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Sediment Conditions In Backwater Lakes Along The Illinois River - Phase 2

by.

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SUMMARY

This research project has been a continuation of last year's project, titled, "Sediment Conditions in the Backwater Lakes Along the Illinois River."

Fifteen lakes were studied In all. Six of them had detailed cross-section surveys, and nine of them were based on reconnaissance surveys. The sedimentation rates of these 15 lakes were calculated. In addition of the quantity of sedimentation, we also sampled the lake beds. These sediment samples were analyzed for physical and chemical properties. Eighteen sediment samples were subjected to volume-weight and particle-size analyses. Five core samples were taken for detailed chemical analyses.

The lakes which were selected for this study were located along the Illinois River from river mile 5 in the Alton pool to river mile 248 in the Marseilles pool. Two lakes are in the Alton pool, 5 in the LaGrange pool, 7 in the Peoria pool and one in the Marseilles pool. The surface areas range from 19 to 15,745 acres. The lake capacities range from 19 to 114,277 ac-ft.

The reductions of lake capacities due to sedimentation in the last 73 years range from 18% to 80% reduction. Most of the lake beds have risen from 0.3 to 0.5 inches per year. The surface areas of the lakes did not have significant changes.

Chapter 1

INTRODUCTION

This report is a continuation of an earlier study by Lee and Stall (1976) of backwater lakes which was submitted to the Division of Water Resources, titled "Sediment Conditions of the Backwater Lakes Along the Illinois River". Four lakes were described in the earlier report, and 11 lakes are described here. The discussions and conclusions are based on the Information from the entire two-year study.

The objectives of this two-year project have been to obtain: (1) the amount of sediment deposited in the backwater lakes, (2) the rate of sediment accumulation, and (3) the physical and chemical nature of the deposited sediment. This project was designated as a pilot study to provide information for the future management of these backwater lakes.

Authority

This study was conducted by the State Water Survey, at the University of Illinois, under an Agreement For Cooperative Project with the State of Illinois Division of Water Resources using funds provided to the State by the U. S. Water Resources Council under Title III of the Water Resources Planning Act. The project was one year in duration lasting from 1 January 1976 to 31 December 1976. The contract number was 1-47-26-84-398 at the University of Illinois, and the title was Future Use of Backwater Lakes Along the Illinois River.

Acknowledgement

This study was conducted as part of the work of the Hydrology Section of the State Water Survey, under the general supervision of John B. Stall, Head. Ming T. Lee, Associate Engineer directed the project and conducted the field surveys. Thomas A. Butts, Associate Engineer, Water Quality Section, Peoria aided in the field surveys. K. W. Kim, part-time Graduate Research Assistant did much of the data analysis and calculations of sediment in lakes. John W. Brother, Jr. drafted the figures; Mary M. Schoville and Waneta McDaniel typed the report.

Analyses of the sediment samples were made at the State Geological Survey with the help of Neil Shimp, Richard R. Ruch, Paul B. DuMontelle, and Gary Dreher.

Construction of Locks and Dams

As early as 1816 the Illinois River, the Des Plaines River, and the Chicago River were used for canoe traffic. There was a portage of about 8 miles through marshy land between the upper Des Plaines River and the Chicago River.

In 1822 U. S. Congress passed the first of several improvement acts which made possible the construction of the Illinois and Michigan Canal, completed in 1848. This I&M Canal provided for barge traffic between Lake Michigan (at river mile 327) and LaSalle at river mile 225. According to the U. S. Army Corps of Engineers (1974), muledrawn barges plied this canal.

During the years about 1871 to 1899 a total of 5 low dams were built along the Illinois River as described in Table 1. Descriptions of these dams were provided by Alvord and Burdick (1915).

Built primarily during the 1930's were a total of 9 lock-and-dam installations that exist today in 1977 and control water levels in the Illinois Waterway. These are.listed in Table 2.

Dredging

The U. S. Army Corps of Engineers is responsible for operation of the Illinois Waterway. This includes maintenance of a 9-foot navigation channel for the entire 327 river miles from the mouth of the Illinois River at Grafton to Lake Michigan in downtown Chicago.

When sediment is dredged from the river channel to maintain the 9-foot depth, the sediment is usually disposed of on the river floodplain along the banks of the river. In the past it has sometimes been disposed of in shallow areas of backwater lakes.

The U. S. Army Corps of Engineers (1974) summarized dredging activities in the Illinois River upstream of Havana at river mile 121. In Table 3 are given these locations and amounts of sediment removed by dredging during the years 1964 to 1974. The locations of these areas are shown on the map in Figure 1. The dredging described can be considered typical of the entire Illinois River.

Figure 1 and Table 3 give data for 22 areas that have been dredged. At 9 of these locations the dredging is done annually while at the remaining 13 locations dredging is carried out at variable intervals of 2 to 10 years. No general number can be derived as being the average annual amount of sediment dredged out of the Illinois River. The dredging described in Table 3 is representative .

Table 1. Early Dams Built on the Illinois River

Name	River Mile	Year Built	Builder	Purpose
Kampsville	32	1893	federal	navigation
LaGrange	80	1899	federal	navigation
Copperas Creek	137	1877	state	navigation
Henry	196	1871	state	navigation
Marseilles	245	1871	state	hydropower

Table 2. Lock-and-Dams Existing In 1977 Which Control Water Levels In the Illinois Waterway

Name of Lock-and-Dam	River Mile	Year Completed	River
Alton, No. 26	(-14)	19^0	Mississippi, mile 203
LaGrange	80	1939	Illinois
Peoria	158	1939	Illinois
Starved Rock	230	1933	Illinois
Marseilles	247	1933	Illinois
Dresden Island	272	1933	Illinois
Brandon Road	285	1933	Des Plaines
Lockport	292	1933	Des Plaines
Thomas J. Obrien	327	196l	Calumet

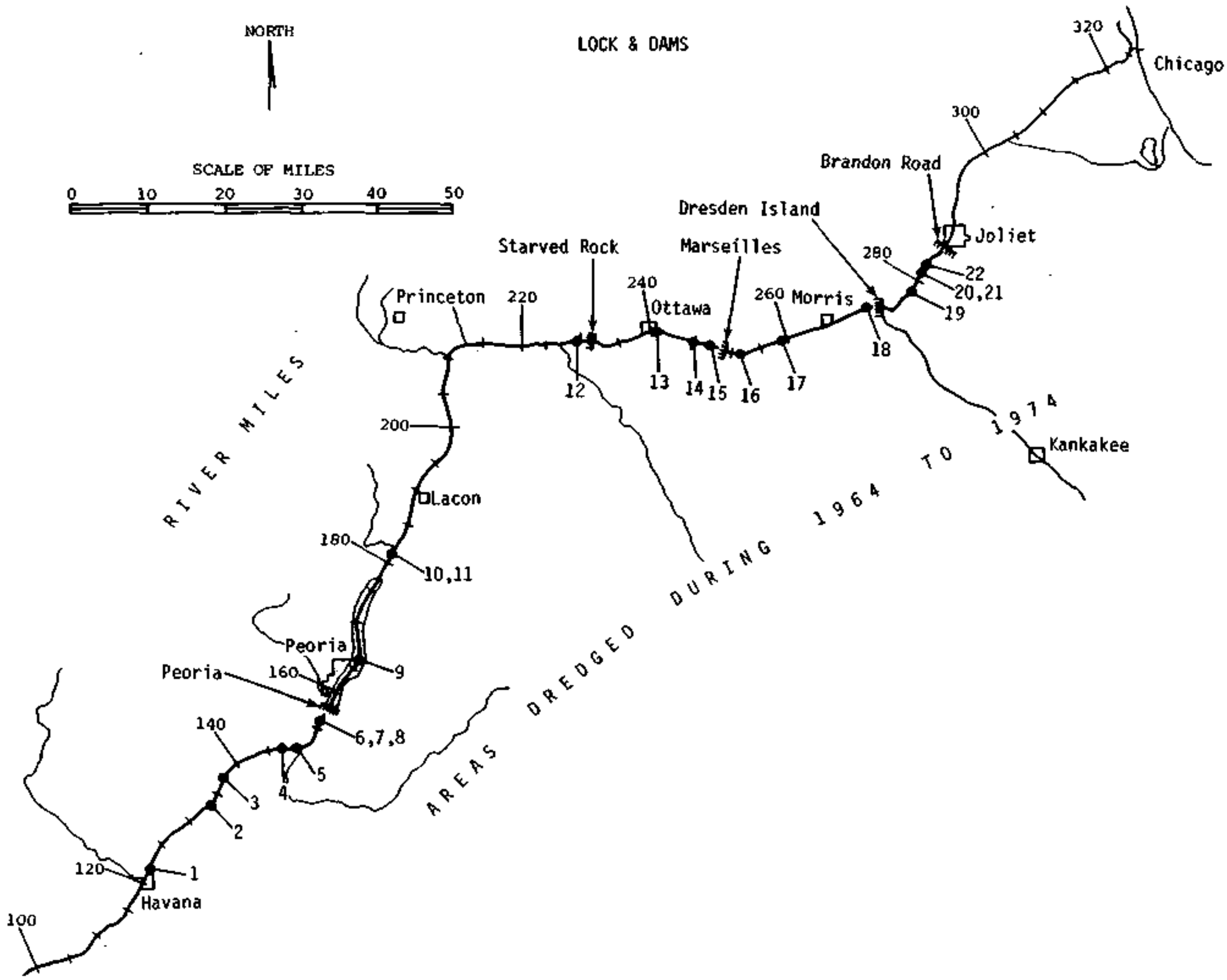

Figure 1. Locations of Areas Dredged in the Upper Illinois River. For Amounts see Table 3.

Table 3 Areas Dredged During 1964 to 1974
(Data from Corps of Engineers, 1974)

Site	Approx River Mile	Description	Year	Quantity, Cu.yards Total	Annual
1	121	Along Bank	1966-67	114,641	23,399
			1972	114,351	
2	133	Eank along Senate Island	1972	96,287	9,629
3	137	Alluvial Fan at mouth	1972	115,378	11,538
4	147	Alluvial Fan at mouth	1965	93,958	59,804
		of Mackinaw River	1965	254,147	
			1968	155,976	
			1972	93,958	
5	149	Bank along river bend	1968	121,732	12,173
6	156	Alluvial Fan at mouth	1963	11,283	6,488
		of Lick Creek	1970	18,838	
			1972	34,761	
7	157	Bank ,1ust downstream of Peoria Lock & Dan	1972	44,620	4,462
8	158	Alluvial Fan at mouth of unnamed creek	1968	16,789	1,679
9	167	Alluvial Fan at mouth of Ten-Mile Creek, in Lake Peoria	1970	41,217	4,122
10	130	Boat Harbor at Chillicothe	1968	5,068	507
11	182	Alluvial Fan at mouth	1966	5,198	12,224
		of Senachwine Creek	1968	52,900	
			1971	64,142	
12	231	In channel downstream	1973	6,000	1,700
		from Starved Rock Lock	1974	4,000	
		& Dam	1974	7,000	
13	240	Along island near Ottawa	annual	1,500	1,500
14	244	Along band downstream from Marseilles Lock & Dam	annual	300	300
15	245	In Marseilles Canal	1965	56,880	5,688

Site	Approx. River Mile	Description	Year	Quantity, Cu. yards Total	Annual
16	252	Along bank	annual	1,000	1,000
17	259	Bank along River bend	annual	900	900
18	271	In channel downstream from Dresdan Island Lock & Dam	annual	150	150
19	279	Reck from old rock cut	annual	300	300
20	281	Bank along river bend	annual	3,000	3,000
21	282	Alluvial fan at mouth of Rock Run	annual	1,500	1,500
22	286	In channel downstream from Brandon Road Lock & Dam	annual	150	150

Chapter 2

DETAILED SEDIMENT SURVEYS

Methods

The general objective of a lake survey is to determine the volume and distribution of sediment accumulated within the reservoir during a specific period of time. Because the backwater lakes are natural lakes, the contours of the lake bed at an earlier date are needed to evaluate the sediment deposition rate. We utilized the Woermann (1903) maps as the reference lake-bed level. A series of cross-sections were established on the 1903 Woermann maps. Prom the Woermann maps we obtained elevations from the 1-foot contours and were able to construct a set of reference cross-sections representing the elevations of the lake bed in about the year 1903. Based on the Eakin (19^5) method, the lake capacity was computed.

In order to determine the rate of sedimentation in these lakes, we needed a set of recent cross-section data. These were obtained from records of the Illinois Division of Water Resources, U. S. Corps of Engineers, or by field survey, as described.

The range method was reported by Eakin (1945) and by Stall and others (19540). The following sections describe the results of four detailed studies.

Results

LAKE PEORIA

Lake Peoria is impounded by Peoria Lock and Dam on the Illinois River at mile 158 in Tazewell and Peoria Counties. This lake extends 24 miles up the river from River Mile 158 to 182. The normal lake stage was raised from about 435 to 440 feet due to the completion of Peoria Lock and Dam in 1939. Lake Peoria is impounded along the main stem of the Illinois River. A portion of the lake is used as navigation channel. The flow in the lake generally is faster than that of a typical backwater lake. Regular dredging is carried out to maintain the 9-foot navigation channel through the lake. Therefore, the comparison of lake cross-sections in two different years shows the manmade disturbance of the dredging. However, the maintenance dredging does not constitute a significant amount of the sediment in the lake. Therefore, the effects on the total lake capacity are not great.

Previous Studies

In 1967 the Illinois State Water Survey established nine water sampling stations in upper Peoria Lake as described by Wang and Brabec (1969) and by Wang and Evans (1969, 1970). The water turbidity, silica and diatoms, and iron in the lake were studied. Starrett (1971) gave an historical account of siltation and pollution since the opening of the Chicago Sanitary and Ship Canal in 1900. Mathis and Cumings (1971) reported on the relation between selected concentrations in bottom sediments, animals, and water. Information on the amounts of sediment deposition was not given by these authors. All of these results relate aquatic conditions to sediment conditions and are important in the future management of the lake.

Data

In 1903 detailed cross-sections of the Illinois River and the Des Plaines River were mapped by W. J. Woermann (1903). Based on these 1903 maps, we developed 15 cross-sections on Lake Peoria approximately matched to 1973 cross-sections located as shown in Figure 2. The elevation of the 1903 maps was based on the Memphis datum which is about 6.630 feet lower than mean sea level (MSL, 1929 - 5th general adjusted) as described by McKibbin and Schmidt (1954).

The U.S. Corps of Engineers regularly surveys a series of cross-sections at points along the Illinois River. The most recent soundings for Lake Peoria were taken in 1973. The distance between cross-sections varies from 1/10 to 1/5 of a mile. We utilized these sounding data to develop 15 cross-sections throughout the Lake Peoria. The location and representative cross-sections are shown in Figures 2 and 3.

Comparison of the 1903 to 1973 Surveys

Based on the cross-sections, the lake was divided into 14 segments. The referenced water surface level is 440 feet MSL. The cross-section areas were calculated. We utilized the Eakin method (1945) to calculate the volume of each segment. Table 4 shows the storage capacities of the 14 segments in 1903 and 1973. The capacity loss during the 70 year period was computed as the differences of these two capacities. It is shown in Table 4 in acre-feet and percent. The results indicate that the 1903 capacity of Lake Peoria was 114,277 acre-feet. In 1973 the capacity had been reduced to 79,099 acre-feet. Lake Peoria has lost 35,178 acre-feet or 30.8 percent of its capacity during the years 1903 to 1973.

The reach from River Mile 166.0 to 166.9 is a narrow section. The lake which is downstream of this narrow section is called

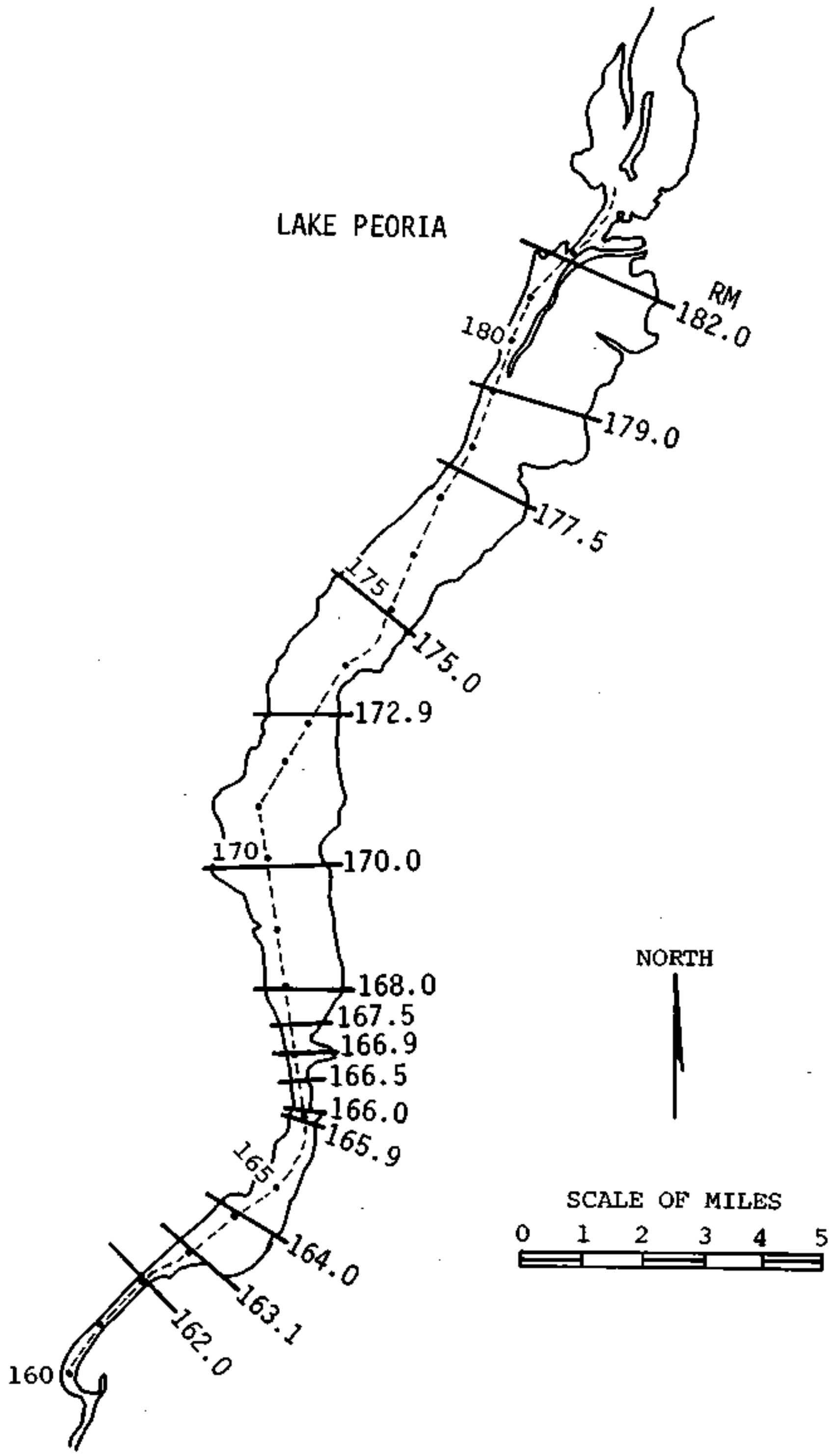

Figure 2. Location of Cross-Sections on Lake Peoria

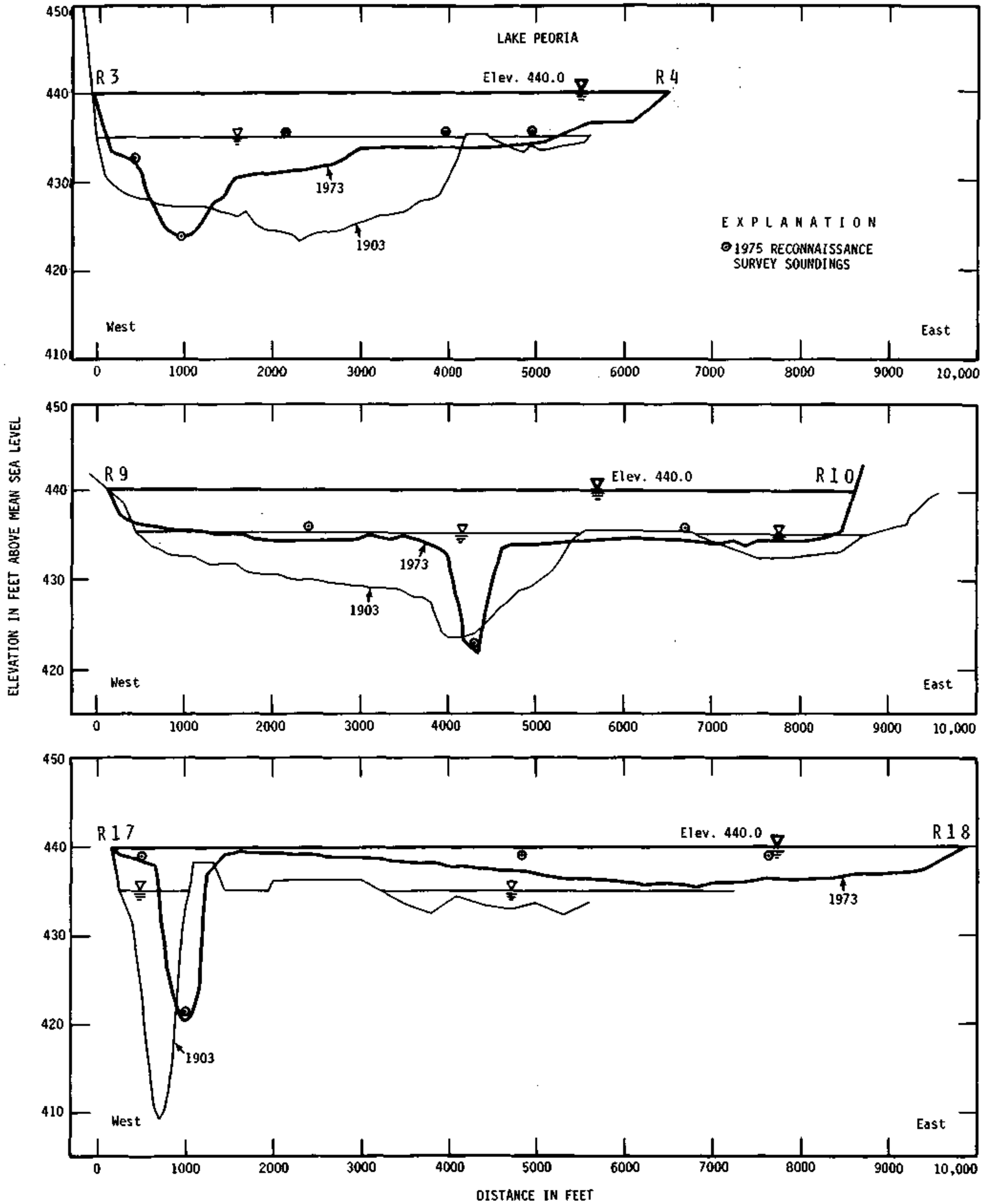

Figure 3. Typical Cross-Sections on Lake Peoria

Table 4. Distribution of Storage Loss in Lake Peoria

Segment	River Mile From	River Mile To	Storage Capacity (ac-ft) 1903	Storage Capacity (ac-ft) 1973	Capacity Loss ac-ft	Capacity Loss percent
1	162.0	163.1	3680.1	4054.3	-374.2	-10.2
2	163.1	164.0	6763.5	5657.2	1106.3	16.4
3	164.0	165.9	10691.6	7759.0	2932.7	27.4
4	165.9	166.0	417.6	342.4	75.2	18.0
5	166.0	166.5	1382.5	1256.3	126.2	9.1
6	166.5	166.9	526.4	298.5	227.9	43.3
7	166.9	167.5	2523.4	2062.8	460.5	18.3
8	167.5	168.0	3084.3	2582.4	501.9	16.3
9	168.0	170.0	13060.1	10691.3	2368.8	18.1
10	170.0	172.9	20422.0	13168.8	7253.2	35.5
11	172.9	175.0	11840.5	6061.8	5778.6	48.8
12	175.0	177.5	13024.4	7771.8	5252.6	40.3
13	177.5	179.0	9492.0	5655.2	3836.8	40.4
14	179.0	182.0	17368.9	11737.5	5631.3	32.4
Total	162.0	182.0 .	114277.0	79099.3	35177.8	30.8

Lower Peoria Lake. Similiarly, the lake which is upstream of this narrow section is called Upper Peoria Lake. The Lower Peoria Lake capacity in 1903 was 21,551 acre-feet. In 1973 the capacity was reduced to 17,812 acre-feet or 17.3%. On the other hand, the Upper Peoria Lake capacity was reduced from 90,813 to 59,727 acre-feet or 34.2% during the same period. The possible reason for the latter being higher may be that the incoming sediments were trapped in the Upper Peoria Lake.

The sediment data are summarized in Table 5. The results show that the average annual capacity loss in Lake Peoria is 502.5 acre-feet per year or 0.44 percent per year. If we assume this amount of sediment deposited uniformly, the lake bed would rise at an average rate of 0.40 inches per year. In reality, we should recognize that the deep navigation portions have high water velocity and maintenance dredging. Therefore, the deposition rate in the channel would be smaller than that of shallow portions of the lake.

MUSCOOTEN BAY

The Muscooten Bay is located in Cass County at the junction of the Sangamon River and the Illinois River as shown in Figure 4. Before 1949, the Sangamon River flowed through the north end of Muscooten Bay into the Illinois River. In 1949, a new outlet channel was built to divert the Sangamon River southward through Muscooten Bay into the Illinois River. Since then, the sediments from the upland agricultural watersheds being carried by the straightened Sangamon River are settling down in Muscooten Bay. In recent years, the deposited sediments have started to hamper the access to the Beardstown community harbor.

Table 5. Summary of Sediment Data on Lake Peoria

Age of Reservoir		
1903-1973	70	Years
Water Surface Area		
1903	15,745	Acres
1973	14,998	Acres
Storage Capacity		
1903	114,277	Ac-ft
1973	79,099	Ac-ft
Sedimentation		
1903-1973	35,178	Ac-ft
Average Annual Sed. Accumulation		
1903-1973	502.5	Ac-ft per year
Loss of Original Storage Capacity		
1903-1973	30.78	Percent
Annual Rate of Loss of Original Capacity		
1903-1973	0.44	Percent per year
Annual Rate of Rise of Lake Bed	0.40	Inches per year
Average Depth in 1973	5.27	Ft
Expected Life	166	Years

The U.S. Corps of Engineers was authorized to study the area based on a resolution adopted by the House Committee on Public Works on 11 December, 1969. A preliminary. report of the U.S. Army Corps of Engineers (1976) was released. Three alternative plans were investigated: (1) a training wall from the entrance of the Beardstown community Boat Harbor to the Illinois River, (2) annual maintenance dredging, and (3) an outlet channel extension. The preliminary results indicated that the annual maintenance dredging was the most cost-effective alternative at the annual cost of $36,800 based on 1976 price levels.

The Muscooten Bay has a few features which are different from a typical backwater lake. First, the Muscooten Bay is located at the junction of two rivers. Due to the interaction of the sediment-laden water from the Sangamon River and the backwater from the Illinois River, the sediment deposition is rather complicated. Second, the configuration of the Muscooten Bay is not a closed waterbody. It is rather a part of the marshy Sangamon River delta which is a series of connected sloughs.

Sounding Records

The U.S. Corps of Engineers has been doing a series of sounding in Muscooten Bay. The earliest soundings were done by Woermann (1903). Since then, 18 sounding surveys on the Muscooten Bay were performed in various years as shown in Table 6. Since the Muscooten Bay is not a closed water body, we limited our study area as shown in Figure 4. Three soundings, those In years 1903, 1960

Table 6. List and Dates of U.S. Army Sediment Information on Muscooten Bay, Beardstown, IL.

Date	File No.	Title
1939	M-34-17	Muscooten Bay Sediment Study, 1939. Sounding
April, 1940	T-12-40	Mouth of Sangamon River Proposed Channel "A" (1 to 9).
Aug., 1957	T-5-58	Sangamon River RMF 0.0 to 11, 5 sheets.
May,	1960	Knoxville Gun Club Condition Survey, 3 sheets
Aug., 1960	M-34-l8	Muscooten Bay Sedimentation Study, 1960 Soundings.
April, 1966	M-34-19	Muscooten Bay Sedimentation Study, 1966 Soundings.
March, 1967	M-34-20	Muscooten Bay Sedimentation 1967 Soundings.
August, 1968	M-34-21	Muscooten Bay Sedimentation 1968 Soundings.
May, 1969	M-34-22	Muscooten Bay Sedimentation 1969 Soundings.
Jan., 1970	M-34-23	Muscooten Bay Sedimentation 1970 Soundings.
Oct., 1971	M-34-24	Muscooten Bay Sedimentation 1971 Soundings
August, 1972	M-17-21	Entrance to Beardstown Boat Harbor.
July, 1973	M-17-21A	Entrance to Beardstown Boat Harbor.
Sept., 1973	M-17-21B	Entrance to Beardstown Boat Harbor.
April, 1974	M-17-21C	Entrance to Beardstown Boat Harbor.
May, 1974	M-34-25	Muscooten Bay Sedimentation 1974 Soundings.
Nov., 1975	M-17-21D	Entrance to Beardstown Boat Harbor.

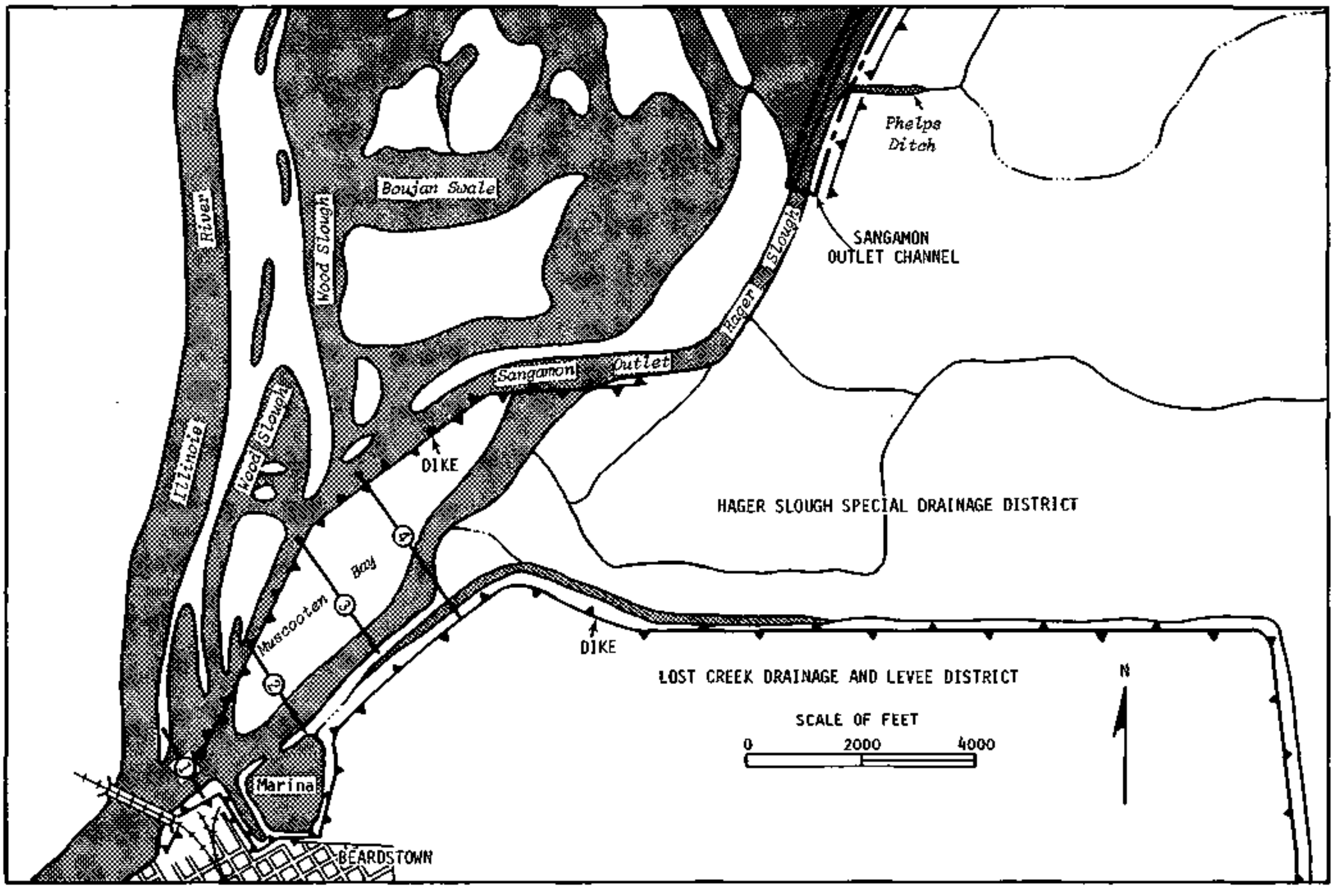

Figure 4. Locations of Cross-Sections on Muscooten Bay

and 1974, were utilized to compute the sediment deposition.

Comparison ,of 1903, 1960 and 1974 Soundings

Based on the 1903, 1960 and 1974 data, we have developed 4 cross-sections throughout the Muscooten Bay. The sediment levels for these cross-sections are shown on Figure 5. We utilized the Eakin's method (1945) to calculate the volume of each segment. Table 7 shows the capacities of these five segments. The capacity loss of each period was calculated in acre-feet per year and in percent per year. The reference surface lake is 429 feet MSL.

The results indicated that the Muscooten Bay lost 61.6% during 1903 to 1960. It was reduced an additional 23.3% of capacity during 1960 to 1974. In terms of acre-feet, the Muscooten Bay lost 898 acre-feet during 1903 to 1960 and 476 acre-feet during 1960 to 1974. As far as the sediment distribution is concerned, the upper end of the bay had a higher sediment accumulation rate than that of the lower end during 1903 to 1960.- However, during 1960 to 1974 period, the sediment was gradually carried into middle section and lower end of the bay. Therefore, the sediment deposition rate increases rather rapidly in the area adjacent to the Beardstown Community Harbor as shown in Figure 4.

The sediment deposition in the Muscooten Bay area not only reduced the capacity but also eliminated the surface area. In 1903, the surface area of the Muscooten Bay was 172.3 acres. At the end of 1974, the surface area was reduced to 75.4 acres. Most of the surface area eliminated was located at upper end of the bay.

The sediment data are summarized in Table 8. Two significant

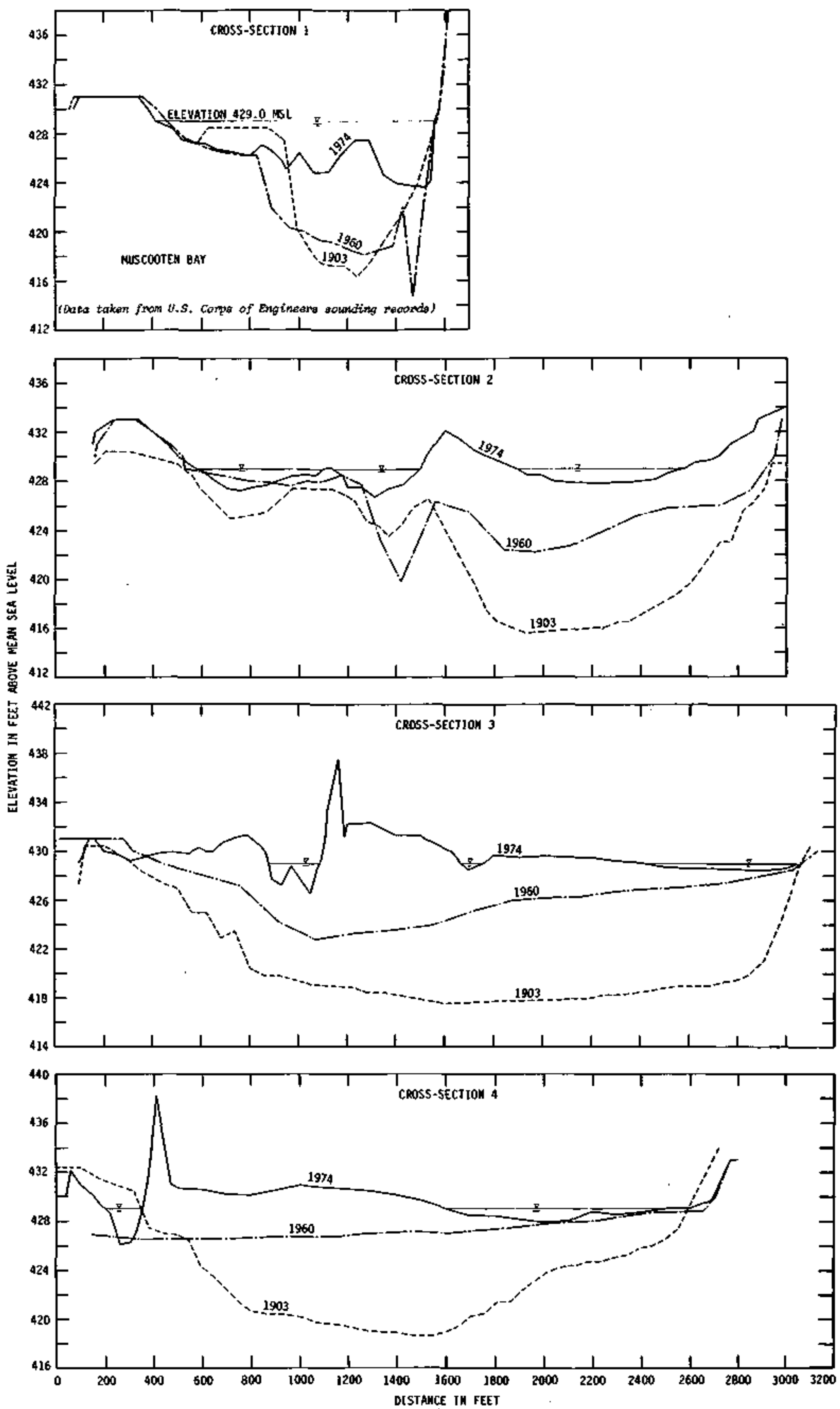

Figure 5. Cross-Sections of Muscooten Bay

Table 7. Distribution of Storage Loss in the Muscooten Bay

Segment		From	To	1903	1960	1974	1903-60 ac-ft	%	1960-74 ac-ft	%
A	A1	0+00	4+42		45.31	22.19			23.12	48.9
	A2	4+42	8+67	300.44	77.98	21.75	128.77	42.9	56.23	72.1
	A3	8+67	12+63		48.35	6.66			41.69	86.3
B		12+63	27+87	672.81	244.20	17.24	428.61	63.7	226.96	92.9
C		27+87	39+54	485.91	144.67	16.61	341.24	70.2	128.06	88.5
Total capacity in ac-ft				1459.13	560.51	84.45	898.62	61.6	476.06	84.9
Surface Area ac				172.3	163.91	75.44				

findings are:

(1) The annual rates of capacity loss are 1.23% during 1903 to 1960 and 6.07% during 1960 to 1974. The accelerated sediment deposition was mainly due to the diversion of the Sangamon River into Muscooten Bay in 1949.

(2) The average rate of rise of lake bed was calculated as 1.13 inches per year during 1903 to 1960 and 4.30 inches per year during 1960 to 1974.

According to the U.S. Corps of Engineers study entitled, Preliminary Feasibility Report, Muscooten Bay, Illinois, Small Boat Harbor Study (1976), the capacity of the Muscooten Bay during 1939 to 1974 decreased as shown in Table 9. The area of the Muscooten Bay in this Corps of Engineers study is slightly larger than that of Figure 4 studied here. Therefore, the capacity of Muscooten Bay shown in Table 9 by the Chicago District, Corps of Engineers is slightly larger than those reported for this study in Table 7.

Column (4) of Table 9 shows the variation of the Bay capacity in consecutive years. Column (5) shows the annual sediment deposition rates. The results indicate that the sediment deposition rate reaches a peak in 1968. Since then, most areas of the bay were filled up and became dry land. Therefore, the rate starts to decrease as shown in Table 9.

LAKE CHAUTAUQUA

Lake Chautauqua is shown on the map in Figure 6. It is located along the Illinois River at mile 125. A previous sediment survey was made in 1950 by Stall and Melsted (1951). The past history and the management of the lake were described in the 1951 report. In an effort to appraise the amount of sedimentation that has

Table 8. Summary of Sediment Data on
Muscooten Bay, Beardstown, IL

	Quantity	Unit
Sedimentation		
1903-1960 (57 years)	897	Ac-ft
1960-1974 (14 years)	476	Ac-ft
Average Annual Accumulation		
1903-1960	15.7	Ac-ft per year
1960-1974	34.0	Ac-ft per year
Depletion of Storage		
1903-1960	70.2	Percent
1960-1974	85.0	Percent
Annual Rate of Loss of Original Capacity		
1903-1960	1.23	Percent per year
1960-1974	6.07	Percent per year
Annual Rate of Rise of Lake Bed		
1903-1960	1.13	Inches per year
1960-1974	4.30	Inches per year
Average Depth (1974)	1.12	Inches
Expect Life	3.12	Years

Table 9. Capacity of Muscooten Bay 1939 to 1974, as Reported by U.S. Army Corps of Engineers.

(1) Year	(2) Period Years	(3) Capacity ac-ft	(4) Sediment Deposit Vol. ac-ft	(5) Annual Sed. Deposit ac-ft/yr
1939	36	1261.0	-	-
1960	21	799.6	461.1	21.96
1966	5.7	463.7	335.9	58.92
1967	0.9	420.7	42.9	47.66
1968	1.4	265.2	155.4	111.00
1969	0.8	214.2	51.1	64.63
1970	0.7	172.7	41.5	59.29
1971	1.8	140.3	32.4	18.00
1974	2.6	134.7	5.6	2.15
1960 to 1974	14			47.49

The volume of Muscooten Bay was calculated based on the surface elevation at 429.0 msl.

The area covers only up to range sta. 39 + 54 on U.S. Corps of Engineers report (1976).

Source data: U.S. Corps of Engineers report, "Preliminary Feasibility Report, Muscooten Bay, Illinois, Small Boat Harbor Study," January, 1976.

For the total 1960 to 1974 period, the average annual deposition rate is 47.49 ac-ft per year. This value is comparatively higher than the value of 34.0 ac-ft per year as shown in Table 8 for a smaller part of Muscooten Bay studied here and shown in Figure 4.

occurred in the past 25 years, a survey of the water depth of Lake Chautauqua was made by the Illinois Natural History Survey on February 9-11, 1976 and the results are given below.

A new cross-dike was built in the lake in 1970. Hence, the lake was divided into upper and lower pools. The upper pool (northern part of the lake) was maintained to have a higher water level than that of lower pool (southern part of the lake).

The Results of 1976 Survey

The locations of the cross-sections taken in the 1976 survey are approximately the same as those of the 1950 survey as shown in Figure 6.

Due to the construction of the cross-dike, two additional cross-sections were established adjacent to the dike. Therefore, the segment E of the 1950 survey was divided into three subsegments as shown in Figure 6. In order to separate the sediment and the filled material due to the earth dike, we assumed that the lake bed between R9a-R10a and R7a-R8a is uniform and level. The sediment deposited in the past 25 years was defined as the difference of the volumes of 1950 and 1976.

The results of the 1976 lake bed are shown in Figures 7a to 7b. Based on these cross-sections, the lake capacity was calculated for 1926, 1950 and 1976 based on eight segments as shown in Table 10. The results indicate that, during the 1926-1950 period, the sediment deposition pattern is relatively uniform in all the segments. However, during the 1950-1976 period, the segments A and H which are located at the southern and northern ends of the lake, have the highest capacity loss. Those segments near the new cross-dike (at segment E on Figure 6) have less sediment deposition.

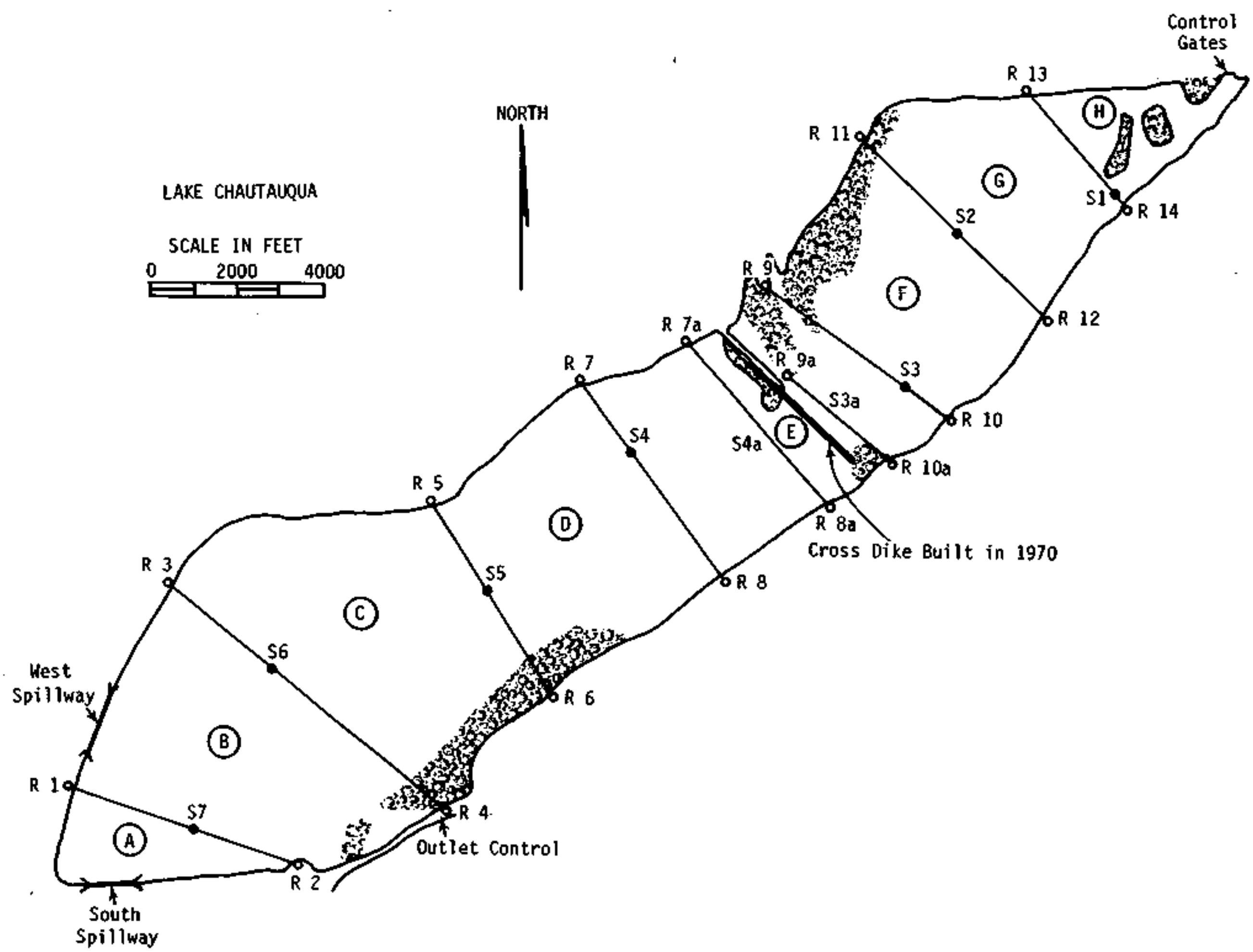

Figure 6. Locations of Cross-Sections on Lake Chautauqua

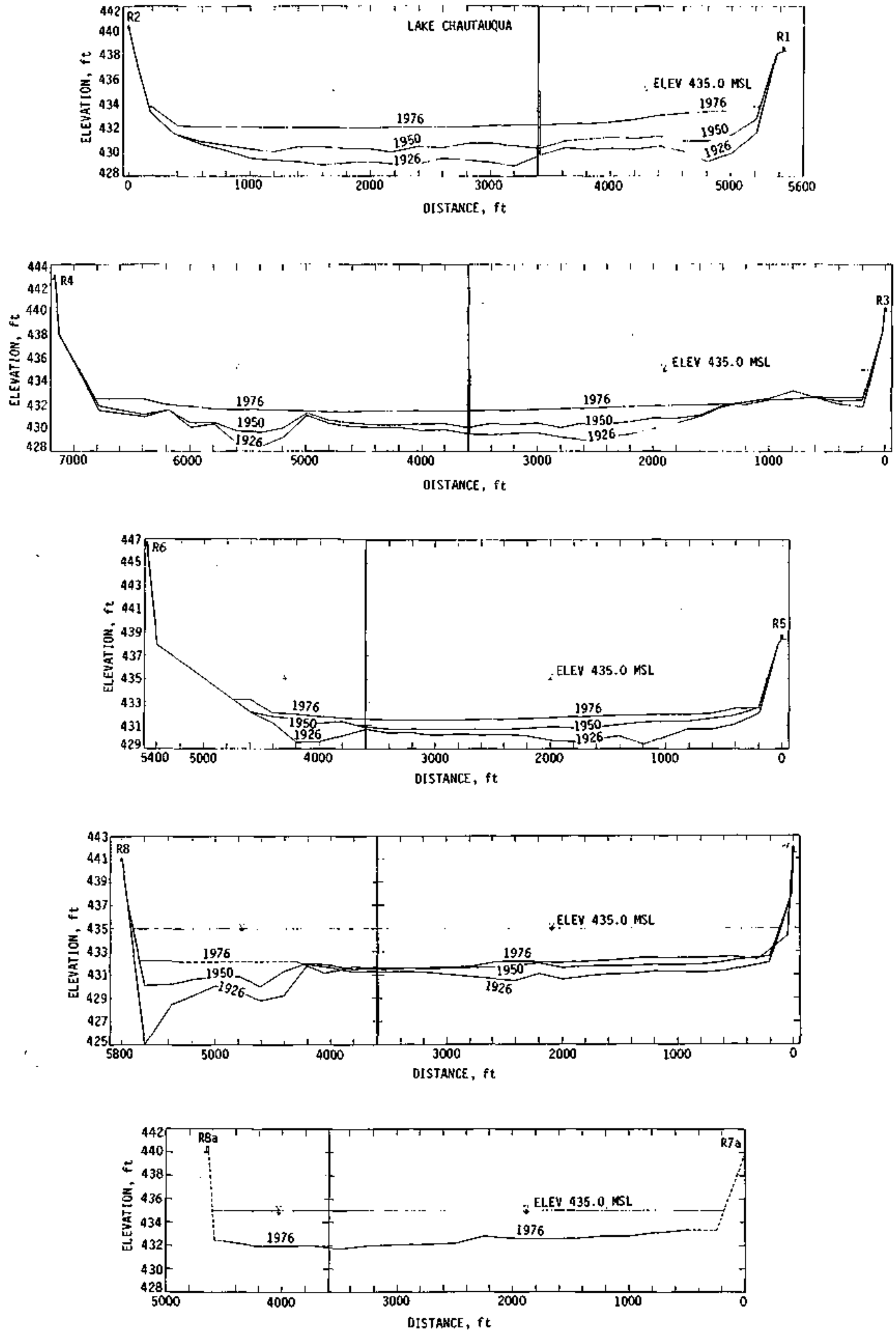

Figure 7a. Cross-Sections R1-R2 to R7a-R8a at Lake Chautauqua

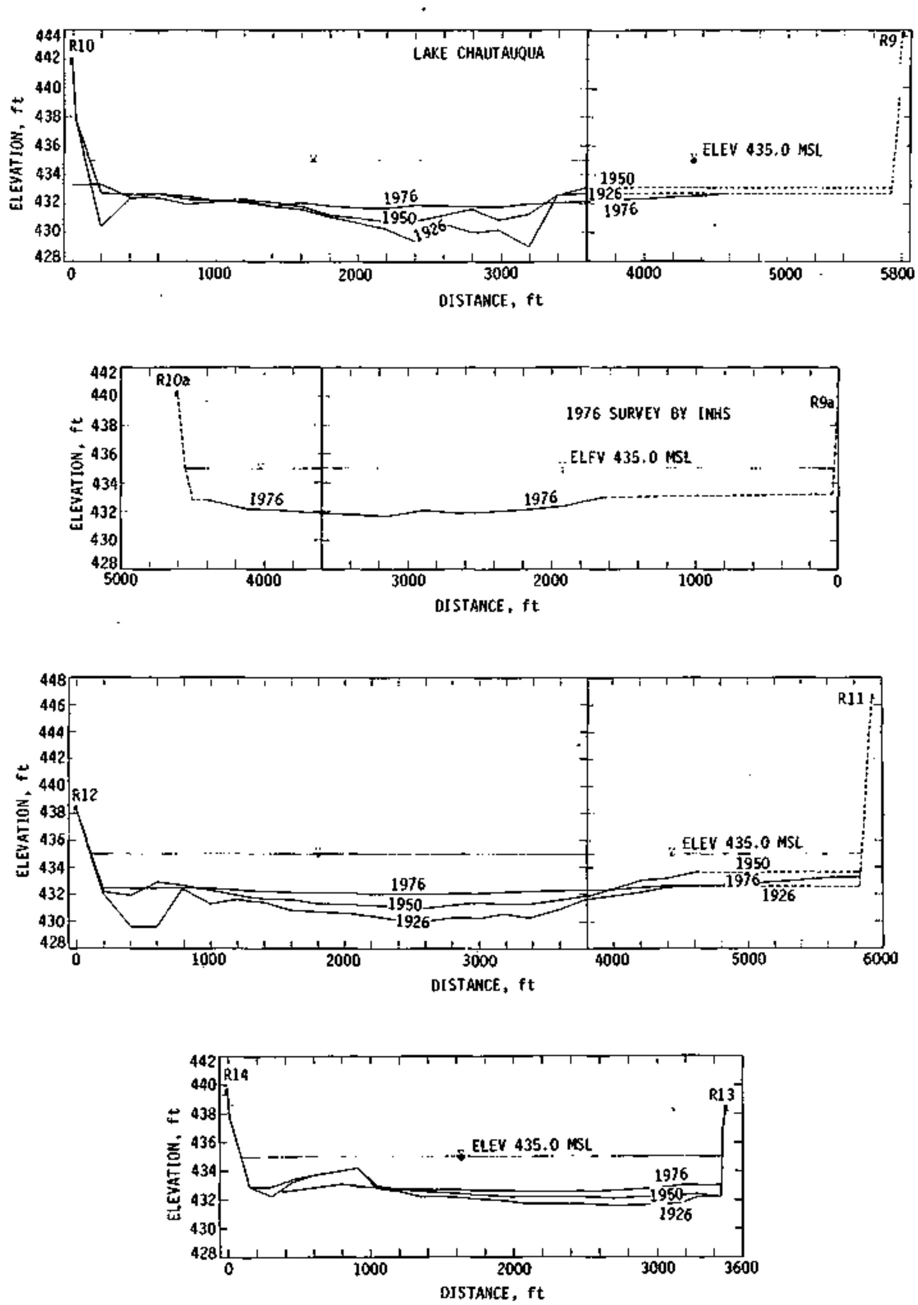

Figure 7b. Cross-Sections R9-R10 to R13-R14 at Lake Chautauqua

Table 10. Distribution of Storage Loss In Lake Chautauqua, Havana, IL

Segment	Location		Storage Capacity (ac-ft) 1926	1950	1976	Capacity Loss 1926 - 1950		1950 - 1976		1926 - 1976	
	From	To				Vol.	%	Vol.	%	Vol.	%
A	END	R l-R 2	742.2	602.6	230.7	139.6	18.8	371.9	61.7	511.5	68.9
B	R 1-R 2	P. 3-R 4	2695.0	2286.4	1663.3	108.6	15.2	623.1	27.3	1031.7	38.3
C	R 3-R 4	R 5-R 6	2902.3	2482.7	2084.3	419.6	14.5	398.4	16.0	818.0	28.2
D	R 5-R 6	R 7-R 8	2385.6	1912.5	1536.4	473.1	19.8	376.1	19.7	849.2	35.6
E	R 7-R 8	R 9-R10	2449.0	1914.9	1571.8	534.1	21.8	343.1	17.9	877.2	35.8
P	R 9-R10	R11-R12	1560.6	1192.0	1191.0	368.6	23.6	1.0	0	369.6	23.7
G	R11-R12	R13-R14	1141.4	981.4	866.5	223.0	19.5	51.9	5.7	274.9	24.1
H	R13-R14	DAM	416.7	369.6	193.8	47.1	11.3	175.8	47.6	222.9	53.5
	Total		14,292.8	11,679.1	9,337.8	2,613.7	18.3	2,341.3	20.0	4,955.0	34.7

Note: 1. Surface Elevation is based on normal pool elevation 435.0 msl.

2. Water Surface Area is assumed unchanged at elevation 435.0 msl.

The results are summarized in Table 11. The significant findings are:

(1) The average annual sediment accumulation is 110 acre-feet or 0.77% per year during the 1926-1950 period, and 90.1 acre-feet or 0.62% per year during the 1950-1976 period. This indicates the sedimentation rate of the past 26 years (1950-1976) is about 82% of that of the 1926-1950 period.

(2) The average rate of rise of the lake bed is defined as the ratio of the annual sediment deposition volume to the lake surface area, in terms of inches per year. The average rate of rise of the lake bed on Lake Chautauqua is about 0.37 inches per year for the 1926-1950 period and 0.30 inches per year for the 1950-1976 period.

(3) The upper pool (northern part of the lake) has a slightly lower sedimentation rate than that of the lower pool (southern part of the lake).

(4) The western shore of the lake near ranges 7, 9, 11 shows a mild shore erosion. This may be due to lake current in high river stage.

PATTERSON BAY

This backwater lake is located at river mile 107 and about 3 miles southwest of Bath, Illinois. This bay is twice-removed from the main stem of the Illinois River. This bay is connected to Sincarte Slough which in turn is joined with Bath Chute and with the Illinois River.

TABLE 11. Summary of Sediment Data on Lake Chautauqua, Havana, Illinois, 1976.

Reservoir	Quantity	Unit
(1) Area	3,562	Acres
(2) Storage Capacity		
Original	14,293	Acre-feet
1950	11,679	
1976	9,338	
(3) Sedimentation		
1926-1950 (23.75 yrs.)	2,614	Acre-feet
1950-1976 (26 yrs.)	2,341	"
1926-1976 (49.75 yrs.)	4,955 "	
(4) Average Annual Accumulation		
1926-1950	110.1	Ac-ft per year
1950-1976	90.1	"
1926-1976	99.60	"
(5) Depletion of storage Loss of Original Capacity		
1926-1950	18.3	Percent
1950-1976	16.4	Percent
1926-1976	34.7	Percent
(6) Annual Rate of Loss of Original Capacity		
1926-1950	0.77	Percent per year
1950-1976	0.63	"
1926-1976	0.70	"
(7) Annual Rate of rise of Lake Bottom		
1926-1950	0.37	Inches per year
1950-1976	0.30	Inches per year
1926-1976	0.34	Inches per year
(8) Average Depth (1976)	2.62	Feet
(9) Expected Life*[1]	92	Years

Note: *[1]Expected life is defined as the ratio of average depth and annual rate of rise of lake bed.

The bay is about 1.5 miles long and 500 feet wide. A cross-dike has been built at the north end of the bay. Most of the water comes into Patterson Bay from the Sincarte Slough. A relatively insignificant amount of water originates from springs in the east bank of the lake.

In the past, Patterson Bay was a fine recreational area and attracted a large development of cottages along the east bank of the bay. However, in recent years, the bay has been silted up to one or two feet of water depth. The access to the Illinois River has become extremely difficult under normal flow conditions. In order to manage this area, the estimation of siltation is important.

Estimating Siltation Rate

There are two surveys available in this area. We utilized the 1903 Woermann maps as our reference level. In 1968, the Division of Waterways performed a cross-section survey of the area in conjunction with a possible improvement. Based on these two surveys, we developed seven cross-sections as shown in Figure 8 for comparison. The cross-sections are shown graphically in Figure 9.

We utilized these cross-section data to develop six segments. The Eakin Method (1945) was used to calculate the lake volume for each segment in 1903 and 1968. The results are shown in Table 12.

The total volume in 1903 was 271.3 ac-ft. In 1968, the volume had been reduced to 165.6 ac-ft which is a 39.0% capacity loss. The sediment distribution indicated that the north and south ends of the lake have higher deposition than the middle section.

The surface areas at the water surface elevation of 432 feet msl were 64.0 acres in 1903 and 59.5 acres in 1968. These results indicate that there was no significant variation in water surface area.

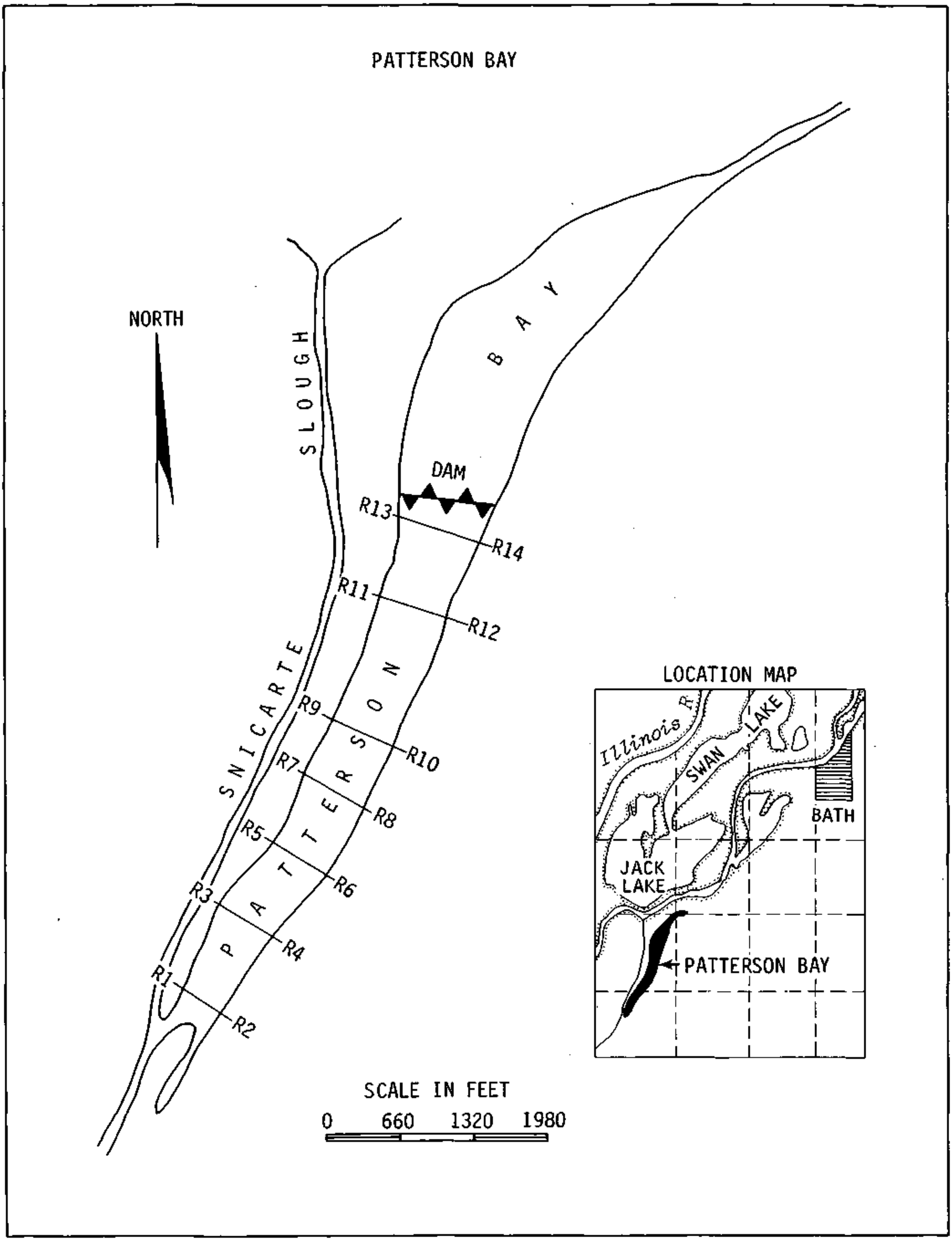

Figure 8. Location of Cross-Sections on Patterson Bay

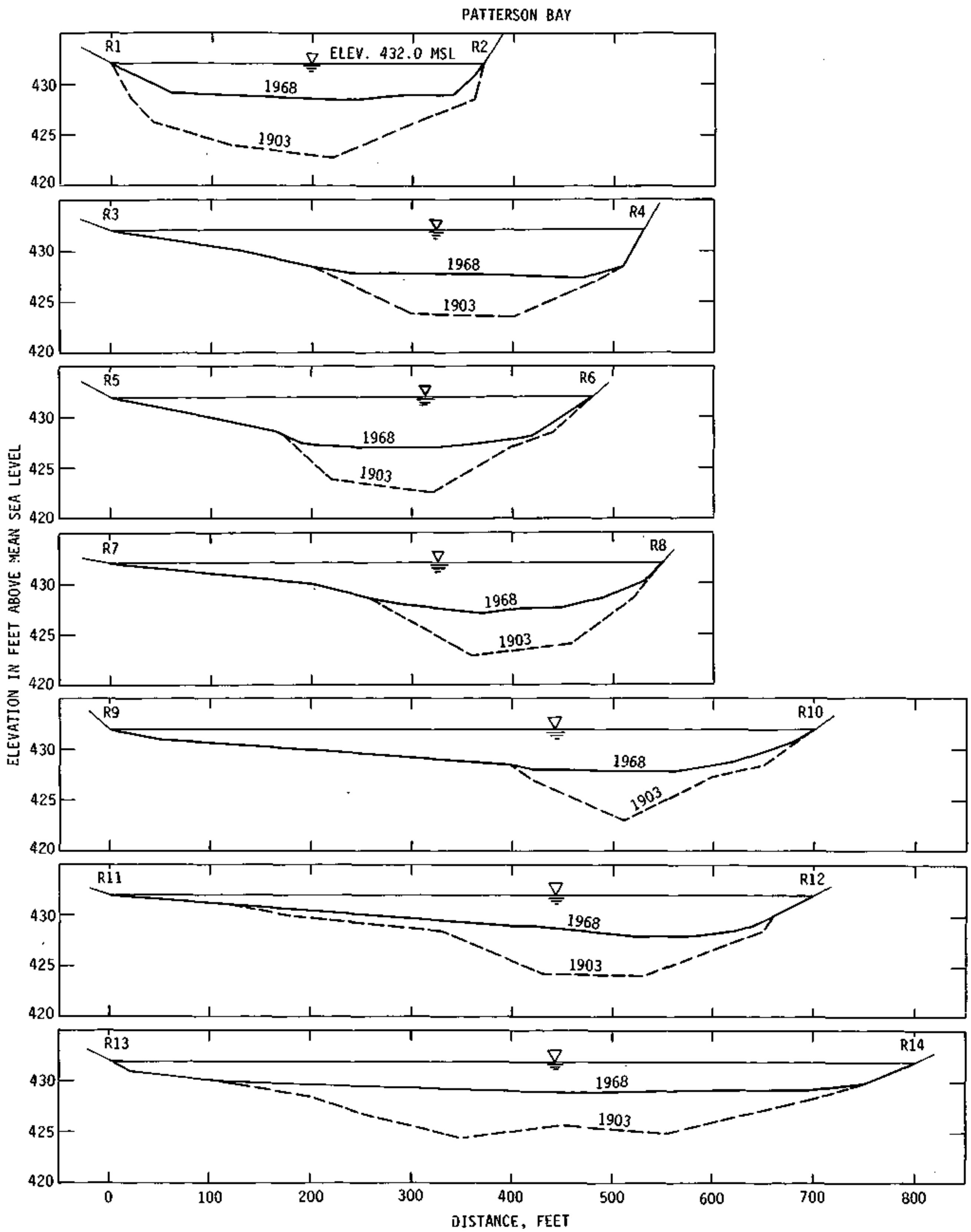

Figure 9. Cross-Sections at Patterson Bay

Table 12. Distribution of Storage Loss in Patterson Bay

Segment	From	To	Storage Capacities 1903	Storage Capacities 1968	Capacity Loss (ac-ft	Capacity Loss (%)
1	R1-R2	R3-R4	48.4	26.3	22.0	45.6
2	R3-R4	R5-R6	41.8	30.7	11.1	26.6
3	R5-R6	R7-R8	29.7	21.0	8.7	29.2
4	R7-R8	R9-R10	35.5	25.0	10.5	29.6
5	R9-R10	R11-R12	64.9	39.6	25.4	39.1
6	R11-R12	R13-R14	50.9	23.0	28.0	54.9
Total Capacity (ac-ft)			271.3	165.6	105.7	39.0
Surface area (acres)			64.0	59.5		

Summary Sedimentation Data

The results of these data are summarized in Table 13. The significant findings are as follows:

1. In terms of average annual sedimentation rate in the past 65 years (1903 to 1968), the lake lost 1.6 acre-feet per year, or 0.60 percent per year of its capacity.
2. In terms of the rise of lake bed, the lake gets 0.31 inches shallower per year. The 1903 average depth at 432 feet msl water elevation was 4.24 feet. In 1968, the average depth was 2.79 feet. If the same trend holds, the lake will be dried out within about 110 years.

Table 13. Summary of Sediment Data on Patterson Bay

Age of Reservoir		
1903-1968	65	Years
Water Surface Elevation	432.0	ft (MSL)
Water Surface Area		
1903	64.0	Acres
1968	59.4	Acres
Storage Capacity		
1903	271.3	Ac-ft
1968	165.6	Ac-ft
Sedimentation		
1903-1968	105.7	Ac-ft
Average Annual Sed. Accumulation		
1903-1968	1.6	Ac-ft per year
Loss of Original Storage Capacity		
1903-1968	38.95	percent
Annual Rate of Loss of Original Capacity		
1903-1968 -	0.60	percent per year
Annual Rate of Rise of Lake Bed		
1903-1968	0.31	Inches per year
Average Depth in 1903	4.24	ft
Average Depth in 1968	2.79	ft
Expected Life	110	years

Chapter 3

RECONNAISSANCE SURVEYS

After we made detailed studies of backwater lakes in the Illinois River floodplain, we felt it is necessary to carry out additional lake studies in order to have a general understanding of the sediment deposition in the backwater lakes. Therefore, we selected 7 additional backwater lakes for reconnaissance survey. The method of the reconnaissance survey is described as follows.

Method

First, we utilized the 1903 Woermann maps at the selected lake sites to develop cross-sections. The 1903 maps had detailed soundings in the water portions of the lakes. The land portions had 1 foot contours. The lakes were divided into segments based on the selected cross-sections. In 1975 a reconnaissance survey was made; 3 to 4 water depth measurements were taken along each cross-section. One sediment sample was taken to determine dry volume-weight.

Based on these two different dated cross-sections, we utilized the Eakin method (1945) to compute the lake capacities at these two date's. The change of the lake volume was attributed to the sediment deposition. From these changes of lake capacities, the average annual sediment deposition was defined as the volume change divided by the number of years between these two surveys. The annual rise of lake bed was defined as the annual sedimentation volume divided by the lake surface area.

The following section summarizes the results of reconnaissance surveys.

Worley (Pekin) Lake

This lake is located at river miles 153 to 154 in Tazewell County. The area studied is part of the Pekin Lake Conservation Area. We have developed two cross-sections based on the 1903 Woermann maps. These two cross-sections had a deepest portion of about 5 feet of water on the south end and 3 feet of water on the north end.

In the 1975 reconnaissance survey, we measured the water depth at four points along each cross-section. Three segments were delineated for comparison purposes. The results for Worley Lake, and for all 7 reconnaissance surveys, are shown in Table 14.

The total surface area of the Worley Lake is 207.6 acres. The storage capacity of the studied area in 1903 was 323.2 acre-feet. Since then, the capacity has been reduced to 225.8 acre-feet in 1975. In terms of annual capacity loss rate, this is 1.40 acre-feet per year or 0.08 percent per year.

Babb's Slough

This slough is located at river mile 185 in Marshall County. The area studied is located on the left (east) bank of the Illinois River. This slough is connected to the Illinois River at both the northern and southern ends. The whole area is within the Marshall County Conservation Area.

Based on the 1903 Woermann maps, we developed four cross-sections. Three segments were delineated for volume computation. In the 1975 reconnaissance survey, we made three soundings along each cross-section. Based on these two sets of data, the change of lake bed was determined. The volume of each segment was calculated based on Eakin's Range Method (1945). The results are shown in Table 14.

The surface area of this slough is 896 acres. In 1903, the total capacity of this slough was 1376.6 acre-feet. The capacity has been reduced to 625 acre-feet in 1975. In terms of percent capacity loss, 54.3% of the capacity was lost during the last 72 years. The annual capacity loss rate is 0.76. The annual lake bed rise rate is 0.14 inches per year.

Weis Lake

This lake is located between River Mile 191 and 193 in Marshall County at the west bank of the Illinois River. Part of the lake is owned by the U. S. Fish and Wildlife Service and is under the supervision of the Chautauqua National Wildlife Refuge.

We utilized the 1903 Woermann maps to develop four cross-sections. The 1975 reconnaissance survey found that the water depth was too shallow for access by boat. However, we did estimate the water depth was about 0.5 feet in the lake. Based on these data, three segments were delineated. The volumes in 1903 and 1975 were computed by the Eakin Range Method (1945). The results were shown in Table 14.

The results indicated that the area studied has a surface area cf 371 acres. The capacity in 1903 was 445 acre-feet. It has been reduced to 110 acre-feet, which is a 75-6% capacity loss. The annual capacity loss is 1.05% per year. The lake bed rises at a rate of 0.15 inches per year.

Ballard's Slough

This slough is located at River Mile 248 in LaSalle County at the south bank of the Illinois River. The studied area is a privately-owned boat harbor. The harbor is connected to the Illinois River through the east end. The west end of the slough has been cut off from the Illinois River by a low earth dam.

Based on the 1903 Woermann maps, we developed four cross-sections. In the 1975 reconnaissance survey, we made three soundings along each cross-section. For the purpose of calculating capacity, we delineated three segments on this slough. The results are shown in Table 14.

The results indicate that the slough surface area is 19.95 acres. In 1903, the capacity was 142.2 acre-feet. It has been reduced to 36.2 acre-feet in the last 72 years.

Lake Senachwine

This lake is located at River Mile 199 to 203 in Marshall and Putnam counties at the west bank of the Illinois River. Most of lake area is privately owned. The State has considered developing a new water-fowl refuge area as described by the Division of Waterways (1969).

Based on the 1903 Woermann maps, we developed two cross-sections in this lake. In the 1976 reconnaissance survey, we measured four soundings in the southern part of the lake. The northern part of the lake was too shallow for access by boat. However, we did estimate the water depth was not more than a foot. We assumed the water depth was 6 inches for the two northern cross-sections. Using these two sets of data, we calculated the siltation volume in three segments in this lake. The results are presented in Table 14.

Lake Senachwine has a surface area of 3784 acres. The 1903 lake capacity was 9240 acre-feet. Since then, the lake capacity has been reduced to 2468 acre-feet for a 73.3 percent capacity loss. The northern end of the lake has a higher siltation rate than the southern end. In terms of annual lake capacity loss, this lake lost about 94.1 acre-feet per year or 1.02 percent per year. If this amount of silt was distributed uniformly around the lake, the lake bed would rise at a rate of 0.30 inches per year.

Rice Lake

This lake is located at River Mile 133 to 136 in Pulton County at the west bank of the Illinois River. This area is separated from the Illinois River by Duck Island, Big Lake, Goose Lake, and a few small ponds.

The area was well-mapped in the 1903 Woermann Survey. We developed 12 cross-sections in the lake area. Since there is a small island in the lake, we located 6 cross-sections on each side of the island. Six segments were delineated in the studied area. In the 1976 survey, we made 3 soundings along each cross-section. The change of lake bed was calculated based on the Eakin Range Method (1945). The results are shown in Table 14.

The surface area of this lake was 1025 acres in 1903, and 1015 acres in 1976. The lake had a capacity of 3064 acre-feet in 1903; it has been reduced to 1119 acre-feet in 1976. The lake has lost 63.5 percent of the 1903 capacity. The sediment is distributed rather uniformly around the lake. The average annual capacity lost in this lake is 27.0 acre-feet or 0.88%. If the sediment were uniformly distributed, the lake bed would rise about 0.32 inches per year.

Huse Lake

This lake is located at River Mile 221 in LaSalle County at the south bank of the Illinois River. Most of the area of this lake is privately owned. The 1903 Woermann maps showed the detailed water depth in the area. We developed six cross-sections based on 1903 data.

In the 1975 reconnaissance survey, we found the lake bed was completely dry when the river water surface elevation was 440.5 feet, msl, at Spring Valley. We estimated the lake bed was about 1 foot above the water surface. Based on these two sets of data, we can determine the change of these six cross-sections. Furthermore, we utilized the Eakin Range Method to calculate the lake capacity loss. The results are shown in Table 14.

The lake surface of this lake is 33.3 acres. The lake capacity was 252.7 acre-feet in 1903. The lake capacity has been reduced to 51.3 acre-feet in the past 72 years. In terms of average annual capacity loss, the lake lost 2.8 acre-feet per year or 1.11% per year. The lake bed rises at an average rate of 0.96 inches per year.

The sediment data for all 7 reconnaissance surveys are summarized in Table 15.

Table 14: Summary of Sediment Distribution on Selected Backwater Lakes in Reconnaissance Survey

Segment Number	1903 Surface Area (acres)	1903 Storage (ac-ft)	1975 Surface Area (acres)	1975 Storage (ac-ft)	Capacity Loss ac-ft	Capacity Loss percent
Worley (Pekin) Lake						
1.	81.8	138.1	80.0	70.2	67.8	49.1
2.	93.9	155.7	91.6	130.2	25.5	16.3
3.	34.7	29.4	36.0	25.4	4.0	13.8
Total	210.4	323.2	207.6	225.8	97.4	30.1
Babbs Slough						
1.	332.2	275.9	344.0	303.3	-27.4	-9.9
2.	327.9	619.9	340.0	227.0	392.9	63.4
3.	207.4	480.8	212.0	94.0	386.1	80.3
Total	867.5	1376.6	896.0	625.0	751.6	54.3
Weis Lake						
1.	79.3	114.7	80.0	34.4	80.3	70.1
2.	71.0	115.8	59.8	25.8	89.5	77.6
3.	238.2	219.8	231.2	49.5	170.3	77.5
Total	388.5	444.9	371.0	109.7	340.1	75.6
Ballards Slough						
1.	5.79	41.2	6.18	13.2	28.0	67.9
2.	8.26	57.8	8.44	15.0	42.8	74.1
3.	5.37	43.1	5.33	7.9	35.2	81.6
Total	19.42	142.2	19.95	35.2	106.0	74.6
Senachwlne Lake						
1.	248.0	866.7	276.0	421.7	445.0	51.3
2.	1267.0	4173.4	1285.6	1376.9	2796.5	67.0
3.	2190.0	4200.3	2222.2	669.8	3530.5	84.1
Total	3705.0	9240.4	3783.8	2468.4	6772.0	73.3
Rice Lake						
1.	81.3	155.5	80.0	55.8	99.7	64.1
2.	298.6	943.2	297.2	408.8	534.4	56.7
3.	126.9	402.6	120.0	101.4	301.2	74.8
4.	262.4	805.9	265.0	343.9	462.0	57.3
5.	95.0	305.2	91.2	81.5	223.7	73.3
6.	151.2	451.5	161.2	127.8	323.8	71.7
Total	1025.4	3064.0	1014.6	1119.1	1944.9	63.5

Table 14. (continued)

Segment Number	1903 Surface Area (acres)	1903 Storage (ac-ft)	1976 Surface Area (acres)	1976 Storage (ac-ft)	Capacity Loss ac-ft	Capacity Loss percent
			Huse Slough			
1.	3.98	33.8	4.13	6.3	27.5	81.3
2.	8.76	77.0	8.91	14.3	62.7	81.5
3.	9.50	72.6	9.99	15.6	57.0	78.5
4.	6.03	34.8	6.04	9.1	25.7	73.9
5.	6.53	34.5	4.26	6.0	28.5	82.6
Total	34.8	252.7	33.3	51.3	201.4	79.7

Table 15- Summary of Sediment Based on Reconnaissance Surveys

Items	Unit	Rice Lake	Pekin Lake	Babbs Slough	Weis Lake	Huse Slough	Ballard Slough	Senachwine
(1) Time Period 1903-1975	year	72	72	72	72	72	72	72
(2) Water Elevation	ft(msl)	437	437.0	440.0	440.0	443.0	433.7	440
Pool		LaGrange	LaGrange	Peoria	Peoria	Peoria	Marseilles	Peoria
River Mile		133	153	185	191	221	248	199
(3) Water Surface								
Area 1903	acres	1025.3	210.4	867.5	388.5	34.8	19.4	3705
1975	acres	1014.5	207.6	896.0	371.0	33.3	19.9	3784
(4) Lake Capacity								
1903	ac-ft	3064.0	393.2	1376.6	449.9	252.7	142.2	9240
1975	ac-ft	1119.1	225.8	625.0	109.7	51.3	36.2	2468
(5) Loss of Lake	ac-ft	1944.9	97.4	751.6	340.2	201.4	106.0	6772
Capacity	percent	63.5	30.1	54.6	75.6	79.7	74.6	73.3
(6) Annual Capacity	ac-ft	27.0	1.40	10.4	4.7	2.8	1.50	94.1
Loss Rate	percent	0.88	0.42	0.76	1.05	1.11	1.04	1.02
(7) Annual Rate of Rise of Lake Bed	inches	0.32	0.08	0.14	0.15	0.95	0.91	0.30

Chapter 4

SEDIMENT SAMPLE ANALYSIS

In order to understand the physical and chemical properties of sediment in the backwater lakes; we took 18 sediment samples in the backwater lakes in 1975 for determining volume-weight and particle size analysis. The names of lakes sampled are shown in Table 16. In addition to these sediments, we also took sediment cores for chemical analyses: (1) Lake Meredosia, (2) Lake DePue, (3) Sawmill Slough, and (4) Matanzas Bay. All the samples were analyzed by the Illinois State Geological Survey.

Previous Studies

In 1951, the Lake Chautauqua study, reported by Stall and Melsted (1951), revealed that the total carbon and total nitrogen values in the sediment samples are extremely high. This may be due to wildlife excreta. The sediment particles were, in general, quite fine in texture. The results also showed the sediment to be quite high in fertility. The Upper Peoria Lake Study, reported by Collinson and Shimp (1972), showed both organic carbon and clay fractions to increase southward within the lake. All values are larger in the navigation channel than in the shallows.

Mathis et al. (1971) found with the exception of iron and lithium, mean concentrations for metals (Cu, Ni, Fe, Ca, Pb, Cr, k, Mg, Na, Zn, Co and Cd) were higher in sediment of the Illinois River than its tributaries.

In order to further understand sediment physical and chemical properties in the backwater lakes along the Illinois River, three categories of sediment analysis were carried out as follows: (1) Dry volume weight, (2) particle size analysis, and (3) chemical analysis. Results are described later.

Sample Collection

The State Water Survey piston-type core sampler was utilized for collecting samples as shown in Figure 10. The first 6 inches was taken and put into a plastic bag to deliver to the laboratory for volume-weight and particle size analysis. The sediment core samples for chemical analysis were taken by the same piston-type sampler. The sediments were cut into 3-inch segments from top to the bottom. All these samples were delivered to the Illinois State Geological Survey which carried out all the chemical and physical analysis.

Analysis Method

The methods for determining volume-weight, particle size and major and trace elements are described as follows.

1. Volume weight: The samples taken from the field were weighed to obtain the wet weight. Then the samples were put into the oven to be dried. The dry weight was measured. The dry volume-weight was determined based on the following equation:

$$V_w = \frac{62.4 W_d}{\{\frac{Wd}{2.65} + (W_w - W_d)\}}$$

where

V_w = dry volume-weight in pounds per cubic foot,

W_d = dry weight of the sample in grams,

W_w = wet weight of the sample in grams.

Figure 10. Piston-Type Sampler For Obtaining Sediment Cores

2. Particle-Size Analysis: The less than 2-micron clay fraction was determined by conventional pipette analysis. Deionized water was added to an amount of the moist sediment equivalent to 10 grams of oven-dried (100°C) material and agitated in an Osterizer. A deflocculating solution was added and the suspension was allowed to stand overnight in a bath with a constant temperature of 30°C. A 10 ml aliquot was then taken at the depth and time indicated for removal of the less than 2-micron clay fraction. This aliquot was evaporated to dryness, weighed, and the percentage of clay calculated to the oven-dry weight basis.

The sand and silt fractions in the sediment were determined by standard sieve analysis.

3. Chemical Analysis: The method of analysis used on the samples has been described by Shimp *et al*. (1972) and (1970).

Results

1. Volume-Weight and Particle-Size Analysis - the results of the volume weight and particle-size analysis are tabulated in Table 16. The volume-weight values range from 32.6 to 97.2 pounds per cubic foot. However, most of the volume-weights of the sediment samples are within 30 to 50 pounds per cubic foot. The particle-size analysis indicates the sediments contain almost equal silt and clay with insignificant sand, as shown in Figure 11 and Table 16. These results suggest that the sediments are coming from upland watersheds. The silt and clay particles were probably transported to the Illinois river as wash load.

2. Chemical Analyses - The results of the chemical analyses are tabulated in Table 17.

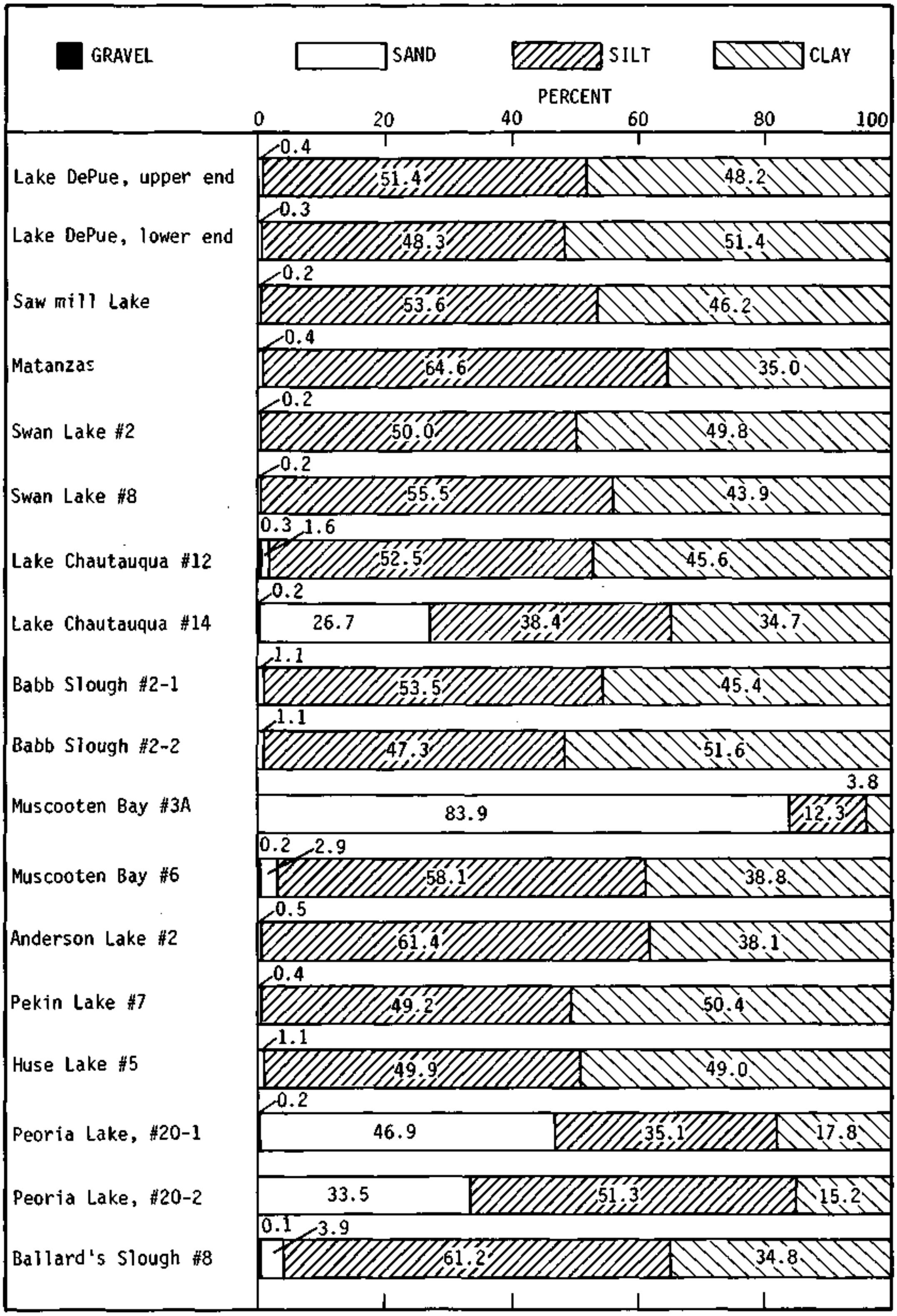

Figure 11. Size Distribution of Sediment Samples

Table 16. Summary Results of Volume-weight and Particle-Size Analyses

		Dry Volume Weight (lb/cu ft)	Particle-Size Analysis (%)		
			Gravel & Sand	Silt	Clay
1.	Lake DePue, Upper End	42.1	0.4	51.4	48.2
2.	Lake DePue, Lower End	44.1	0.3	48.3	51.4
3.	Sawmill Lake	45.1	0.2	53.6	46.2
4.	Mantanzas Bay	51.2	0.4	64.6	35.0
5.	Swan Lake, #2	34.9	0.2	50.0	49.8
6.	Swan Lake, #8	42.6	0.6	55.5	43.9
7.	Lake Chautauqua, #12	32.6	1.9	52.5	45.6
8.	Lake Chautauqua, #14	45.9	26.7	38.4	34.7
9.	Babbs Slough, #2-1	49.2	1.1	53.5	45.4
10.	Babbs Slough, #2-2	37.4	1.1	47.3	51.6
11.	Muscooten Bay, #3	97.2	83.9.	12.3	3.8
12.	Muscooten Bay, #6	45.8	3.1	58.1	38.8
13.	Anderson Lake, #2	57.1	0.5	61.4	38.1
14.	Pekin Lake, #7	43.6	0.4	49.2	50.4
15.	Huse Slough, #5	65.3	1.1	4.9.0	49.0
16.	Lake Peoria, #20	84.8	0.2	46.9	35.1
17.	Lake Peoria, #4	81.6	33.5	51.3	15.2
18.	Ballard Lake, #8	62.2	3.9	61.2	34.8

Table 17-

(A) Major Elements of the Sediment Samples in the Backwater Lakes Along the Illinois River
In percent

	Lake DePue					Matanzas Bay								Sawmill Lake					
	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2	3	4	5	6
(in)	0-3	3-6	6-9	9-12	12-15	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	0-3	3-6	6-9	9-12	12-15	15-18
AlOx	16.03	111.73	15.66	15.814	16.32	13.21	11.06	11.03	13.60	13.10	13.90	11.89	11.53	15.96	15.09	15.70	15.50	15.76	15.68
CaO	3.38	3.66	3.93	3.86	2.56	2.79	3.15	1.01	1.08	6.39	1.29	2.31	2.67	1.58	3.61	3.82	3.95	3.98	1.32
FeOx	6.56	0.35	6.56	6.11	6.31	6.19	5.18	5.36	5.31	5.58	5.56	5.80	5.51	6.63	6.79	6.67	6.73	6.57	6.38
p 0	0.90	1.10	0.82	0.55	0.37	0.27	0.27	0.20	0.22	0.12	0.17	0.17	0.16	0.37	0.36	0.33	0.10	0.32	0.21
K_2O	2.73	2.66	2.75	2.85	2.91	2.36	2.38	2.31	2.39	2.31	2.36	2.16	2.17	3.13	3.00	3.01	3.13	3.07	3.06
SiO_2	59.70	57.10	60.10	61.00	61.98	70.37	68.79	69.12	69.62	63.15	66.19	70.09	69.39	59.23	58.12	59.27	59.11	58.56	56.38
TiO	0.81	0.80	0.83	0.78	0.82	0.81	0.81	0.79	0.83	0.77	0.89	0.88	0.87	0.77	0.73	0.76	0.76	0.78	0.75
MgO	2.71	2.56	2.65	2.17	2.29	1.71	1.69	1.77	1.80	1.87	1.53	1.57	1.75	2.52	2.25	2.21	2.60	2.67	2.10
MnO	0.10	0.10	0.10	0.11	0.09	0.09	0.09	0.07	0.08	0.09	0.09	0.09	0.07	0.10	0.11	0.10	0.10	0.09	0.09
Na_2O	0.50	0.50	0.50	0.57	0.57	0.80	0.71	0.70	0.75	0.62	0.67	0.73	0.73	0.16	0.16	0.17	0.50	0.50	0.11
S	0.20	0.19	0.21	0.20	0.07	0.10	0.05	0.05	0.05	0.09	0.11	0.07	0.06	0.11	0.15	0.12	0.13	0.17	0.23
C	5.08	1.35	1.51	1.11	3.95	2.60	2.68	3.33	3.23	3.17	2.52	2.25	2.55	1.76	1.71	5.21	1.66	1.58	5.15

(B) Trace Elements of the Sediment Samples in the Backwater Lakes Along the Illinois River
in PPM

	Lake DePue					Matanzas Bay								Sawmill Lake					
Br	5.9	8.1	6.8	5.7	6.0	3.6	1.1	1.0	1.1	1.1	3.5	4.1	4.4	5.1	5.0	6.1	1.9	5.1	7.1
Cl	157	229	113	77	108	88	60	38	108	95	91	32	31	123	170	57	17	13	56
V_2O_5	182	253	175	215	181	193	196	187	187	22T	198	180	215	196	216	225	207	221	166
B	54	53	48	55	55	35	35	33	26	32	31	33	31	56	58	59	60	53	51
Cu	128	119	130	107	16.5	30.6	31.3	30.2	29.8	30.5	27.5	27.5	29.0	105	159	109	76	16	31
Co	18	18	13	12	9.3	7.9	9.1	9.2	8.6	9.6	9.1	7.9	10.0	9.7	10	10	9.2	12	9.1
Ni	61.3	53.1	61.0	11.0	37.8	28.7	30.3	30.5	30.6	30.3	26.9	26.5	21.5	32.6	36.5	31.1	29.5	27.8	27.1
Be	3.4	3.8	3.3	3.7	3.0	3.1	2.9	2.8	2.7	3.0	2.8	2.7	3.8	2.5	3.6	3.5	3.1	3.1	2.8
Cr	170	180	210	170	130	83	89	93	91	92	88	93	89	160	200	150	110	86	93
Mo	1.8	7.5	5.2	6.9	1.3	1.8	1.1	1.1	3.5	5.8	3.9	3.8	6.1	1.3	7.0	6.1	5.0	5.7	3.8
Ge	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Zr	220	267	231	270	215	259	262	252	258	285	242	216	331	190	220	237	216	232	179
Pb	141	119	183	211	12	25.5	30.0	21.7	18.9	22.8	11.0	33.3	17.9	661	173	156	121	71.5	39.7
Zn	5000	5000	1100	3100	348	152	155	149	HO	117	131	119	126	508	651	525	396	283	218
Cd	51.5	31.2	101	116	5.5	<0.6	<0.6	<0.6	<0.5	<0.6	<0.5	<0.5	<0.6	1.0	3.2	1.1	0.8	<0.5	<0.5
As	19	11	16	20	12	8.0	8.0	6.8	8.2	7.2	7.2	7.6	8.6	13	18	38	27	16	11
Ga	20	19	19	22	20	11	17	11	17	H	16	11	19	19	20	21	18	18	19
Hg	0.60	0.52	0.76	0.73	0.31	0.11	0.12	0.10	0.13	0,11	0.11	0.09	0.11	1.25	2.11	1.79	1.10	0,75	0.21
S e	1	3	5	1	2	1	2	2	2	2	1	1	1	1	1	1	1	2	3
Ba	0.73	0.69	0.79	0.80	0.69	66	59	69	65	58	52	72	72	67	72	61	68	19	67
Ce •	81	91	95	96	99	82	90	93	90	96	97	110	100	91	100	96	110	68	88
Hf	6.6	7.3	7.7	7.8	8.2	11	10	10	11	9.1	10	11	11	6.6	7.2	6.1	7.1	5.2	6.3
La	60	55	55	59	59	58	62	50	55	52	51	63	63	57	53	57	59	18	53
Rb	200	220	210	210	210	180	170	170	190	190	180	200	200	210	230	220	230	180	220
Cs	9.8	10	11	10	11	7.5	8.3	8.3	8.0	8.9	8.6	9.3	9.1	11	11	11	11	8.7	11
Sc	16	17	17	17	18	13	15	15	H	15	15	17	16	17	18	17	18	13	17
Sm	7.6	7.1	8.1	9.0	9.0	7.1	8.6	7.3	8.1	7.2	8.2	9.1	7.8	6.5	6.8	7.2	7.1	7.0	7.1
Tb	2.1	1.8	2.3	2.5	2.5	2.3	1.9	1.9	2.1	1.9	1.9	2.8	2.6	2.3	1.6	2.0	2.3	1.6	1.9
By	5.8	1.5	5.3	5.5	5.2	5.2	1.5	1.6	1.7	1.7	1.5	4.6	1.1	5.1	1.8	1.9	5.0	1.8	1.7
Ta	0.67	0.72	0.67	0.73	0.80	0.68	0.81	0.80	0.76	0.76	0.77	0.86	0.81	0.71	0.77	0.75	0.79	0.52	0.59
Y b	2	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2
Th	15	16	16	16	17	11	16	16	16	16	17	18	17	16	17	15	17	12	15
Eu	1.8	1.7	1.7	1.7	1.8	1.5	1.5	1.1	1.5	1.1	1.5	1.6	1.6	1.5	1.5	1.1	1.5	1.3	1.6
Sb	3.9	2.7	3.3	2.8	2.1	1.6	1.6	1.1	1.6	1.1	1.8	1.8	2.0	51	1.0	2.6	2.2	1.3	1.5

Table 17 (continued).

(A) Major Elements of the Sediment Sample In the Backwater Lakes Along the Illinois River

	Lake Heredosia #3 (in percent)									Lake Meredosia #6 (in percent)								
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
(in)	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27
Al	7.03	7.36	1.82	7.13	6.18	8.02	7.82	8.00	7.81	8.18	8.01)	7.56	8.49	8.13	8.07	7.58	7.80	1.09
Ca	1.92	lAl*	1.42	1.46	1.52	1.43	1.55	1.54	1.47	1.67	2.82	4.17	1.34	2.24	2.17	1.72	3.00	3-71
Pe	3.69	3.71	3.56	3.86	3.90	4.17	4.18	4.18	4.20	4.70	4.56	4.25	4.99	4.94	4.80	4.48	4.41	1.96
P	0.16	0.24	0.26	0.12	0.15	0.10	0.25	0.13	0.17	0.28	0.22	0.25	0.19	0.25	0.14	O.38	0.18	0.17
K	1.86	1.86	1.88	1.87	1.85	1.89	1.88	1.88	1.90	1.83	1-78	1.70	1.88	1.89	1.81	1.83	1.77	1.44
Ti	0.52	0.41	0.56	0.55	0.51	0.54	0.51	0.51	0.53	0.49	0.46	0.44	0.53	0.50	0.51	0.50	0.42	0.22
Mg	1.03	0.89	1.02	1.10	1.10	0.80	1.00	1.09	1.10	1.12	1.15	1.08	1.11	1.12	1.15	1.24	1.24	1.08
Si	28.63	28.66	29.79	28.92	28.11	26.73	26.11	26.93	27.71	24.53	24.55	24.57	26.09	25.60	26.49	26.33	25-83	33.88
s	0.05	0.05	0.03	0.06	0.09	0.09	0.09	0.09	0.09	o.o4	0.06	0.12	0.23	0.17	0.18	0.09	0.10	0.08
C	2.10	1.92	1.79	2.01	1.84	2.04	2.13	2.01	1.99	2-79	3-13	3.33	2.87	2.71	2.58	2.53	2.51	2-62
Na	0.63	0.65	0.69	.62	0.60	0.46	0.45	0.46	0.50	0.33	O.37	0.39	0.44	0.40	0.44	0.37	0.41	0.62

(B) Trace Elements of the Sediment Samples in the Backwater Lakes Along the Illinois River

	Lake Meredosia #3 (in ppm)									Lake Meredosia #6 (in ppm)								
Br	4.3	5.9	4.8	6.6	5.0	6.0	7.1	6.5	3.9	11.0	8.7	4.6	5.4	5-3	4.2	4.2	4.1	2.4
CI	54	90	42	50	51	30	49	102	63	36	139	38	42	79	10	142	4.6	3.6
V	76	80	72	80	83	85	108	105	118	123	100	104	118	115	116	115	129	38
Mn	650	590	570	640	640	650	650	710	600	810	930	770	820	880	830	670	730	440
B	25	31	36	35	30	36	25	32	23	26	23	23	30	30	25	29	25	8
Cu	30	32	29	30	29	28	31	29	33	39	37	34	31	33	30	37	35	10
Co	7.4	8.6	7.7	6.6	7.3	6.4	8.2	8.6	10	8.3	8.3	9.2	9.4	8.4	8.4	8.6	8.4	3.9
Ni	34	31	33	29	33	33	35	35	38	43	44	40	37	38	32	38	33	11
Be	1.8	1.9	1-9	1.8	1.8	1.9	2.2	2.1	2.0	2.1	2.1	2.0	2.3	2-3	2.1	2.1	2.2	1.0
Cr	98	100	98	82	98	103	87	101	88	94	96	71	89	94	88	100	96	35
Mo	1.8	2.1	1.8	2.0	1.9	2-3	4.1	2.7	3.1	2.6	2.6	3.0	5.6	4.4	4.2	4.2	4.6	<1
Ge	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Zr	208	210	208	184	198	167	220	208	236	170	178	180	205	218	192	188	197	123
Pb	20	25	18	26	14	13	12	15	21	28	29	28	16	17	17	22	20	2
Zn	137	122	113	114	127	119	129	126	123	154	152	135	135	135	129	143	129	38
Cd	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
As	12	12	12	12	11	11	11	11	10	14	13	10	8.3	9.6	9-4	12	11	3.8
Ga	19	19	23	17	19	22	19	23	20	21	20	17	18	21	23	21	22	9.6
Hg	0.2	0.14	0.16	0.12	0.19	0.15	0.14	0.13	0.14	0.17	0.15	0.13	0.16	0.13	0.14	0.14	0.12	0.07
S e	1	1	2	1	2	1	1	2	1	2	2	1	1	2	2	2	1	.0.5
Ba	680	600	690	530	690	730	520	840	600	590	760	620	410	650	560	820	1020	440
Ce	110	100	110	85	100	110	88	110	94	100	98	74	96	98	93	110	100	48
Hf	12	14	14	10	11	10	8.8	10	9.9	7.2	7.9	6.6	9-5	8.6	9.5	8.3	9-3	9.4
La	57	56	59	57	55	57	56	56	57	52	53	48	48	52	53	56	56	27
Rb	180	180	170	170	170	180	150	200	180	210	200	150	200	210	200	220	220	89
Cs	8.6	8.9	8.3	7-6	9.0	10.0	8.9	10.0	8.9	10.0	9.6	7.6	9.0	9.4	9.1	11	10	3.1
Sc	15	16	16	14	16	18	16	18	16	18	17	13	16	17	17	20	18	6.8
Sm	7.4	7.6	7.4	7.7	7.3	7.6	7.2	8.0	7.8	6.5	7.3	6.2	6.2	6.8	6.7	7.5	8.3	3.7
Tb	2.6	2.1	2.8	2.5	2.7	2.0	2.5	2-0	1.9	2.4	2-5	2-1	2-4	2-5	2.3	2.5	2-3	1.2
Dy	5.8	4.8	6.4	6.4	6.2	4.8	4.2	4.3	4.3	4.7	5.6	5.2	5.4	5.3	5.1	5.2	5-5	2.9
Ta	0.81	0.89	0.88	0.73	0.81	0.90	0.72	0.88	0.83	0.79	O.67	0.62	0.75	0.71	0.79	0.77	0.76	O.36
Yb	4	3	4	3	2	4	3	3	2	3	3	2	2	3	2	3	2	1
Th	18	19	18	15	19	20	17	20	17	18	17	13	17	18	17	20	19	7
Eu	1.7	1.7	1.7	1-7	1.7	1.6	1.6	1.6	1.7	1.7	1.7	1.6	1.5	1.7	1.7	1.9	1.8	0.9
Sb	1.3	1.4	1.4	1.2	1.2	1.3	1.6	1.2	1.4	1.9	1.8	1.5	1.2	1.4	1.8	2.2	1.6	0.7

Chapter 5

DISCUSSION OF RESULTS

Sedimentation Rates

The results of detailed studies and reconnaissance surveys for the entire project are summarized in Table 18. We have studied 15 backwater lakes. We have 2 backwater lakes on the Alton pool, 5 lakes on the LaGrange pool, 7 lakes on the Peoria pool and one lake on the Marseilles pool. In Table 18, column (2) indicates the location of the lake in terms of river mile. Column (3) shows that the survey was either a detailed or reconnaissance survey. Column (4) shows the average water depths in 1903 and 1975. The average water depth is defined as the lake capacity divided by the lake surface area. The average lake depths were reduced ranging from 18% to 79%.

Column (5) shows the lake surface areas in 1903 and 1975. The results indicate the lake surface area has not varied significantly in past 70 years except for Muscooten Bay.

Column (6) shows the lake capacities in 1903 and 1975. The percentage changes during the past 72 years are also indicated. The capacity losses range from 30% up to 87%. For the majority of the lakes the capacity loss was higher than 50%

Column (7) shows the existence of the man-made levees around the lake. There were only two lakes which are surrounded by man-made levees.

Column (8) indicates the rise of lake bed in inches per year. The Muscooten Bay has the highest rate. The Muscooten Bay is located at the junction of the Sangamon River and the Illinois River.

Table 18: Summary of Backwater Lake Studies

Pool	(1) Lake Name	(2) River Mile	(3) Type Survey	(4) Average Depth 1903 / 1975	(5) Surface Area 1903	(5) Surface Area 1975	(6) Capacity 1903	(6) Capacity 1975	(7) Leveed Around Lake	(8) Sed. Rate In/yr.	(9) Sed. Rate Adjstd
Alton pool	Swan Lake	5	R.[1]	2.34 1.50 -36%	2,060	1,853 -10%	4,816	2,783 -42%	No.	0.18	0.38
	Lake Meredosia	72	D.[2]	5.31 3.06 -42%	1,468	1,375 -6%	7,791	4,207 -46%	No.	0.43	0.43
LaGrange pool	Muscooten Bay	89	D.	8.48 1.07 -87%	172	75 -56%	1,459	184 -87%	No.	3.12	3.12
	Patterson Bay	107	D.	4.23 2.78 -34%	64.0	59.4 -7%	271	165 -39%	No.	0.31	0.31
	Lake Chantanqua	125	D.	4.01 3.28 -18%	3,562	3,562 -0%	14,293	11,679 -18%	Yes	0.33	0.33
	Rice Lake	133	R.	2.99 1.10 -53%	1,025	1,014 -1%	3,064	1,119 -63%	Yes	0.32	0.32
	Pekin Lake	153	R.	1.54 1.09 -29%	210	208 -1%	323	226 -30%	No.	0.08	0.08
Peoria pool	Lake Peoria	157	D.	7.26 5.27 -27%	15,745	14,998 -5%	114,277	79,099 -31%	No.	0.40	0.82
	Babb's Slough	185	R.	1.59 0.70 -56%	867	896 +3%	1,377	625 -55%	No.	0.14	0.26
	Weis Lake	191	R.	1.16 0.30 -74%	389	371 -5%	450	110 -76%	No.	0.15	0.30
	Sawmill Lake	197	R.	2.64 0.63 -76%	798	608 -24%	2,110	381 -82%	No.	0.47	0.47
	Lake Senachwine	199	R.	2.49 0.65 -74%	3,705	3,784 +2%	9,240	2,468 -73%	No.	0.30	0.30
	Lake DePue	203	D.	4.90 1.62 -67%	578	479 -17%	2,837	778 -73%	No.	0.59	0.59
	Huse Slough	221	R.	7.26 1.54 -79%	35	33 +6%	253	51 -80%	No.	0.96	0.96
Marseilles pool	Ballard's Slough	248	R.	7.32 1.81 -75%	19.4	19.9 +3%	142	36 -75%	No.	0.91	0.91

[1]R. = Reconnaissance Survey
[2]D. = Detailed Survey

In 1949, the Sangamon River was diverted through the Muscooten Bay into the Illinois River. Therefore, the sedimentation rate is extremely high.

In considering the sedimentation rates in Column 8 of Table 18 the authors deemed an adjustment was needed. In 1939, the completion of the Alton and Peoria locks and dams raised the water levels in the Alton and Peoria pools. This changed somewhat the sediment conditions in these pools. It is speculated by the authors that the major part of the sediment in these pools has been deposited after the completion of these locks and dams. In order to adjust the sedimentation to the proper time span, we multiplied the sedimentation rate in Column 8 of Table 18 by the ratio of time spans 1903-1975 to 1939-1975. The adjusted sediment rates are shown in Column 9 of Table 18 and are believed to be comparable.

General

The data on sedimentation rates in Table 18 give measured, detailed results for 15 lakes along the Illinois River. These results document, much better than ever before, that these backwater lakes are being filled with sediment. The results for the 15 lakes seem to be a reasonable representation of what is happening to all the 53 backwater lakes along the Illinois River.

These backwater lakes were formed during the era 1870 to 1900 by the construction of navigation dams. It is believed that the original size and bed configuration of these lakes is well-defined by the contours of the 1903 Woermann maps of the Illinois River. It is a valuable documentation to have available the results of this elaborate survey by Col. Woermann.

The backwater lakes along the Illinois River were enlarged somewhat by the construction of the newer, and generally higher navigation dams built mostly during the era 1933 to 1940. The dams have not been altered significantly since then.

In the present project, sediment deposition has been evaluated by determining how the lake depth, or lake bed elevation has changed during the period 1903 to 1975. During this 72-year period the various lakes have lost from about 30% to 80% of their depth, as shown in Table 18, Column 4. Lake depth has changed from about 5 feet in 1903 to about 1 foot in 1975.

This great amount of sediment which has deposited in these backwater lakes has changed drastically the physical condition of the lakes, by this change in depth. The many changes which have occurred In the vegetation in these lakes, and in the aquatic life in these lakes is undoubtedly a manifestation of the lakes' filling up with sediment.

The results of this project provide little information on changes in the rate of sediment deposition. The Lake Chatauqua results in Table 11 show comparative rates of sediment deposition for 24 years and then for the subsequent 26 years. The rate of lake bed rise was 0.37 inches per year for the earlier years, and 0.30 for the later years. The difference does not appear to be major because both are in the range shown in Table 18, Column 9 for all 15 backwater lakes. Here the rates of rise of the lake beds vary from 0.1 to 1.0 inch per year for various lakes. Sedimentation rates appear to be generally consistent in magnitude. Variations in sedimentation rates do not appear to be related to identifiable physical factors.

It appears that the Illinois River carries a load of sediment and that much of the fine-grained portion of the sediment is deposited in the backwater areas of the river. While the measured rates of sediment deposition vary, as described above, it appears that this deposition is an inexorable process occurring continuously over a long period of time. It is likely to continue relentlessly.

An object of the present project has been to provide information that might allow planning for the future of the backwater lakes along the Illinois River. The results presented here do document the sedimentation conditions and thus show the scope of the sediment problems in the Illinois River. Results do not indicate a particular solution, or a specific plan for action for the river. Project results will be helpful in continuing planning for use of the Illinois River and the resources represented by the backwater lakes.

Chapter 6

CONCLUSIONS

1. Along the Illinois River there are 53 identifiable backwater lakes. They have a combined surface area of about 38,697 acres of the Illinois River floodplain. These potential natural resources are not completely developed or used. One reason is the sediment deposited in these lakes.

2. Based on published, generalized, sediment yield information, about 15.4 million tons or 11,845 acre-feet of sediment are deposited in the Illinois River floodplain every year. This is equivalent to 0.19 inches per year for the entire 745,408 acres (1164 square miles) of floodplain.

3. For 15 backwater lakes surveyed, except for 1 special case, the average rate-of-rise of the lake bed varied from about 0.1 to 1.0 inch per year.

4. For 18 sediment samples collected from the beds of these backwater lakes, the sediment is fine material, being about half clay and half silt, with sand being rare.

5. Analyses of the sediment are given showing the amounts of 12 major elements and 34 trace elements.

Chapter 7

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