerns the environmental impacts of building the islands.

Studies are being conducted in the upper Mississippi River regarding construction of artificial islands in Pool 5 as part of the Upper Mississippi River enhancement plan. Some of the experience in those areas will be very helpful if creating artificial islands in Peoria Lake becomes a reality. However, because there are significant differences between the upper Mississippi River and the Illinois River, detailed hydraulic and environmental studies will be required in the Peoria Lake area.

Sediment Input Control

The second major component in a comprehensive management plan is control of sediment input to the lake. The major sources of sediment to Peoria Lake can be subdivided into two components: the upper Illinois River watershed and the watersheds of tributary streams which empty directly into the lake. These two sources are estimated to contribute almost all of the sediment, with shoreline erosion contributing a very small percentage of the total sediment. Shoreline erosion could, however, be a major source of sediment at some locations within the lake.

The Illinois River watershed, shown in Fig. 26, covers a total of 28,906 square miles of land, more than one-half of the surface area of the state. Approximately 4000 square miles of the watershed is located in Indiana and Wisconsin. Out of the total Illinois River watershed, approximately half of it (14,165 sq mi) is located upstream of Peoria Lake. This area includes the watersheds of some of the major rivers in the state such as the Vermilion, Kankakee, Fox, and Des Plaines Rivers. The Illinois River watershed upstream of Peoria Lake falls within 25 counties in Illinois, 13 counties in Indiana, and 6 counties in Wisconsin. To control erosion to an acceptable level in the upper Illinois River basin will require tremendous effort at all levels and in all three states. Furthermore, even if sediment control measures were to be implemented today all over the watershed, the impacts of those measures on Peoria Lake sedimentation problems would be minimal for a long period of time. Even though all the attempts to control erosion in the upper watershed should be encouraged and pursued as a means of long-term solutions, they should not be looked upon as a short-term solution to the Peoria Lake problem.

The highest priority for sediment input control must be given to the tributary streams which discharge directly to the lake. The drainage area of all the tributary streams which drain into Peoria Lake is approximately 430 sq mi, which is only 3 percent of the total watershed of the Illinois River upstream of Peoria. However, this 3 percent of the total watershed is estimated to contribute approximately 40 percent of the total sediment in Peoria Lake. Part of the sediment these streams contribute to the lake is indicated by the delta growth at the mouth of the tributaries. However, much of the sediment from these streams is transported further into the lake during storm events in their respective watersheds.

The best results will be achieved if most of the effort and money is spent to control the input of sediment from the tributary streams to the lake. One of the major tributary streams is Farm Creek, which empties into Lower Peoria Lake. The stream formerly discharged into the narrow segment of the Illinois River downstream of the lake as shown in Fig. 31, but it was diverted to its present location for flood control purposes in the 1950s. In terms of controlling sediment input to the lake, consideration should be given to rediverting Farm Creek to its original course and/or to significantly reducing erosion in the watershed.

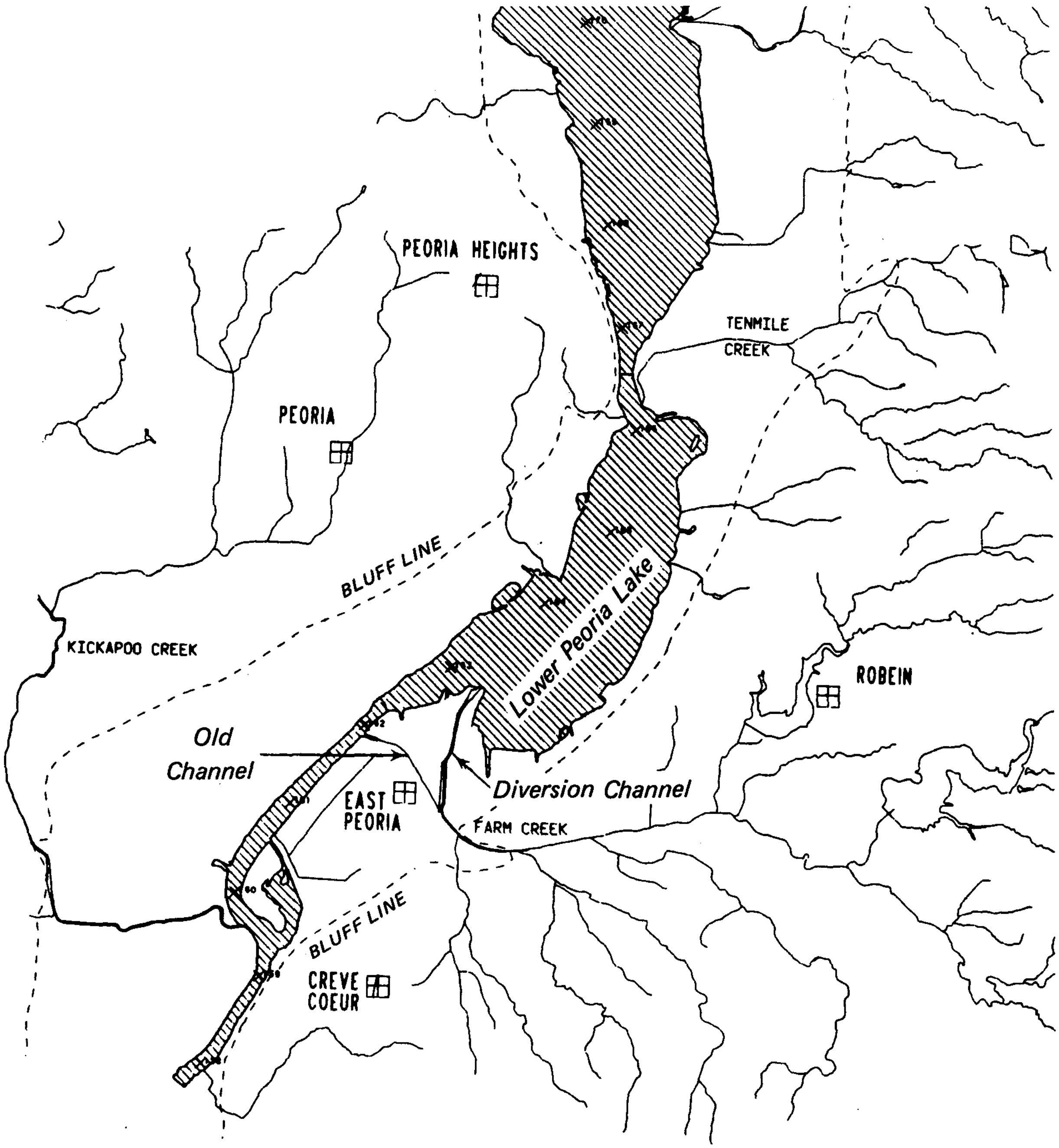

Fig. 31. Change in Farm Creek outlet into Lower Peoria Lake

Rediverting Farm Creek to its original course would cause the sediment-laden water to be discharged to a narrow section of the Illinois River. The sediment would then be carried downstream rather than forming a large delta at the mouth of the creek, as is happening at the present time. However, the rediversion might create sedimentation problems near the mouth of the old channel, and some of this sediment would be deposited in the immediate vicinity of the downstream pool.

The erosion problems are similar along all the other tributary streams, including Dickison Run and Tenmile, Blue, Partridge, Richland, Snag, Crow, and Senachwine Creeks. As one of the initial steps in a comprehensive sediment management plan for Peoria Lake, it is recommended that an integrated plan to control sediment input from the tributary streams be initiated as soon as possible. Such a plan does not have to wait until all the other components of a comprehensive plan, such as selective dredging or creation of artificial islands, are decided upon.

Summary

In summary the recommendations for solving Peoria Lake sedimentation problems identify the following alternatives as the best ones to pursue further:

- Selective dredging
- Creation of artificial islands
- Raising of the dam
- Creation of marshy areas
- Sediment input control

It is recommended that a comprehensive management plan which includes all or most of the above elements be drawn up for Peoria Lake. Any one of the alternatives by itself cannot solve the problems in Peoria Lake caused by sedimentation. Further analysis and detailed studies are needed for most of the alternatives. However, immediate action can be initiated on some of the alternatives, especially on control of sediment input into the lake from tributary streams.

It should also be pointed out that a successful program to solve the Peoria Lake sedimentation problem will require the participation of federal, state, and local agencies involved in the management of water and land resources in the state.

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