

**SEDIMENTATION IN LONG LAKE,
NOBLE COUNTY,
NORTHEASTERN INDIANA, 1959-88**

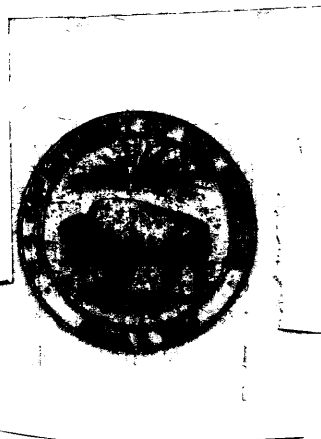
By Danny E. Renn

U.S. GEOLOGICAL SURVEY

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CONTENTS

	Page
Abstract.....	1
Introduction.....	2
Purpose and scope.....	2
Physical setting.....	2
Methods of investigation.....	5
Sedimentation in Long Lake.....	8
Areas of accumulated sediment.....	8
Amount of accumulated sediment.....	23
Potential for future decreases in lake-storage capacity due to accumulated sediment	24
Summary and conclusions.....	25
References cited.....	26
Supplemental data.....	27

ILLUSTRATIONS

Figures 1-4. Maps showing:

1. Location of Long Lake and drainage basin of Thumma Ditch upstream of lake outlet	3
2. Shoreline and location of transects, Long Lake.....	4
3. Location of till and end-moraine deposits in drainage basin of Thumma Ditch.....	6
4. Location of major soil associations in drainage basin of Thumma Ditch	7
5. Depth contours for Long Lake, June 1988.....	9
6-18. Cross sections for transects:	
6. A, B, and C, Long Lake, 1959 and 1988	10
7. D, E, and F, Long Lake, 1959 and 1988	11
8. G, H, and I, Long Lake, 1959 and 1988.....	12
9. J, K, and L, Long Lake, 1959 and 1988.....	13
10. M, N, and O, Long Lake, 1959 and 1988	14
11. P, Q, and R, Long Lake, 1959 and 1988	15
12. S, T, and U, Long Lake, 1959 and 1988.....	16
13. V, W, and X, Long Lake, 1959 and 1988.....	17
14. Y, Z, and AA, Long Lake, 1959 and 1988	18
15. BB, CC, and DD, Long Lake, 1959 and 1988.....	19
16. EE, FF, GG, and HH, Long Lake, 1959 and 1988	20
17. II, JJ, and KK, Long Lake, 1959 and 1988.....	21
18. LL, Long Lake, 1959 and 1988	22

TABLES

	Page
Tables 1-14. Width and depth data for transects:	
1. A and B, Long Lake, June 1988.....	28
2. C, D, and E, Long Lake, June 1988.....	29
3. F and G, Long Lake, June 1988.....	30
4. H and I, Long Lake, June 1988.....	31
5. J and K, Long Lake, June 1988.....	32
6. L and M, Long Lake, June 1988.....	33
7. N and O, Long Lake, June 1988.....	34
8. P and Q, Long Lake, June 1988.....	35
9. R and S, Long Lake, June 1988.....	36
10. T, U, V, and W, Long Lake, June 1988.....	37
11. X, Y, and Z, Long Lake, June 1988.....	38
12. AA, BB, CC, and DD, Long Lake, June 1988.....	39
13. EE, FF, GG, HH, and II, Long Lake, June 1988.....	40
14. JJ, KK, and LL, Long Lake, June 1988.....	41
15. Cross-section areas for transects A through LL, Long Lake, 1959 and 1988	41
16. Percentage change in cross-section areas for transects A through LL, Long Lake, 1959-88	42
17. Volume of water in Long Lake for 1959 and 1988.....	42

CONVERSION FACTORS AND VERTICAL DATUM

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
acre	0.4047	hectare
cubic foot (ft ³ /s)	0.02832	cubic meter
cubic yard (yd ³)	0.7646	cubic meter
foot (ft)	0.3048	meter
gallon (gal)	3.785	liter
gallon per day (gal/d)	0.003785	cubic meter per day
inch (in.)	2.54	centimeter
mile (mi)	1.609	kilometer
square foot (ft ²)	0.09290	square meter
square mile (mi ²)	2.590	square kilometer

Sea Level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

SEDIMENTATION IN LONG LAKE, NOBLE COUNTY, NORTHEASTERN INDIANA, 1959-88

by Danny E. Renn

ABSTRACT

Sedimentation has had little or no effect on the storage capacity or surface area of Long Lake. The lake is a natural lake that formed in unconsolidated glacial deposits. The lake is essentially two lakes: a small southern part and a large northern part. The lake receives drainage from Thumma Ditch. At the outlet of the lake, the drainage area of Thumma Ditch is 12.0 square miles. Locations where the largest amount of sediment has accumulated for the 29-year period 1959-88 are in the southern part of Long Lake where Thumma Ditch enters the lake, and in the narrow channel that connects the southern and northern parts of the lake.

In general, there has been little or no sediment accumulation in most of Long Lake. The surface-area of the lake was 1,738,000 square feet (39.9 acres) in 1959 and was 1,733,400 square feet (39.8 acres) in 1988. In 1959, the volume of water in Long Lake was 27,555,000 cubic feet; in 1988, the volume was 27,511,000 cubic feet. The amount of sediment accumulation in the lake during 1959-88 was 44,000 cubic feet. In 1988, the volume of water remaining in the lake was 99.8 percent of the 1959 volume; 0.2 percent of the 1959 lake volume had filled with sediment. The average annual rate of sediment accumulation in the lake during 1959-88 was 1,520 cubic feet per year.

Potential decreases in the storage capacity of Long Lake for the 29-year period 1989-2018 were estimated assuming steady-state conditions. The volume of water in the lake in 2018 is estimated to be 99.6 percent of the 1959 volume; 0.4 percent of the lake is estimated to be filled with sediment.

INTRODUCTION

Long Lake is located in Chain O' Lakes State Park, near the town of Burr Oak, in Noble County, northeastern Indiana (fig. 1). The lake is used for recreational purposes and is managed by the Indiana Department of Natural Resources. Accumulation of sediment in the lake can decrease the storage capacity of the lake and can affect recreational use. Therefore, information about the location, amount, annual rate of sediment accumulation, and the potential for future decreases in storage capacity is needed to effectively manage the resources of the lake. In 1987, the U.S. Geological Survey, in cooperation with the Indiana Department of Natural Resources, began a study to provide this information.

Purpose and Scope

This report presents (1) locations of sediment accumulation in Long Lake for the 29-year period 1959-88; (2) the amount and annual rate of sediment accumulation in the lake during 1959-88; and (3) estimated decreases in the storage capacity of the lake for the 29-year period 1989-2018.

Width, depth, and surface-area data were used to locate areas of sediment accumulation in Long Lake during 1959-88. Depth-contour data were used to determine the amount and the annual rate of sediment accumulation in the lake during 1959-88. The amount and annual rate of sediment accumulation were used to estimate decreases in the lake's storage capacity during 1989-2018.

Physical Setting

Long Lake is a kettle lake that formed in unconsolidated glacial deposits of the Steuben Morainal Lake Area of the Northern Moraine and Lake Region physiographic unit (Schneider, 1966, p. 41). A kettle lake is formed when a detached block of ice, which is left behind by a retreating glacier, is wholly or partly buried by glacial deposits. Long Lake is essentially two lakes (fig. 2). The small southern part, where the inlet enters, is roughly triangular in shape. This part of the lake is connected to the larger northern part by a narrow channel that widens to the north. The northern part of the lake is generally oval in shape, except where the outlet is located (fig. 2). Long Lake has an established legal level of 896 ft above sea level. This legal level was established in 1965 by the Noble County Circuit Court. The lake level is controlled by the outlet channel. In 1988, the surface-area of the lake was 39.7 acres.

Long Lake receives drainage from Thumma Ditch. Several reaches of Thumma Ditch and its tributaries have been channelized. At the outlet of the lake, the drainage area of Thumma Ditch is 12.0 mi². The drainage basin of Thumma Ditch upstream from the outlet of Long Lake is in the Steuben Morainal Lake Area of the Northern Moraine and Lake Region physiographic unit (Schneider, 1966, p. 41). The basin is underlain by the Antrim Shale of Devonian age (Johnson and Keller, 1972). The bedrock has little, if any, slope and is overlain by thick unconsolidated glacial deposits of Holocene age.

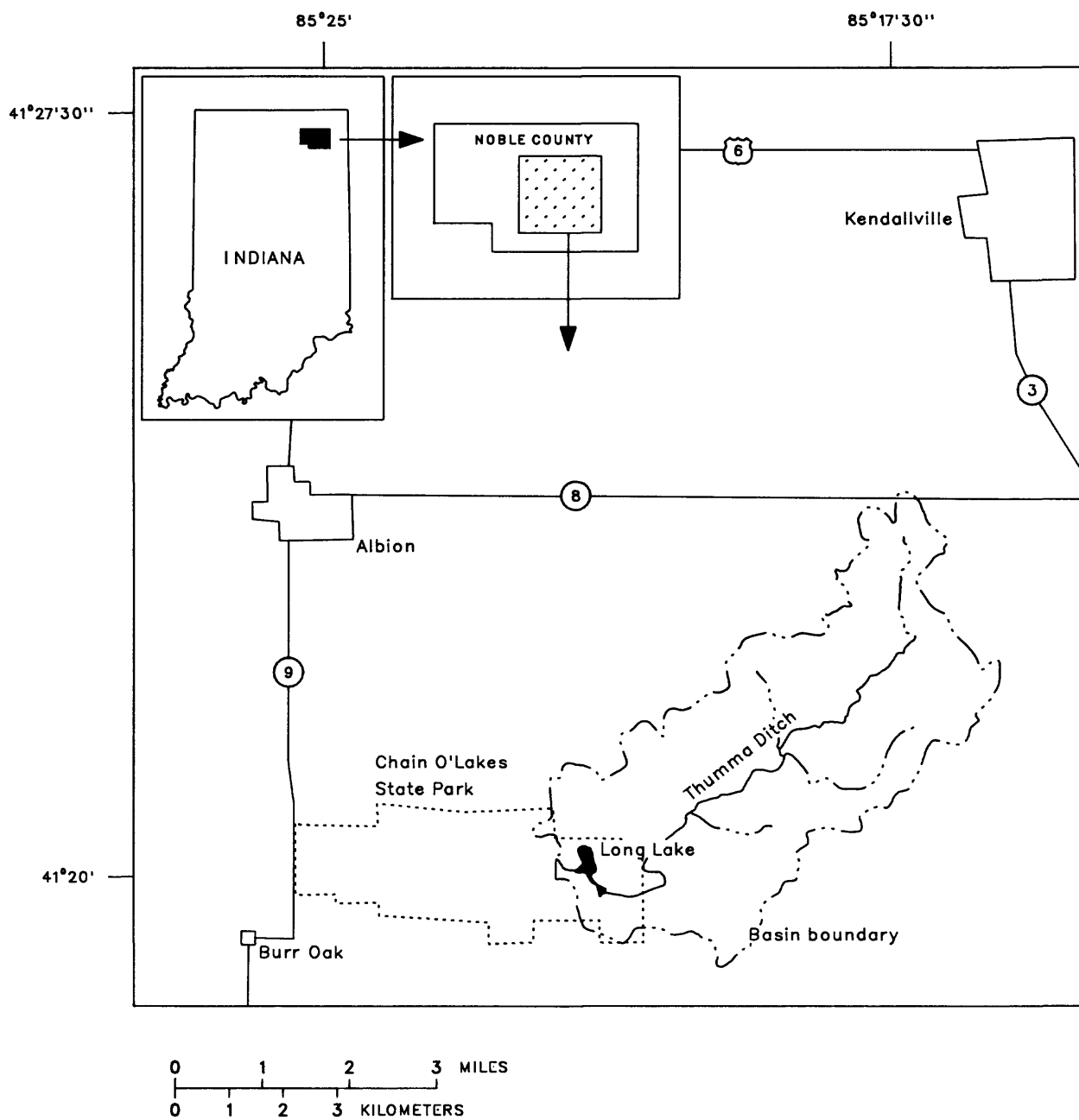


Figure 1.—Location of Long Lake and drainage basin of Thumma Ditch upstream of lake outlet.

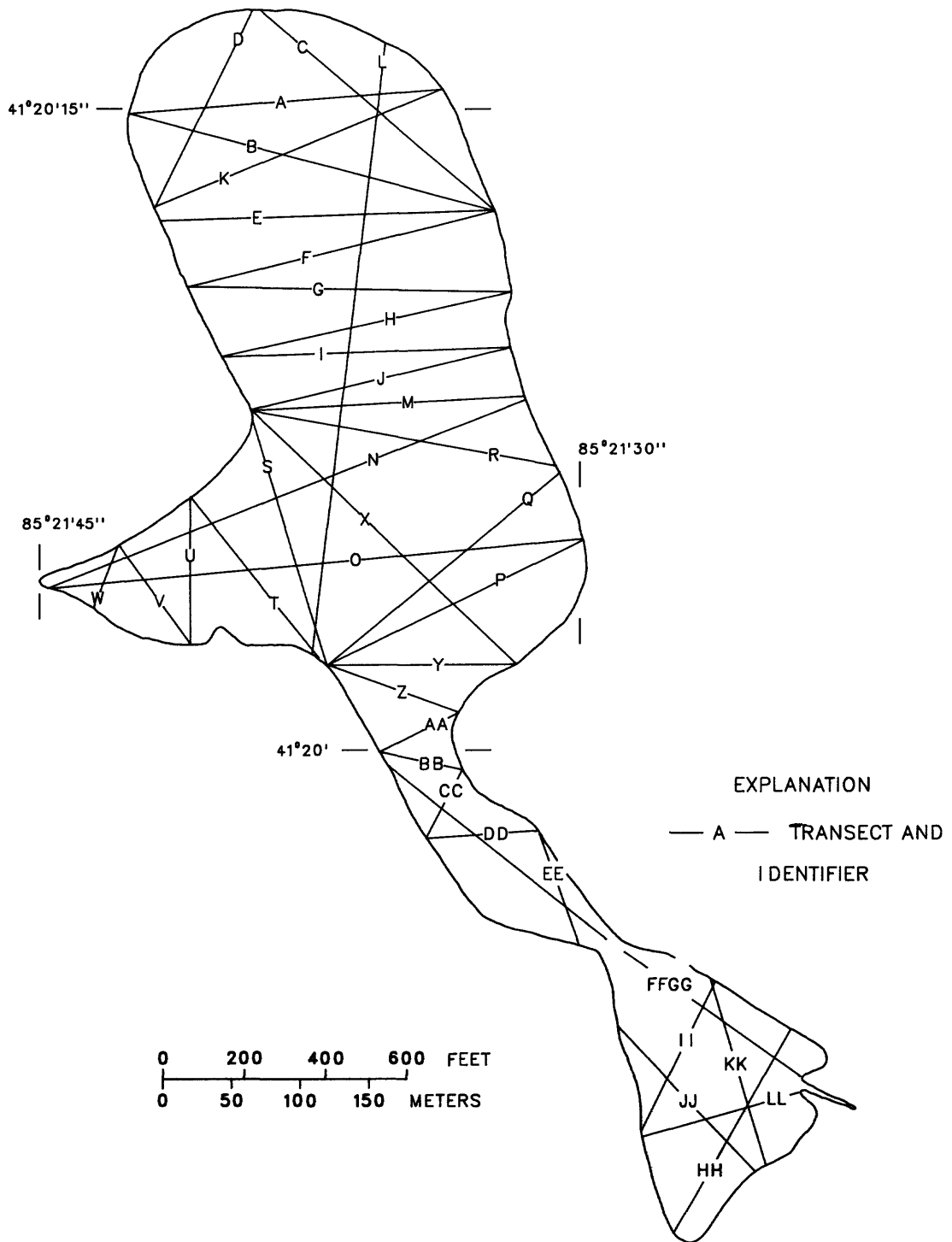


Figure 2.—Shoreline and location of transects, Long Lake.

These deposits, which range in thickness from 375 ft at Albion to 475 ft at Kendallville (fig. 1) (Stallman and Klaer, 1950, p. 20), are composed of till and end-moraine deposits (fig. 3). The till is composed of clay- to gravel-size deposits; the end-moraine is composed of clay- to boulder-size deposits. In general, the areas underlain by till are gently rolling; the areas underlain by the end-moraine are rolling to hummocky, with knob- and kettle-type topography a dominant landform.

Upstream of the inlet of Long Lake, many areas in the drainage basin of Thumma Ditch do not have a well-developed surface-water drainage system; there are many surface depressions, some of which are wetlands. In the upper part of the drainage basin, the maximum altitude of the land surface is approximately 1,040 ft above sea level; in the lower part, the maximum altitude is approximately 980 ft above sea level. The most upstream channel of Thumma Ditch has an altitude of approximately 1,000 ft above sea level; the most downstream channel has an altitude of approximately 895 ft.

The soils of the Thumma Ditch drainage basin are grouped into three major soil associations (fig. 4)--Miami, Riddles, and Brookston; Morley and Blount; and Morley and Miami (McCarter, 1977). The Miami is a loam soil, the Riddles is a sandy loam soil, and the Brookston, Morley, and Blount are silt loam soils. The Miami, Riddles, and Brookston soils range from nearly level to moderately steep and from well drained to very poorly drained. The Morley and Blount soils range from nearly level to moderately sloping and from well drained to somewhat poorly drained. The Morley and Miami soils range from moderately sloping to moderately steep and from well drained to moderately well drained. The erosion hazard for all soils is slight.

A visual inspection made during March 1989 of the drainage basin of Thumma Ditch indicates that land use within the basin is primarily agriculture, row crop and pasture, with some forest. The major crops in the basin are corn and soybeans, which usually are tilled conventionally. There are no municipalities in the basin. Ground water from the unconsolidated glacial deposits is the sole source of water for domestic and agricultural use.

METHODS OF INVESTIGATION

Long Lake width, depth, surface-area, and depth-contour data for 1959 were obtained from a 1959 depth-contour map (Indiana Department of Conservation, 1959). These data were collected during August 1959. During data collection, the lake level was 896 ft above sea level. The 1959 map provided width and depth data for 37 transects (A through LL; fig. 2). Along each transect, a depth value was determined for each contour interval. For each depth value, a corresponding width value was determined by measuring the distance from the beginning of the transect to the location of the depth value. Values for the width data were to the nearest 1 ft, and values for the depth data were to the nearest 5 ft.

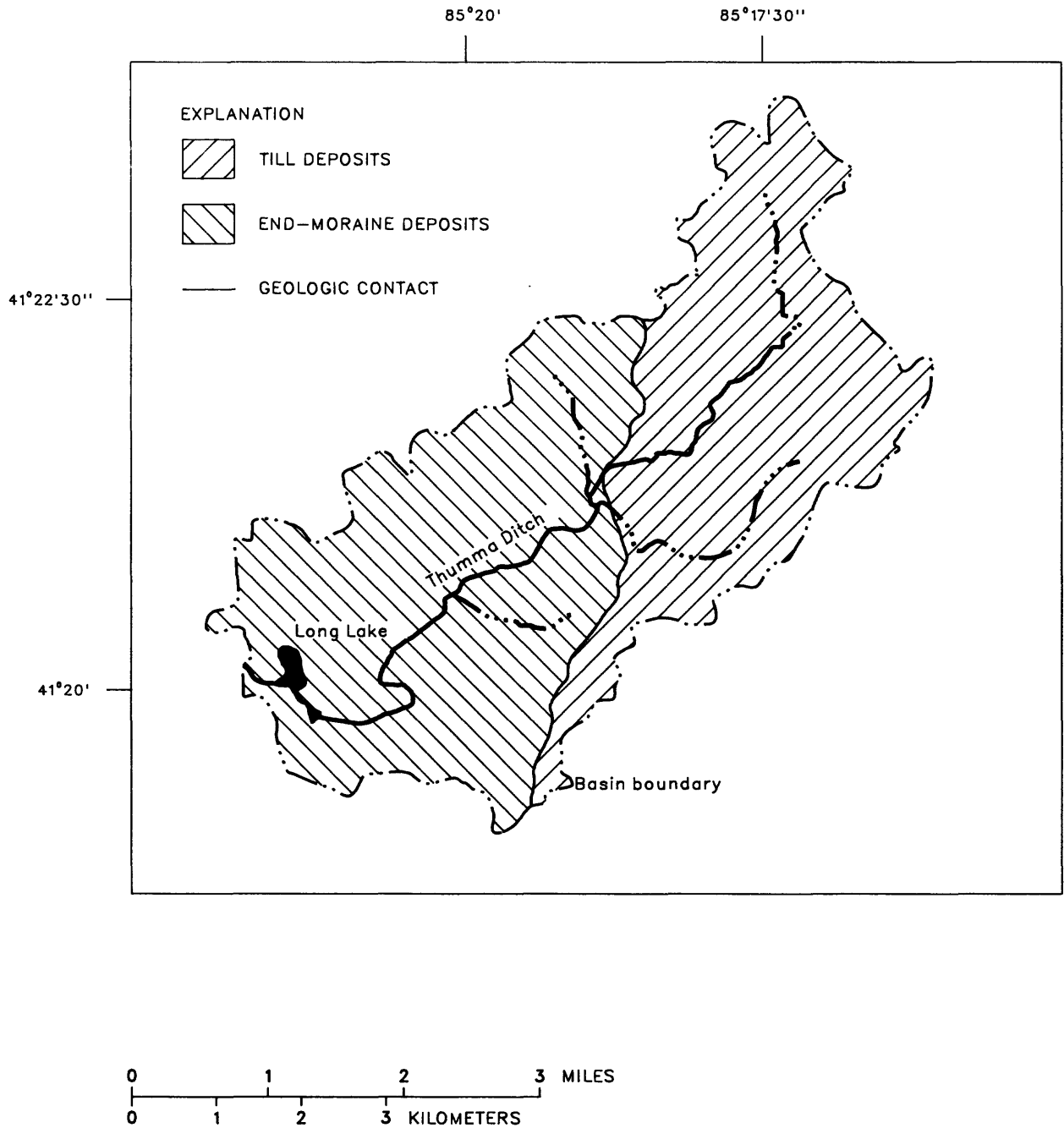


Figure 3.—Till and end-moraine deposits in drainage basin of Thumma Ditch (modified from Stallman and Klaer, 1950).

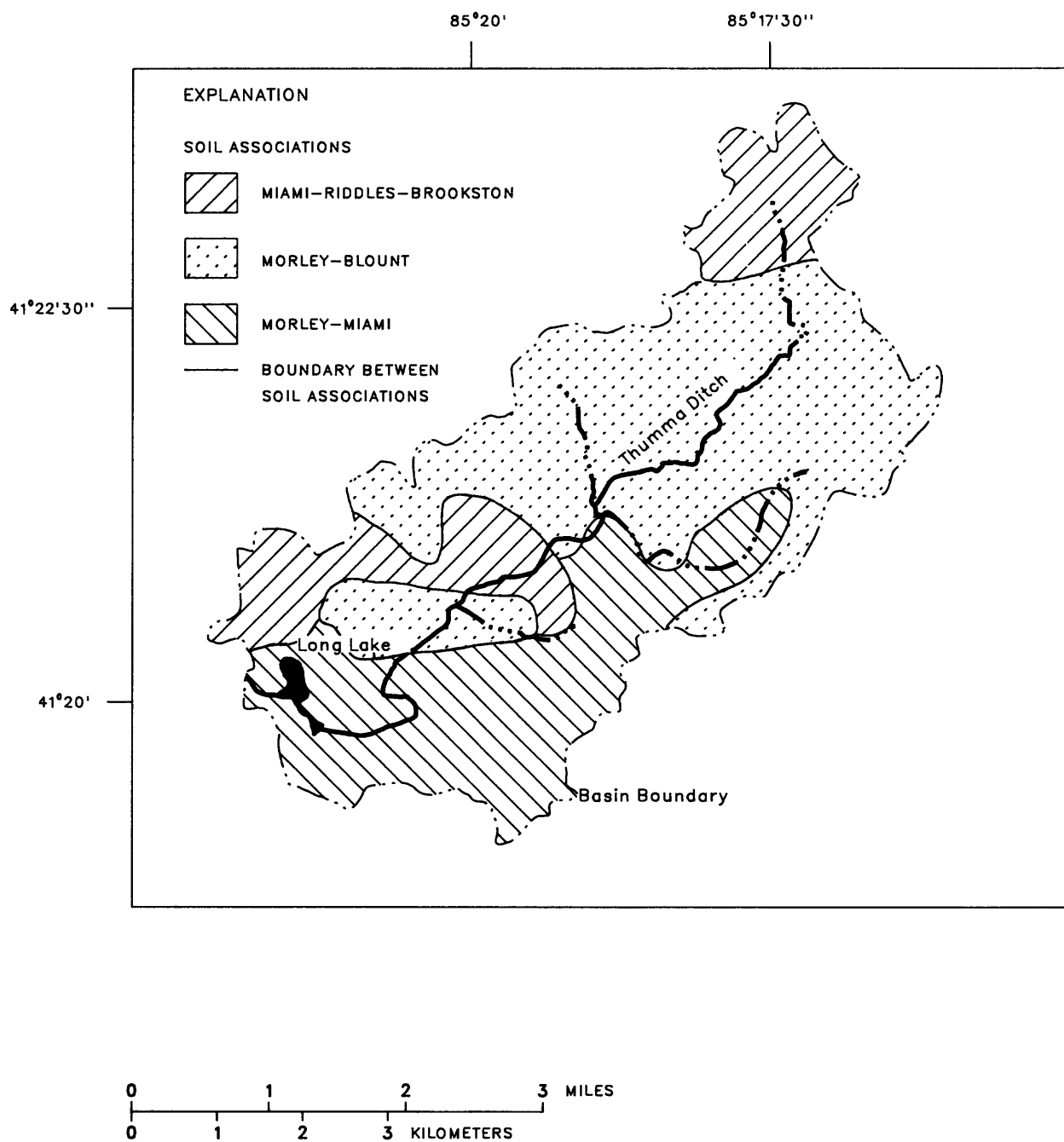


Figure 4.—Major soil associations in drainage basin of Thumma Ditch (modified from McCarter, 1977).

Depth data were collected in Long Lake during June 1988 at 37 transects (A through LL; fig. 2). During data collection, the lake level was 896 ft above sea level. A fathometer was used to measure depth; however, aquatic vegetation in the shallow (less than 9 ft) nearshore parts of the lake interfered with the fathometer signal. As a result, depth data for some of these areas are not available. Widths from the shoreline to the edge of the vegetation in the lake were estimated. A 1977 aerial photograph of the lake (Indiana Department of Highways, written commun., 1988) was used to determine transect widths and surface area for 1988. A visual inspection made during June 1988 of the lake's shoreline indicates that, with the exception of slightly greater deltaic-type deposition at the inlet of the lake, the shoreline had changed little from 1977 to 1988. The shoreline of the 1977 photograph was modified to include this change and then used to determine the transect widths and surface area for 1988.

Along each transect, a depth value was determined for each 1 ft change in the bottom elevation of the lake. For each depth value, a corresponding width value was determined by measuring the distance from the beginning of the transect to the location of the depth value. The width and depth data for 1988 (tables 1-14 in the "Supplemental Data" section at the end of the report) were used to construct a 1988 depth-contour map (fig. 5) with 2-ft contour intervals. Depth contours were estimated for depths of 8 ft or less in the northern part of the lake, for depths of 4 ft or less in the southern part of the lake, and in the channel that connects the southern part of the lake to the northern part of the lake.

SEDIMENTATION IN LONG LAKE

Areas of accumulated sediment in Long Lake from 1959-88 were identified by use of the transect width and depth data for 1959 and 1988 and the surface-area data for 1959 and 1988. The amount and the annual rate of sediment accumulation in the lake from 1959-88 were determined from the depth-contour data for 1959 and 1988.

Areas of Accumulated Sediment

Cross-sectional profiles for 37 transects of Long Lake, A through LL (figs. 6-18), were constructed from the width and depth data. Comparisons of the 1959 and 1988 profiles show where sediment has accumulated. A water-surface datum of 896 ft was used for all cross sections. The area of each cross section was measured to determine the area remaining in the cross-sectional profiles. Areas for the cross sections are given in table 15 (in the "Supplemental Data" section at the end of the report). The area remaining in the cross-sectional profiles was determined for the 37 transects. The area remaining, expressed as a percentage, was determined by dividing one cross-sectional area by another cross-sectional area and multiplying the quotients by 100 (table 16 in the "Supplemental Data" section at the end of the report).

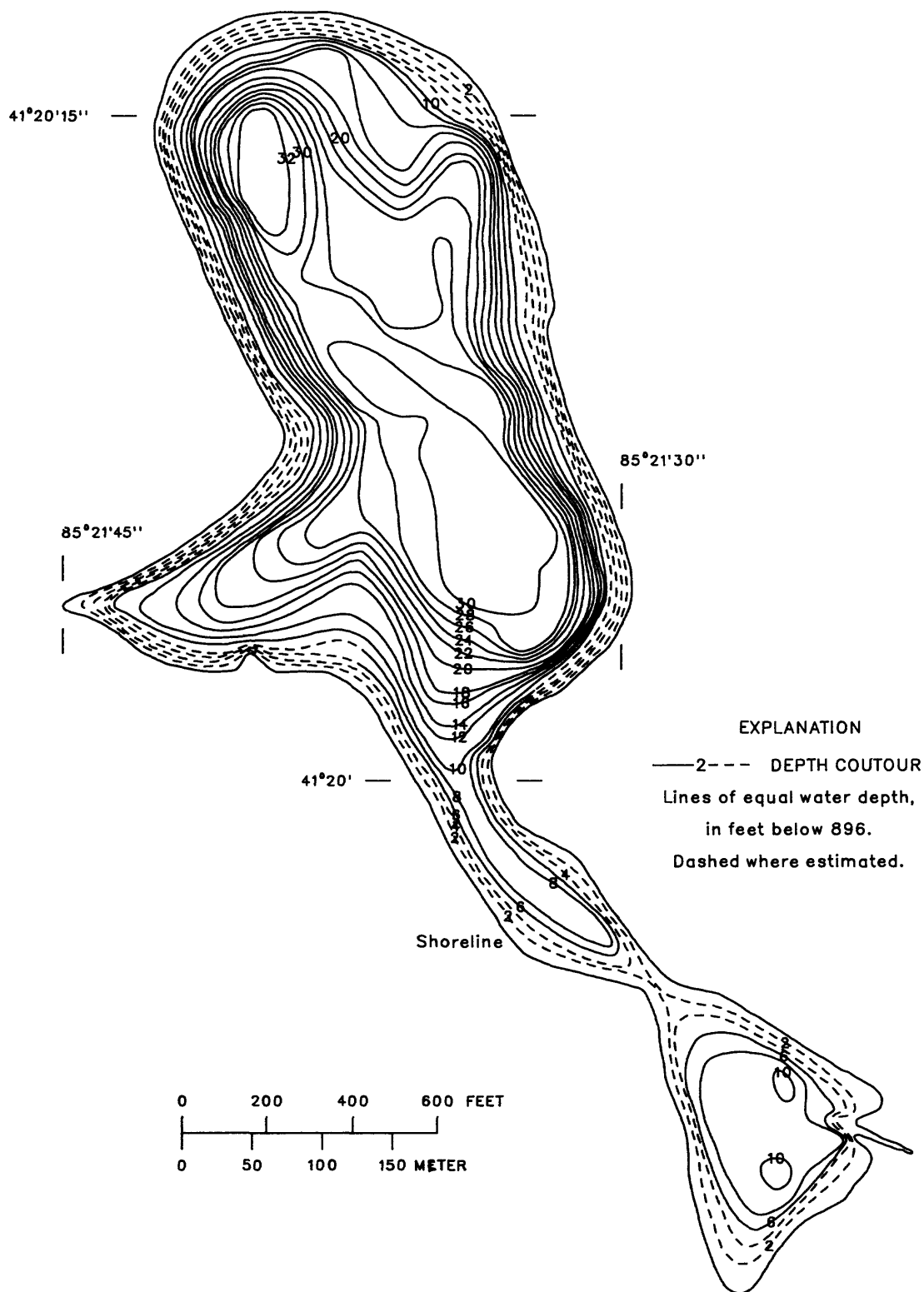


Figure 5.—Depth contours for Long Lake, June 1988.

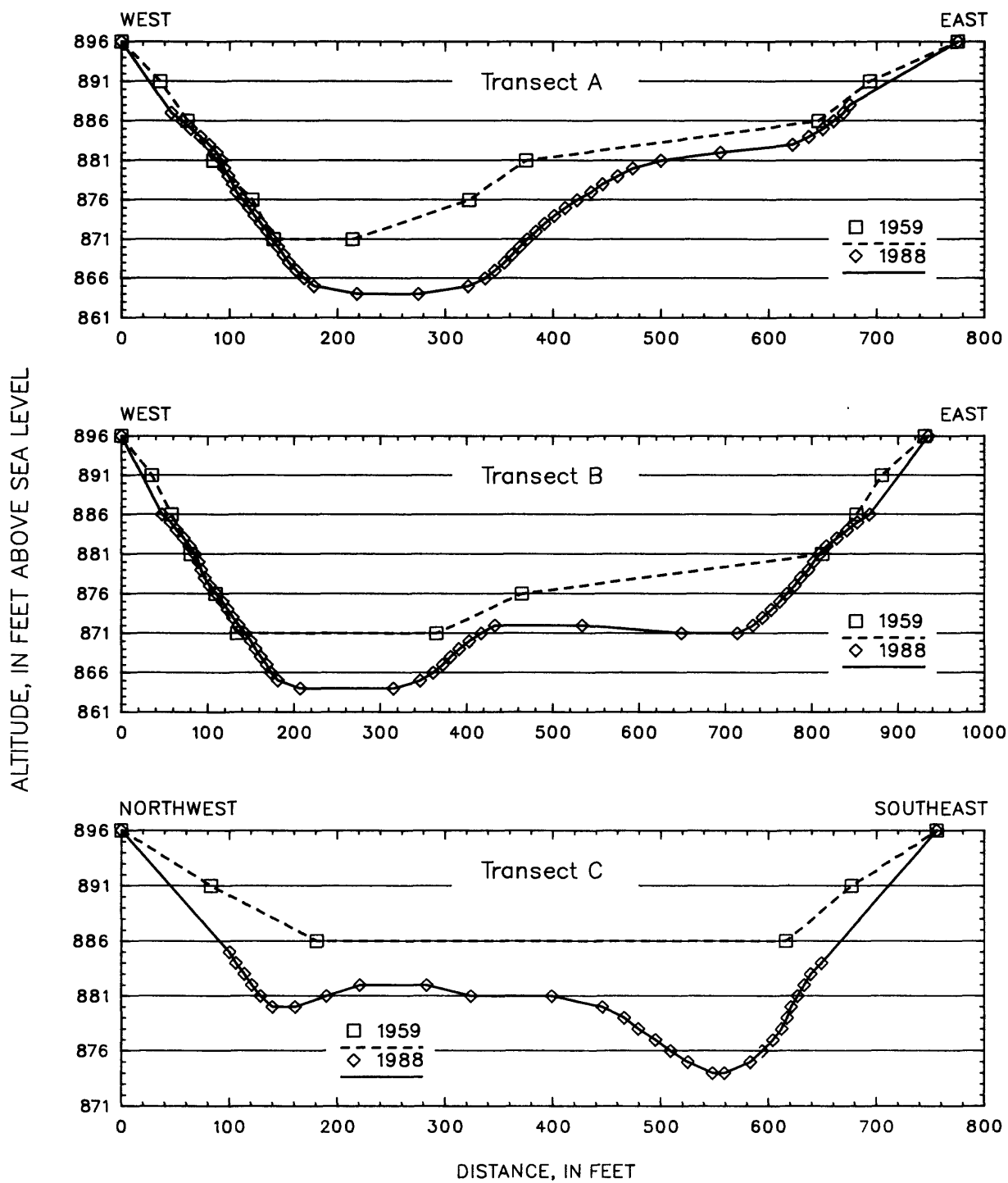


Figure 6.— Cross sections for transects A, B, and C, Long Lake, 1959 and 1988.

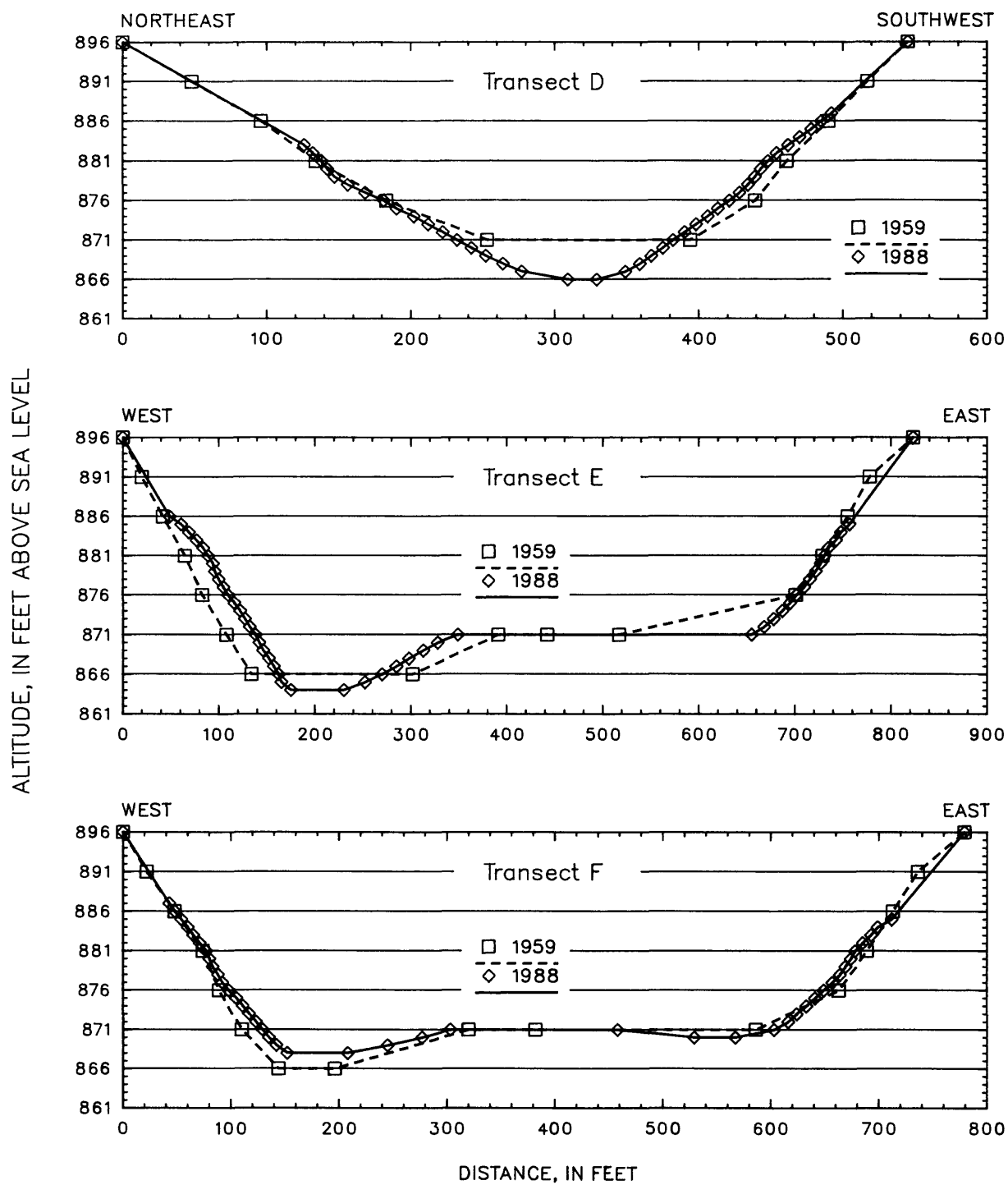


Figure 7.— Cross sections for transects D, E, and F, Long Lake, 1959 and 1988.

ALTITUDE, IN FEET ABOVE SEA LEVEL

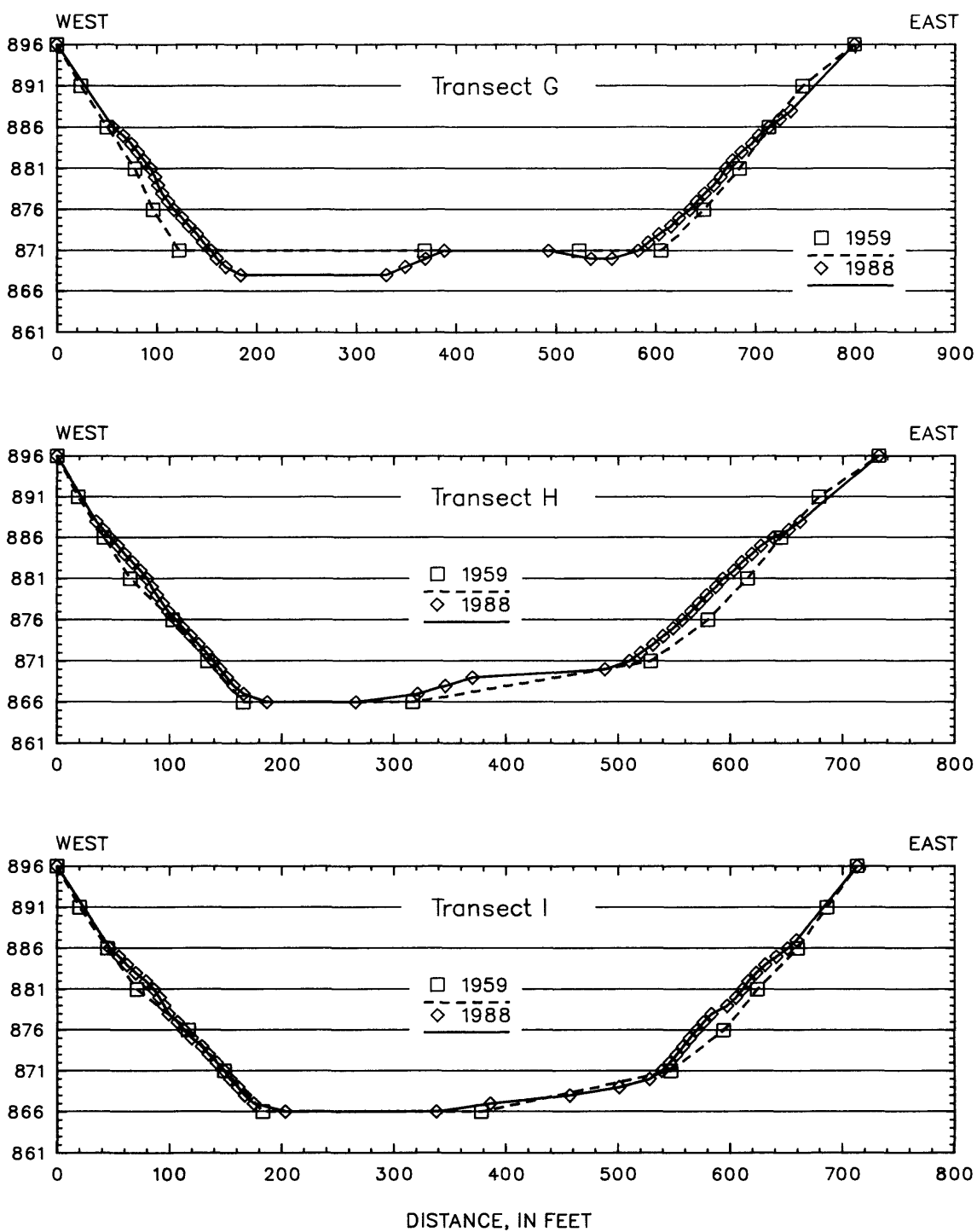


Figure 8.— Cross sections for transects G, H, and I, Long Lake, 1959 and 1988.

ALTITUDE, IN FEET ABOVE SEA LEVEL

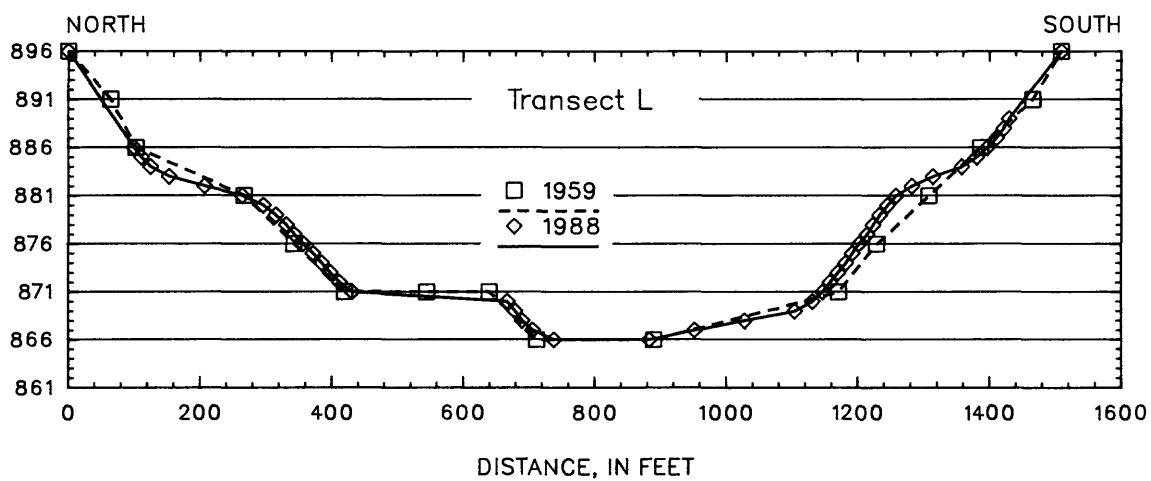
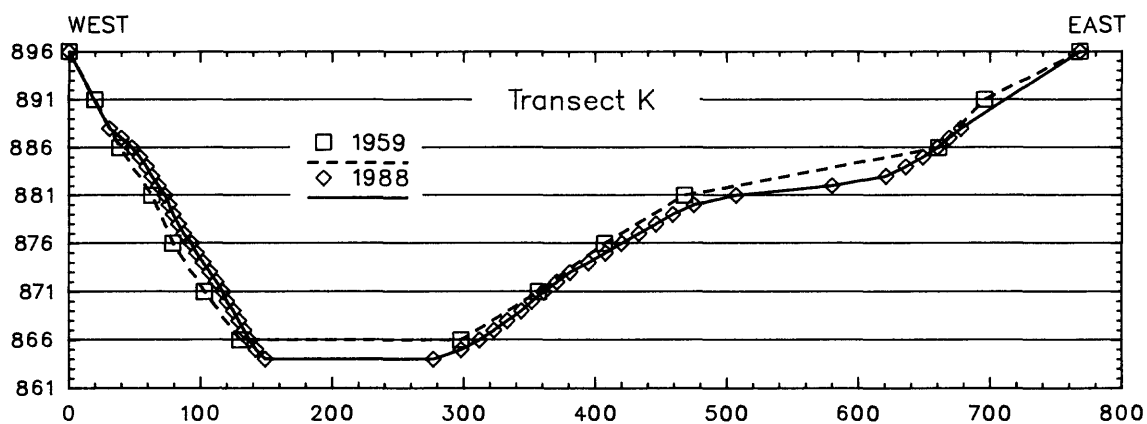
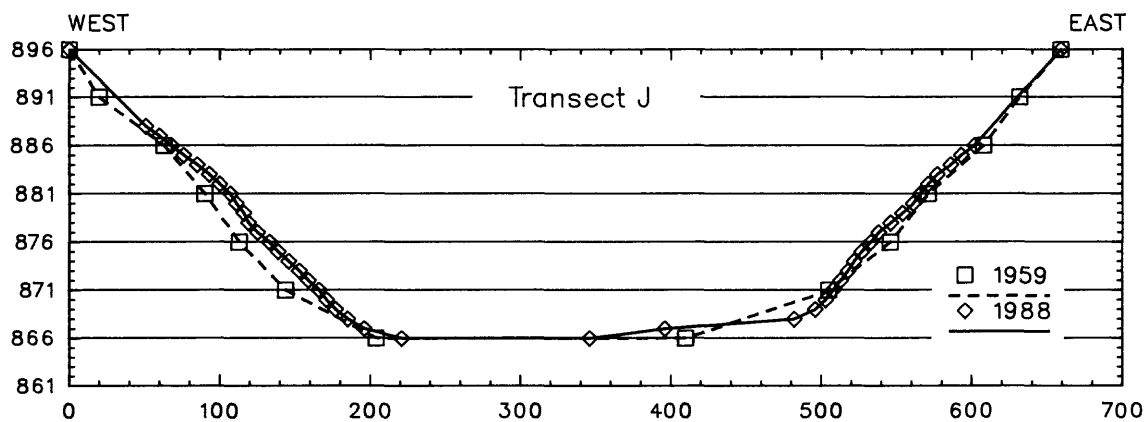


Figure 9.— Cross sections for transects J, K, and L, Long Lake, 1959 and 1988.

ALTITUDE, IN FEET ABOVE SEA LEVEL

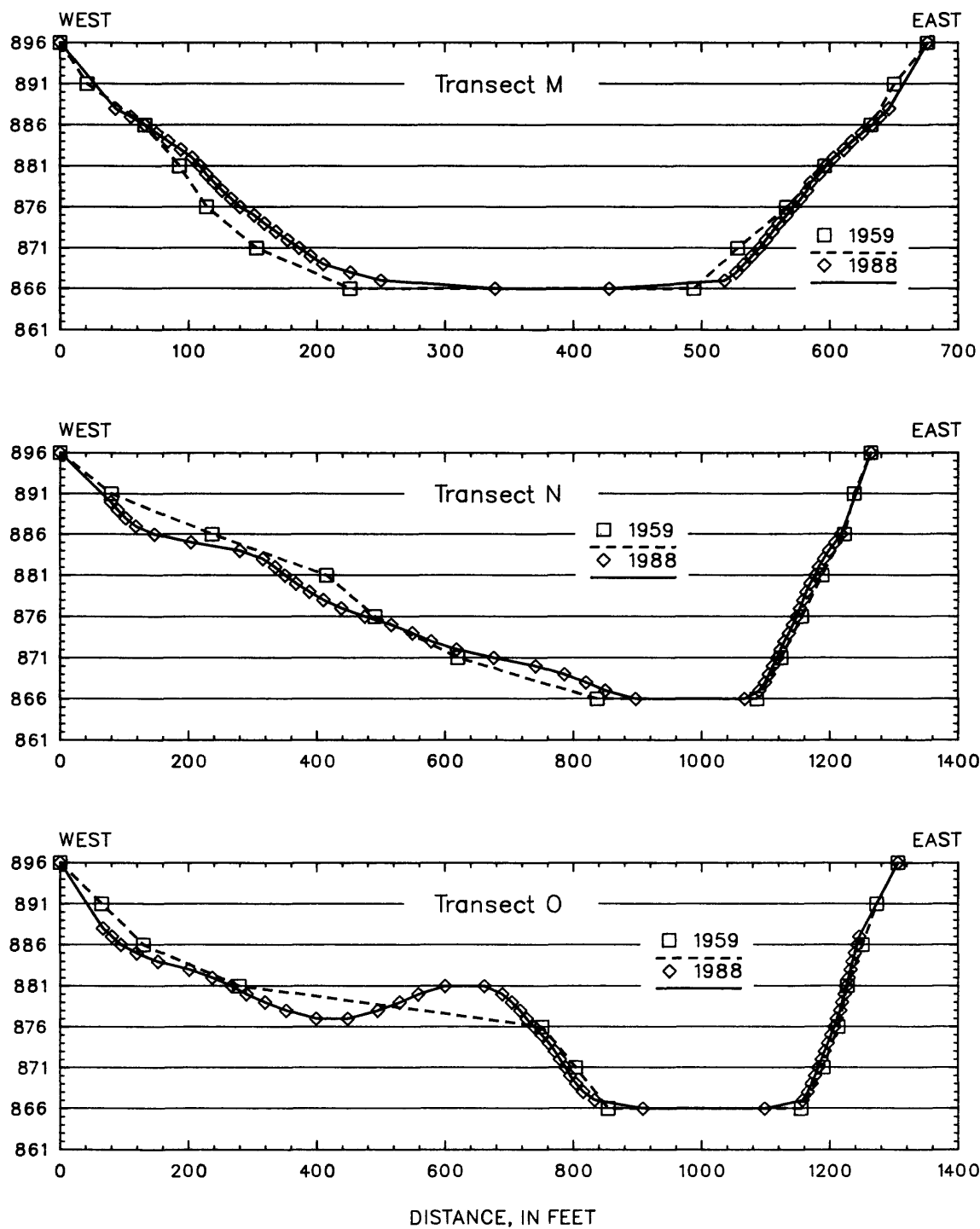


Figure 10.— Cross sections for transects M, N, and O, Long Lake, 1959 and 1988.

ALTITUDE, IN FEET ABOVE SEA LEVEL

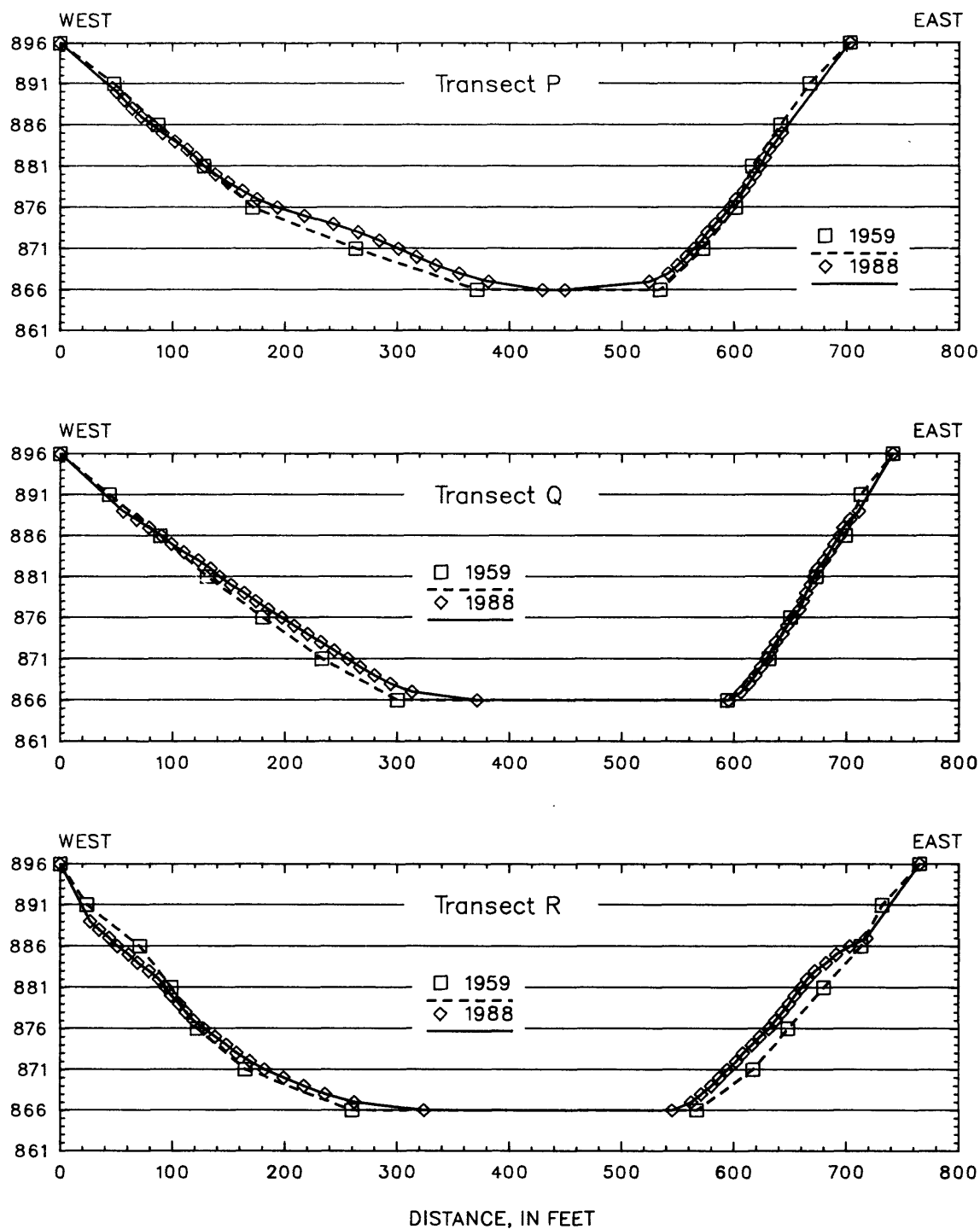


Figure 11.— Cross sections for transects P, Q, and R, Long Lake, 1959 and 1988.

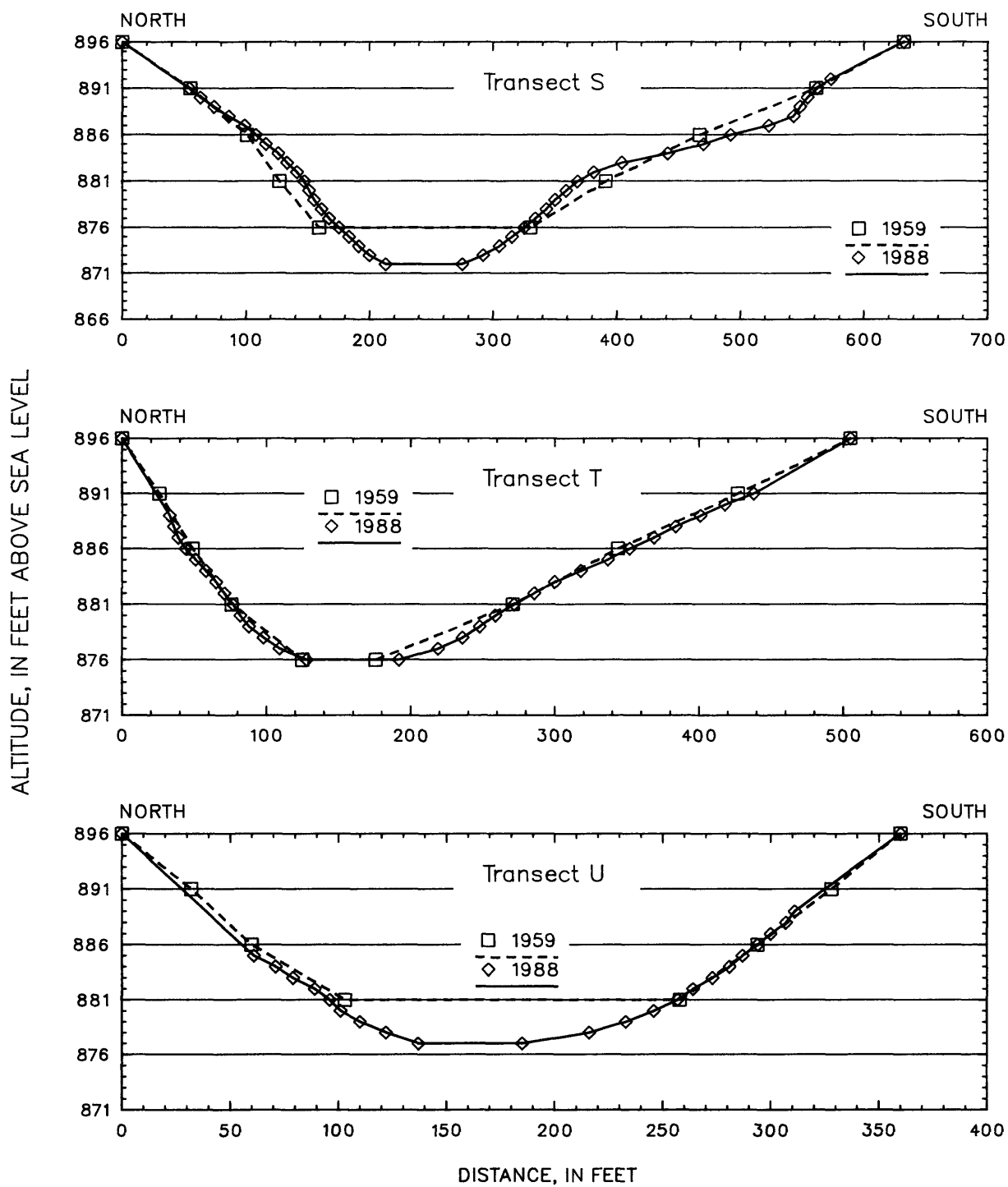


Figure 12.— Cross sections for transects S, T, and U, Long Lake, 1959 and 1988.

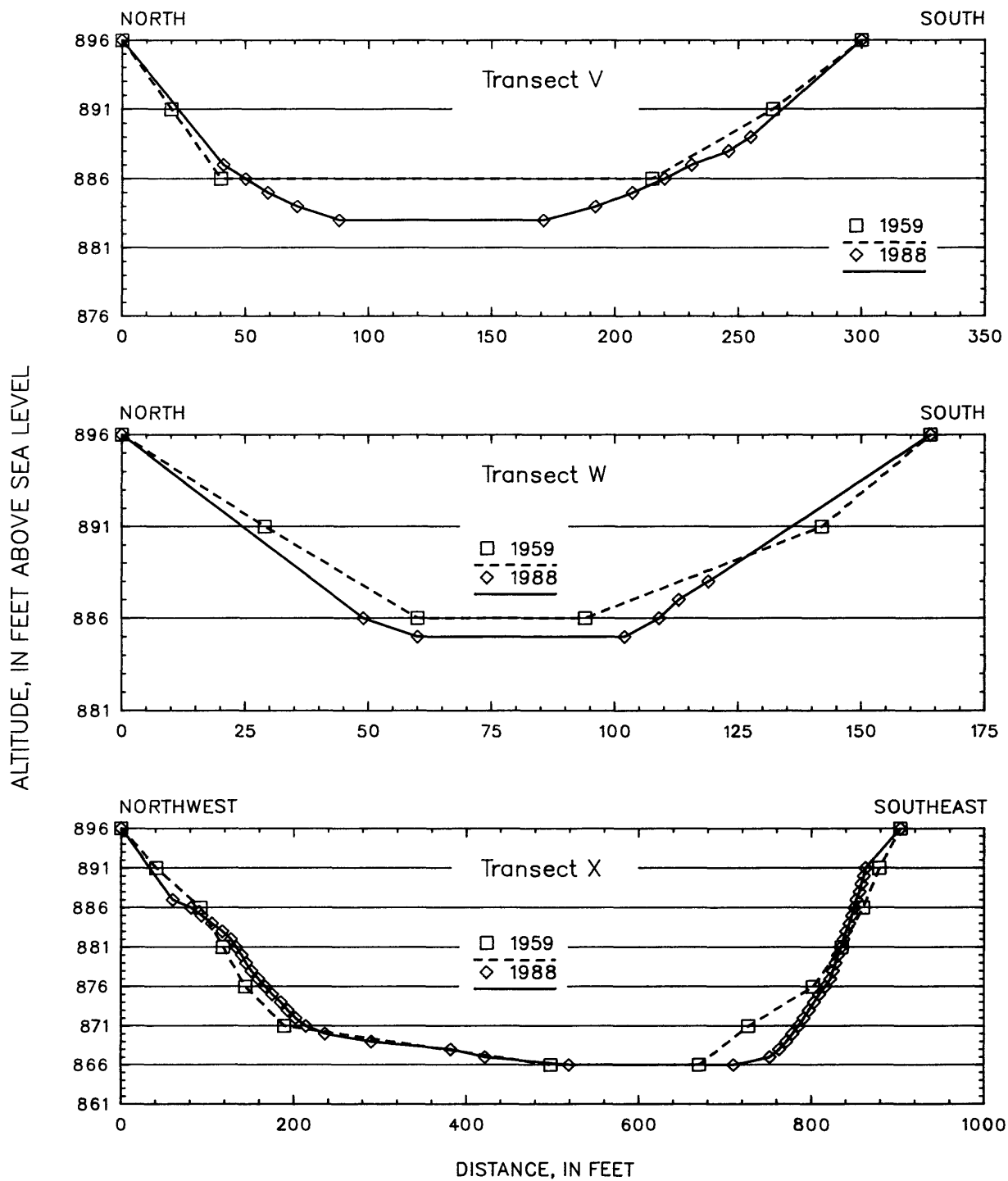


Figure 13.— Cross sections for transects V, W, and X, Long Lake, 1959 and 1988.

ALTITUDE, IN FEET ABOVE SEA LEVEL

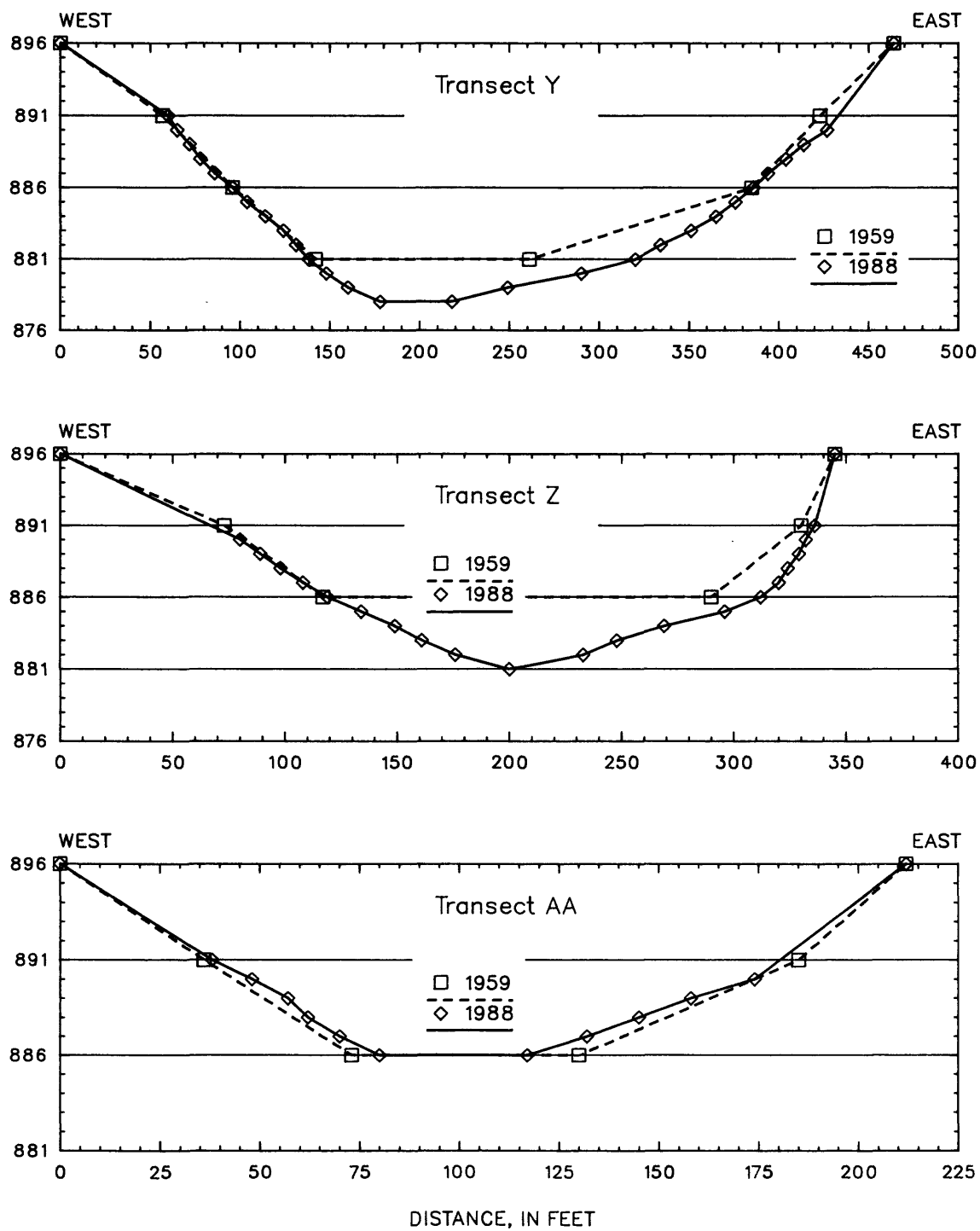


Figure 14.— Cross sections for transects Y, Z, and AA, Long Lake, 1959 and 1988.

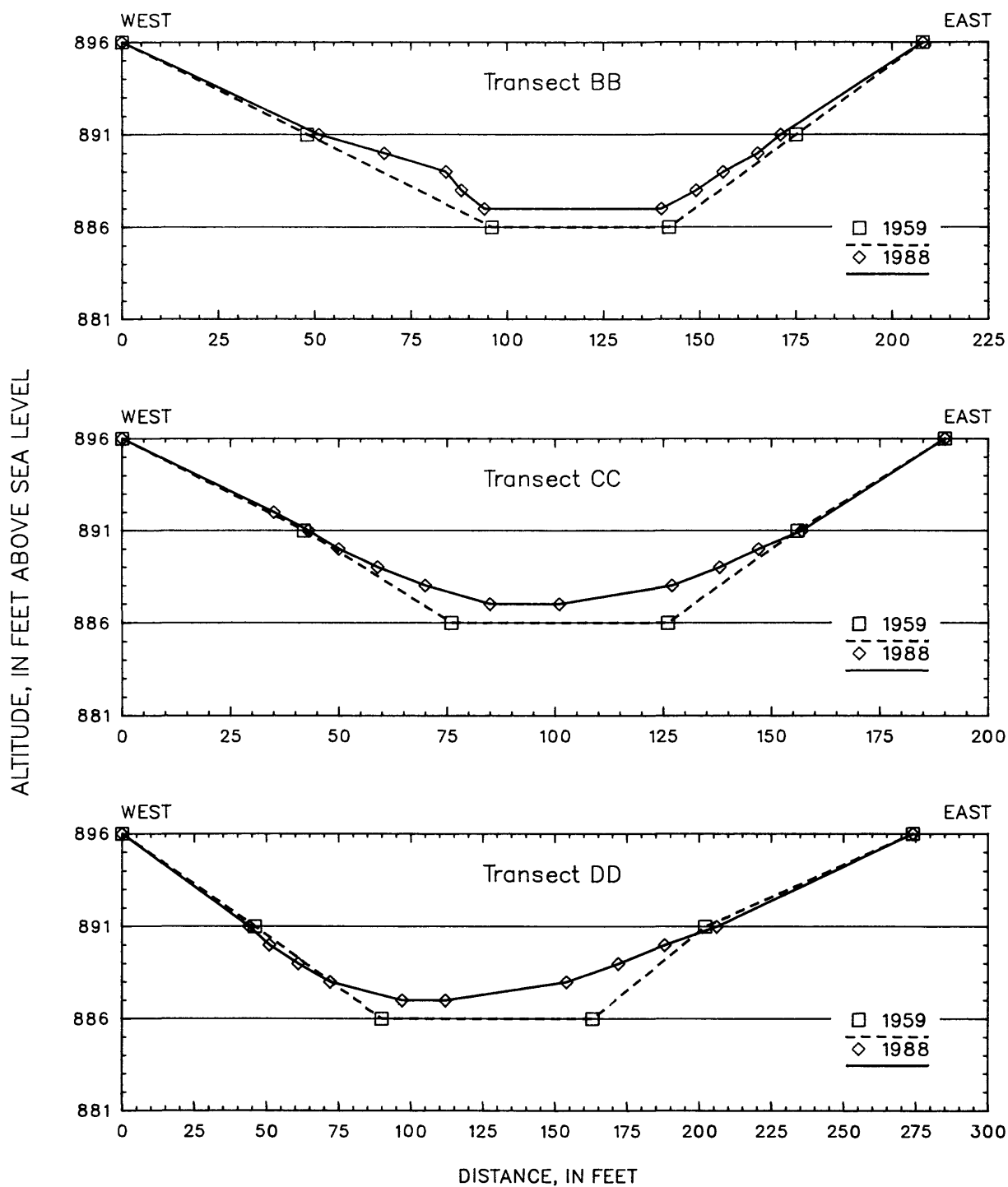


Figure 15.— Cross sections for transects BB, CC, and DD, Long Lake, 1959 and 1988.

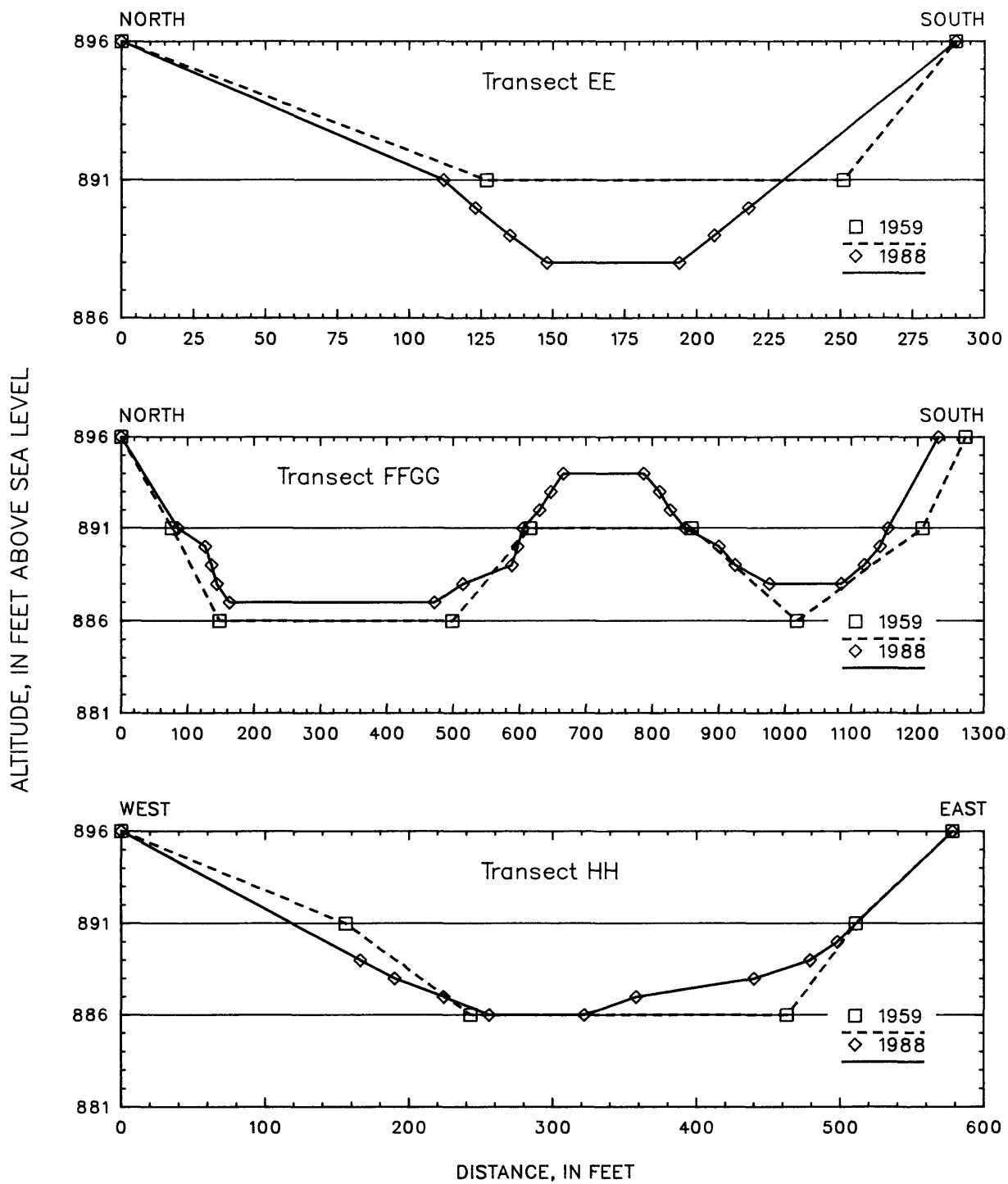


Figure 16.— Cross sections for transects EE, FFGG, and HH, Long Lake, 1959 and 1988.

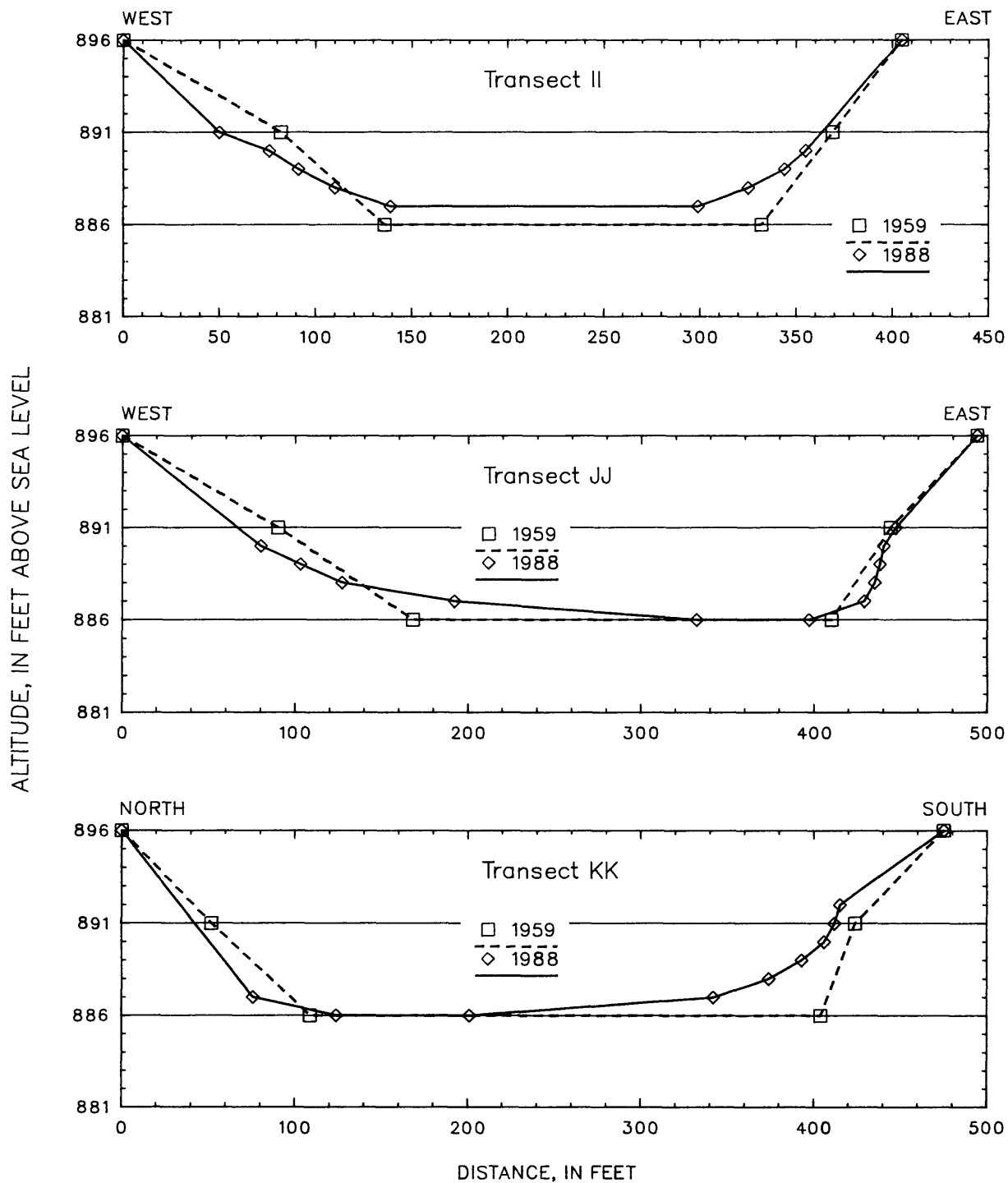


Figure 17.— Cross sections for transects II, JJ, and KK, Long Lake, 1959 and 1988.

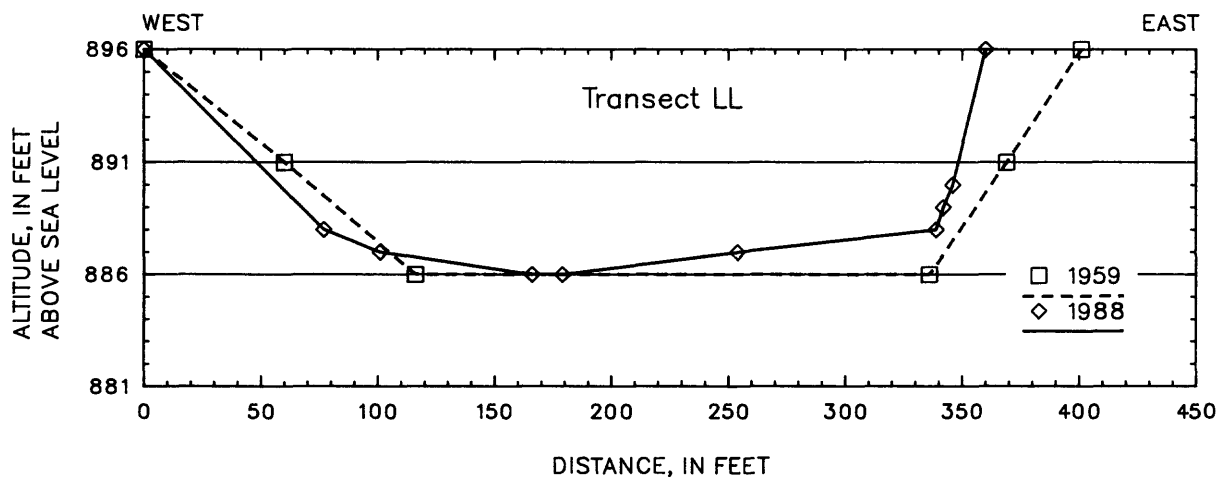


Figure 18.— Cross sections for transects LL, Long Lake, 1959 and 1988.

With transect LL as an example, the 1988 cross-sectional area of 2,790 ft² divided by the 1959 cross-sectional area of 3,100 ft² times 100 equals 90.0; that is, 90.0 percent of the 1959 cross-sectional area remains in 1988. The percent area remaining for the cross-sectional profiles ranged from 83.1 percent (transect FFGG) to 170 percent (transect C). The reason for the anomalously large increase in area for transect C could not be determined. The increases and some of the decreases in cross-sectional areas probably can be attributed to the fact that the depth values were rounded to the nearest 5 ft for 1959 and to the nearest 1 ft for 1988. The largest computed changes in area remaining for the cross-sectional profiles, which represent locations where the largest amount of sediment has accumulated, are in the southern part of the lake where Thumma Ditch enters the lake and in the narrow channel that connects the southern and northern parts of the lake. In general, there has been little or no sediment accumulation in most of the lake from 1959-88.

The 1959 surface-area data for Long Lake were obtained from the 1959 depth-contour map; the data for 1988 were obtained from the modified 1977 aerial photograph. The surface area was 1,738,000 ft² (39.9 acres) in 1959 and 1,733,400 ft² (39.8 acres) in 1988. The decrease in surface area from 1959 through 1988 was 4,600 ft² (0.106 acre). The average annual rate of surface-area decrease for the 29-year period 1959-88 is 159 ft² per year (0.004 acre). Generally, the only difference in the shoreline was in the southern part of the lake at the inlet where there was slightly greater deltaic-type deposition in 1988 than in 1959.

Amount of Accumulated Sediment

The amount and the average annual rate of sediment accumulation in Long Lake during 1959-88 and the volume of water in the lake in 1959 and 1988 were determined from the depth-contour data. The volume of water in the lake in 1988 was subtracted from the volume of water in 1959 to determine the amount of sediment that had accumulated in the lake during 1959-88 and to calculate the average annual rate of sediment accumulation. The areas encompassed by the contour lines of the 1959 and 1988 depth-contour maps were measured, multiplied by the labeled depth value, and then added to determine the volume of water in Long Lake in 1959 and 1988. The following example shows how volumes were computed for 1959:

1. The area enclosed by the shoreline and the 5-ft contour line was measured.
2. The area enclosed by the 5-ft contour line was subtracted from the area enclosed by the shoreline. The resulting value was multiplied by 2.5 ft (2.5 ft is a value halfway between zero, the shoreline, and the 5-ft contour line) to find the volume from the shoreline to the 5-ft contour line.

3. This same procedure was used for all contours. The value for contours that had no greater value than themselves was multiplied by the area enclosed by that contour.
4. All the volumes computed in steps 1-3 were added to give the 1959 volume of water in the lake.

In 1959, the volume of water in Long Lake was 27,555,000 ft³; in 1988, the volume was 27,511,000 ft³ (table 17 in the "Supplemental Data" section at the end of the report). In 1988, the volume of water remaining in the lake was 99.8 percent of the 1959 volume. The volume of water in the lake for 1988 was subtracted from the volume of water for 1959 to determine the amount of sediment that had accumulated in the lake during 1959-88, which was 44,000 ft³. By 1988, 0.2 percent of the 1959 lake volume had filled with sediment. The total amount of accumulated sediment (44,000 ft³), was divided by 29 years to determine the average annual rate of sediment accumulation in Long Lake. That annual rate is 1,520 ft³ per year.

Potential for Future Decreases in Lake Storage Capacity due to Accumulated Sediment

Potential decreases in the storage capacity of Long Lake for the 29-year period from 1989 through 2018 were estimated from the amount of sediment accumulation in the lake during 1959-88 (44,000 ft³) and the average annual rate of sediment accumulation (1,520 ft³ per year). It was assumed that the future rate of deposition would be held constant, sediment compaction would be negligible, and the trap efficiency of the lake would not change. In using the assumptions about sediment compaction and trap efficiency, the potential decreases in storage capacity would be the maximum to occur. The volume of water in Long Lake was 27,555,000 ft³ in 1959 and 27,511,000 ft³ in 1988. In 1988, the volume of water remaining in the lake was 99.8 percent of the 1959 volume; 0.2 percent of the lake had filled with sediment. The volume of water in the lake in 2018 is estimated to be 99.6 percent of the 1959 volume; 0.4 percent of the lake is estimated to be filled with sediment. Most of the new sediment probably will accumulate in the southern part of the lake near the inlet and in the narrow channel that connects the southern part of the lake to the northern part. There probably will be little new sediment accumulation in the rest of the lake at the present rate, and the storage capacity of the lake probably will not change substantially.

SUMMARY AND CONCLUSIONS

Areas of accumulated sediment in Long Lake for the 29-year period 1959-88 were identified by use of width and depth data for 1959 and 1988 and surface-area data for 1959 and 1988. Cross-sectional profiles for 37 transects of the lake were constructed by use of the width and depth data. The area of each cross section was measured to determine the amount of accumulated sediment. The area remaining, expressed as a percentage, also was determined for the 37 cross-sectional areas. The largest decreases and the largest computed percentage changes in cross-sectional areas, which represent locations where the largest amount of sediment has accumulated, are in the southern part of the lake where Thumma Ditch enters the lake and in the narrow channel that connects the southern and northern parts of the lake.

In general, there has been little or no sediment accumulation in most of the lake from 1959-88. The surface-area of the lake was 1,738,000 ft² (39.9 acres) in 1959 and 1,733,400 ft² (39.8 acres) in 1988. The amount and the average annual rate of sediment accumulation in Long Lake from 1959-88 was determined from depth-contour data for 1959 and 1988. In 1959, the volume of water in the lake was 27,555,000 ft³; in 1988, the volume was 27,511,000 ft³. The amount of sediment accumulation in the lake during 1959-88 was 44,000 ft³. In 1988, the volume of water remaining in the lake was 99.8 percent of the 1959 volume; 0.2 percent of the 1959 lake volume had filled with sediment. The average annual rate of sediment accumulation in the lake during 1959-88 was 1,520 ft³ per year.

Potential decreases in the storage capacity of Long Lake for the 29-year period 1989-2018 were estimated from the amount of sediment accumulation in the lake during 1959-88 and the average annual rate of sediment accumulation. It was assumed the future rate of deposition would be held constant, the sediment compaction would be negligible, and the trap efficiency of the lake would not change. The volume of water in the lake in 2018 is estimated to be 99.6 percent of the 1959 volume; 0.4 percent of the lake is estimated to be filled with sediment.

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SUPPLEMENTAL DATA

(Tables 1 - 17)

Table 1.--Width and depth data for transects A and B, Long Lake, June 1988

Transect A				Transect B			
Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	401	22	0	0	714	25
46	9	411	21	47	10	732	24
56	10	422	20	57	11	743	23
64	11	435	19	64	12	753	22
73	12	446	18	72	13	763	21
81	13	460	17	79	14	771	20
88	14	474	16	85	15	780	19
93	15	500	15	89	16	787	18
95	16	555	14	92	17	796	17
99	17	622	13	96	18	802	16
103	18	637	12	102	19	809	15
106	19	650	11	110	20	817	14
112	20	660	10	117	21	829	13
118	21	669	9	123	22	841	12
123	22	675	8	129	23	853	11
129	23	775	0	136	24	867	10
135	24			143	25	935	0
139	25			150	26		
145	26			155	27		
150	27			161	28		
155	28			168	29		
162	29			173	30		
169	30			181	31		
178	31			207	32		
218	32			315	32		
275	32			346	31		
321	31			361	30		
337	30			372	29		
346	29			381	28		
355	28			391	27		
362	27			403	26		
369	26			417	25		
376	25			433	24		
384	24			534	24		
392	23			649	25		

¹Measured from west to east.

²Depth below pool stage of 896 feet (above sea level).

Table 2.--Width and depth data for transects C, D, and E, Long Lake, June 1988

Transect C		Transect D				Transect E			
Width ¹	Depth ²	Width ³	Depth ²	Width ³	Depth ²	Width ⁴	Depth ²	Width ⁴	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	0	0	443	16	0	0	668	24
100	11	126	13	448	15	49	10	678	23
106	12	132	14	454	14	61	11	687	22
114	13	138	15	462	13	69	12	695	21
121	14	142	16	470	12	77	13	702	20
129	15	147	17	478	11	84	14	710	19
140	16	156	18	485	10	89	15	716	18
161	16	168	19	492	9	94	16	722	17
190	15	181	20	545	0	96	17	727	16
221	14	190	21			100	18	731	15
283	14	202	22			105	19	735	14
324	15	212	23			110	20	743	13
399	15	222	24			116	21	748	12
446	16	232	25			122	22	757	11
466	17	242	26			127	23	823	0
479	18	252	27			132	24		
495	19	264	28			138	25		
509	20	277	29			142	26		
525	21	309	30			146	27		
548	22	329	30			152	28		
559	22	349	29			157	29		
583	21	359	28			162	30		
594	20	367	27			165	31		
604	19	375	26			175	32		
612	18	382	25			230	32		
617	17	390	24			252	31		
621	16	398	23			270	30		
627	15	406	22			285	29		
633	14	413	21			298	28		
639	13	421	20			313	27		
649	12	428	19			328	26		
756	0	434	18			349	25		
		439	17			655	25		

¹Measured from northwest to southeast.

²Depth below pool stage of 896 feet (above sea level).

³Measured from northeast to southwest.

⁴Measured from west to east.

Table 3.--Width and depth data for transects F and G, Long Lake, June 1988

Transect F				Transect G			
Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	664	18	0	0	658	17
43	9	669	17	56	10	665	16
48	10	674	16	66	11	670	15
54	11	678	15	74	12	677	14
60	12	685	14	81	13	686	13
65	13	693	13	87	14	696	12
71	14	699	12	94	15	703	11
77	15	712	11	98	16	713	10
80	16	779	0	101	17	724	9
83	17			105	18	735	8
88	18			111	19	799	0
92	19			117	20		
98	20			125	21		
105	21			132	22		
111	22			140	23		
117	23			146	24		
123	24			154	25		
129	25			160	26		
135	26			169	27		
142	27			184	28		
152	28			330	28		
208	28			349	27		
245	27			369	26		
277	26			388	25		
303	25			492	25		
458	25			535	26		
529	26			556	26		
567	26			582	25		
603	25			592	24		
616	24			603	23		
624	23			615	22		
633	22			623	21		
641	21			634	20		
649	20			641	19		
657	19			649	18		

¹Measured from west to east.

²Depth below pool stage of 896 feet (above sea level).

Table 4.--Width and depth data for transects H and I, Long Lake, June 1988

Transect H				Transect I			
Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	565	19	0	0	597	17
35	8	572	18	47	10	605	16
41	9	579	17	55	11	611	15
47	10	587	16	62	12	616	14
54	11	593	15	70	13	623	13
60	12	603	14	79	14	631	12
67	13	610	13	86	15	641	11
74	14	619	12	91	16	651	10
80	15	627	11	95	17	659	9
84	16	638	10	99	18	713	0
89	17	652	9	107	19		
94	18	662	8	113	20		
99	19	732	0	120	21		
106	20			129	22		
112	21			135	23		
119	22			142	24		
126	23			149	25		
133	24			154	26		
139	25			161	27		
145	26			167	28		
151	27			175	29		
157	28			203	30		
166	29			338	30		
187	30			386	29		
266	30			457	28		
321	29			501	27		
346	28			528	26		
370	27			539	25		
488	26			546	24		
510	25			552	23		
520	24			558	22		
531	23			564	21		
540	22			570	20		
549	21			576	19		
557	20			583	18		

¹Measured from west to east.

²Depth below pool stage of 896 feet (above sea level).

Table 5.--Width and depth data for transects J and K, Long Lake, June 1988

Transect J				Transect K			
Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	538	19	0	0	381	23
51	8	546	18	31	8	395	22
60	9	554	17	40	9	408	21
68	10	561	16	48	10	420	20
76	11	566	15	54	11	433	19
85	12	571	14	59	12	446	18
93	13	577	13	63	13	459	17
100	14	586	12	68	14	475	16
107	15	593	11	73	15	507	15
111	16	602	10	76	16	580	14
116	17	659	0	79	17	621	13
119	18			83	18	636	12
125	19			87	19	649	11
133	20			93	20	660	10
139	21			97	21	669	9
146	22			102	22	678	8
153	23			107	23	768	0
159	24			112	24		
166	25			117	25		
171	26			120	26		
177	27			125	27		
185	28			129	28		
196	29			133	29		
221	30			137	30		
346	30			142	31		
396	29			149	32		
482	28			277	32		
496	27			298	31		
503	26			312	30		
508	25			323	29		
513	24			333	28		
518	23			344	27		
522	22			352	26		
527	21			361	25		
533	20			371	24		

¹Measured from west to east.

²Depth below pool stage of 896 feet (above sea level).

Table 6.--Width and depth data for transects L and M, Long Lake, June 1988

Transect L				Transect M			
Width ¹	Depth ²	Width ¹	Depth ²	Width ³	Depth ²	Width ³	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	1,223	18	0	0	571	20
100	10	1,233	17	43	8	577	19
111	11	1,245	16	55	9	582	18
125	12	1,258	15	66	10	585	17
153	13	1,282	14	75	11	592	16
207	14	1,314	13	84	12	597	15
264	15	1,358	12	94	13	603	14
296	16	1,381	11	103	14	611	13
315	17	1,397	10	109	15	617	12
331	18	1,411	9	114	16	625	11
343	19	1,422	8	120	17	633	10
357	20	1,430	7	126	18	639	9
372	21	1,509	0	133	19	646	8
385	22			140	20	676	0
398	23			151	21		
412	24			159	22		
431	25			168	23		
667	26			177	24		
679	27			186	25		
690	28			195	26		
706	29			205	27		
738	30			226	28		
883	30			250	29		
952	29			339	30		
1,028	28			428	30		
1,104	27			518	29		
1,131	26			527	28		
1,147	25			533	27		
1,158	24			539	26		
1,170	23			545	25		
1,182	22			550	24		
1,192	21			555	23		
1,202	20			560	22		
1,214	19			566	21		

¹Measured from north to south.

²Depth below pool stage of 896 feet (above sea level).

³Measured from west to east.

Table 7.--Width and depth data for transects N and O, Long Lake, June 1988

Transect N				Transect O			
Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	1,142	21	0	0	1,157	29
79	6	1,148	20	67	8	1,165	28
90	7	1,153	19	81	9	1,171	27
102	8	1,158	18	95	10	1,177	26
118	9	1,163	17	119	11	1,182	25
147	10	1,169	16	152	12	1,187	24
204	11	1,177	15	201	13	1,192	23
280	12	1,183	14	237	14	1,197	22
316	13	1,191	13	267	15	1,202	21
335	14	1,199	12	290	16	1,207	20
350	15	1,209	11	319	17	1,211	19
367	16	1,218	10	352	18	1,216	18
388	17	1,264	0	399	19	1,219	17
410	18			448	19	1,223	16
438	19			495	18	1,226	15
475	20			529	17	1,229	14
516	21			558	16	1,232	13
549	22			600	15	1,235	12
578	23			661	15	1,239	11
618	24			689	16	1,243	10
676	25			704	17	1,246	9
741	26			717	18	1,306	0
786	27			727	19		
820	28			739	20		
850	29			751	21		
897	30			762	22		
1,067	30			771	23		
1,090	29			779	24		
1,099	28			788	25		
1,105	27			795	26		
1,111	26			804	27		
1,118	25			815	28		
1,123	24			833	29		
1,129	23			908	30		
1,136	22			1,098	30		

¹Measured from west to east.

²Depth below pool stage of 896 feet (above sea level).

Table 8.--Width and depth data for transects P and Q, Long Lake, June 1988

Transect P				Transect Q			
Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	590	21	0	0	652	20
50	6	596	20	56	7	658	19
57	7	601	19	68	8	661	18
64	8	608	18	79	9	664	17
72	9	613	17	90	10	668	16
82	10	618	16	99	11	671	15
91	11	623	15	110	12	674	14
102	12	627	14	123	13	680	13
113	13	631	13	134	14	685	12
121	14	637	12	142	15	689	11
128	15	642	11	152	16	694	10
138	16	703	0	164	17	697	9
149	17			174	18	703	8
162	18			185	19	711	7
175	19			197	20	741	0
193	20			208	21		
217	21			220	22		
243	22			232	23		
265	23			244	24		
284	24			256	25		
301	25			267	26		
317	26			280	27		
334	27			294	28		
355	28			313	29		
381	29			371	30		
429	30			595	30		
449	30			606	29		
524	29			613	28		
541	28			619	27		
549	27			624	26		
557	26			629	25		
564	25			633	24		
571	24			637	23		
576	23			643	22		
583	22			647	21		

¹Measured from west to east.

²Depth below pool stage of 896 feet (above sea level).

Table 9.--Width and depth data for transects R and S, Long Lake, June 1988

Transect R				Transect S			
Width ¹	Depth ²	Width ¹	Depth ²	Width ³	Depth ²	Width ³	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	623	21	0	0	470	11
27	7	631	20	54	5	492	10
35	8	637	19	63	6	523	9
44	9	643	18	74	7	543	8
51	10	649	17	86	8	548	7
61	11	654	16	99	9	554	6
69	12	660	15	108	10	562	5
79	13	665	14	116	11	573	4
88	14	672	13	126	12	632	0
94	15	682	12	133	13		
99	16	691	11	141	14		
106	17	703	10	147	15		
112	18	718	9	151	16		
119	19	765	0	155	17		
128	20			161	18		
138	21			167	19		
148	22			175	20		
157	23			183	21		
169	24			191	22		
182	25			200	23		
199	26			213	24		
217	27			275	24		
236	28			292	23		
262	29			305	22		
324	30			315	21		
545	30			325	20		
562	29			334	19		
571	28			343	18		
580	27			350	17		
587	26			359	16		
594	25			368	15		
602	24			381	14		
608	23			404	13		
616	22			441	12		

¹Measured from west to east.

²Depth below pool stage of 896 feet (above sea level).

³Measured from north to south.

Table 10.--Width and depth data for transects T, U, V, and W, Long Lake, June 1988

Transect T		Transect U		Transect V		Transect W	
Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	0	0	0	0	0	0
33	7	61	11	41	9	49	10
36	8	71	12	50	10	60	11
39	9	79	13	59	11	102	11
44	10	89	14	71	12	109	10
51	11	96	15	88	13	113	9
58	12	101	16	171	13	119	8
65	13	110	17	192	12	164	0
71	14	122	18	207	11		
77	15	137	19	220	10		
82	16	185	19	231	9		
88	17	216	18	246	8		
98	18	233	17	255	7		
109	19	246	16	300	0		
128	20	257	15				
192	20	264	14				
219	19	273	13				
236	18	281	12				
248	17	287	11				
259	16	294	10				
272	15	300	9				
286	14	307	8				
300	13	311	7				
318	12	360	0				
337	11						
352	10						
369	9						
384	8						
401	7						
418	6						
438	5						
505	0						

¹Measured from north to south.

²Depth below pool stage of 896 feet (above sea level).

Table 11.--Width and depth data for transects X, Y, and Z, Long Lake, June 1988

Transect X				Transect Y		Transect Z	
Width ¹	Depth ²	Width ¹	Depth ²	Width ³	Depth ²	Width ³	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	816	20	0	0	0	0
60	9	822	19	60	5	80	6
81	10	825	18	65	6	89	7
93	11	828	17	72	7	98	8
105	12	831	16	78	8	108	9
117	13	834	15	86	9	119	10
127	14	837	14	96	10	134	11
133	15	840	13	104	11	149	12
140	16	844	12	114	12	161	13
145	17	847	11	124	13	176	14
151	18	850	10	131	14	200	15
159	19	852	9	138	15	233	14
167	20	856	8	148	16	248	13
175	21	858	7	160	17	269	12
185	22	861	6	178	18	296	11
193	23	863	5	218	18	312	10
202	24	903	0	249	17	320	9
214	25			290	16	324	8
236	26			320	15	329	7
290	27			334	14	332	6
382	28			351	13	336	5
422	29			365	12	345	0
519	30			376	11		
710	30			386	10		
752	29			394	9		
763	28			404	8		
771	27			414	7		
778	26			427	6		
785	25			464	0		
791	24						
797	23						
803	22						
809	21						

¹Measured from northwest to southeast.

²Depth below pool stage of 896 feet (above sea level).

³Measured from west to east.

Table 12.--Width and depth data for transects AA, BB, CC, and DD, Long Lake, June 1988

Transect AA		Transect BB		Transect CC		Transect DD	
Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²	Width ¹	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	0	0	0	0	0	0
38	5	51	5	35	4	44	5
48	6	68	6	43	5	51	6
57	7	84	7	50	6	61	7
62	8	88	8	59	7	72	8
70	9	94	9	70	8	97	9
80	10	140	9	85	9	112	9
117	10	149	8	101	9	154	8
132	9	156	7	127	8	172	7
145	8	165	6	138	7	188	6
158	7	171	5	147	6	206	5
174	6	208	0	157	5	274	0
212	0			190	0		

¹Measured from west to east.

²Depth below pool stage of 896 feet (above sea level).

Table 13.--Width and depth data for transects EE, FFGG, HH, and II, Long Lake,
June 1988

Transect	EE	Transect	FFGG	Transect	HH	Transect	II
Width ¹	Depth ²	Width ¹	Depth ²	Width ³	Depth ²	Width ³	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	0	0	0	0	0	0
112	5	85	5	166	7	50	5
123	6	126	6	190	8	76	6
135	7	136	7	224	9	91	7
148	8	144	8	256	10	110	8
194	8	163	9	322	10	139	9
206	7	472	9	358	9	299	9
218	6	515	8	440	8	325	8
290	0	589	7	479	7	344	7
		597	6	498	6	355	6
		605	5	578	0	405	0
		630	4				
		647	3				
		666	2				
		787	2				
		811	3				
		827	4				
		849	5				
		900	6				
		925	7				
		977	8				
		1,085	8				
		1,120	7				
		1,143	6				
		1,155	5				
		1,231	0				

¹Measured from north to south.

²Depth below pool stage of 896 feet (above sea level).

³Measured from west to east.

Table 14.--Width and depth data for transects JJ, KK, and LL, Long Lake, June 1988

Transect JJ		Transect KK		Transect LL	
Width ¹	Depth ²	Width ³	Depth ²	Width ¹	Depth ²
(feet)	(feet)	(feet)	(feet)	(feet)	(feet)
0	0	0	0	0	0
80	6	76	9	77	8
103	7	124	10	101	9
127	8	201	10	166	10
192	9	342	9	179	10
332	10	374	8	254	9
397	10	393	7	339	8
429	9	406	6	342	7
435	8	412	5	346	6
438	7	415	4	360	0
440	6	475	0		
447	5				
494	0				

¹Measured from west to east.²Depth below pool stage of 896 feet (above sea level).³Measured from north to south.

Table 15.--Cross-section areas for transects A through LL, Long Lake, 1959 and 1988

Transect	Cross-section area (square feet)		Transect	Cross-section area (square feet)	
	1959	1988		1959	1988
A	10,800	13,900	S	7,680	7,980
B	16,500	20,500	T	5,840	6,050
C	5,940	10,100	U	3,940	4,450
D	8,950	9,290	V	2,410	2,820
E	18,000	17,900	W	1,060	1,160
F	16,600	16,300	X	20,300	20,600
G	15,900	16,100	Y	4,730	5,290
H	15,600	15,000	Z	2,580	3,220
I	15,800	15,400	AA	1,420	1,350
J	14,300	13,800	BB	1,270	1,130
K	13,800	14,300	CC	1,170	1,060
L	30,400	30,200	DD	1,640	1,510
M	15,000	14,600	EE	1,040	1,270
N	24,200	24,500	FFGG	9,100	7,560
O	24,600	24,800	HH	3,770	3,710
P	14,100	13,800	II	2,940	2,780
Q	16,000	15,800	JJ	3,600	3,650
R	17,200	16,900	KK	3,780	3,570
			LL	3,100	2,790

Table 16.--Percentage change in cross-section areas for transects A through LL, Long Lake, 1959-1988

Transect	Percentage change	Transect	Percentage change
A	129	S	104
B	124	T	104
C	170	U	113
D	104	V	117
E	99.4	W	109
F	98.2	X	101
G	101	Y	112
H	96.2	Z	125
I	97.5	AA	95.1
J	96.5	BB	89.0
K	104	CC	90.6
L	99.3	DD	92.1
M	97.3	EE	122
N	101	FFGG	83.1
O	101	HH	98.4
P	97.9	II	94.6
Q	98.8	JJ	101
R	98.3	KK	94.4
		LL	90.0

Table 17.--Volume of water in Long Lake for 1959 and 1988

Year	Volume of water			
	cubic-feet	cubic-yards	acre-feet	gallons
1959	27,555,000	1,021,000	633	206,111,000
1988	27,511,000	1,019,000	632	205,782,000