RECENT SEDIMENT ACCUMULATION IN LAKE GEORGE, LAKE COUNTY, HOBART, INDIANA

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A Cooperative Undertaking by the U.S. Army Corps of Engineers Chicago District and the U.S. Geological Survey, Woods Hole, MA

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INTRODUCTION

Purpose

In the spring of 1994, the Chicago District of the U. S. Army Corps of Engineers requested the U.S. Geological Survey to conduct a geophysical study of Lake George, a small, man-made lake in Hobart, Indiana (Fig. 1). The purpose of the study was to assess the thickness of sediments that have almost filled the lake since the area was flooded by a small dam first constructed in 1840 on Deep River. Because the lake had filled with sediment to a level that has limited its recreational and aesthetic value to the community, Congressional funding was authorized to dredge the lake to its original depth. Thus, information on sediment volume was essential to plan and carry out the dredging operation.

Geologic and Hydrologic Setting

The area (Fig. 1), located on the gently dipping northeast flank of the Kankakee Arch, is underlain by Silurian limestones, dolomites, and shales veneered by glacial till and lacustrine sediments (Patton, 1956). Physiographically, it forms part of the Calumet Lacustrine Plain.

Deep River is part of a fluvial system that drains about 10% of Indiana northward into the Great Lakes basin. Just north of Lake George it becomes the Little Calumet River that flows into Lake Michigan (Crawford and Mansue, 1988). Lake George is fed by several small meandering streams the largest of which are Deep River and Turkey Creek. The damming of the main stream, Deep River, produced a narrow, sinuous lake that is approximately 5 km long and as much as 300 m wide. From 1948 to 1993, the mean flow rate out of the lake at a gaging station 122 m downstream from the dam was 3.2 m^3/sec or 114 ft^3/sec (Stewart and others, 1994).

Previous Work

The only previous effort to measure accumulated sediment thickness in the lake that we are aware of was carried out on a contract from the Corps of Engineers and is unpublished (U.S. Army Corps of Engineers, written commun.). In this study, carried out in September, 1991, the thickness of the sediment deposited since the lake formed, henceforth referred to as lacustrine sediment, was measured by pushing a probe into the sediments until it met resistance along eleven profiles. Five representative profiles from this survey are shown in Fig. 2 and their locations are shown in Figure 4. Hydrologic data in the area of the lake have been acquired by the Water Resources Division of the U.S. Geological Survey since 1947 (Stewart and others, 1994).

Basin 1 (Fig. 3) was dredged intermittently from 1980 to 1984. The amount of sediment removed, however, is not known. Water is deeper and lacustrine sediments thinner on our geophysical records in Basin 1 than in the other basins which may be the results of that operation.

METHODS

The cruise was carried out from April 5-8, 1994 aboard a 4.9 m (16 ft) open boat operated by the Corps of Engineers. Thirty-four profiles (Fig. 3) were run covering a total distance of 12 km at a speed of about 5.7 km/hr.

The southwestern half of the lake is less than 2 ft (0.6 m) deep and hence too shallow for the survey boat to navigate. The navigable northeastern half of the lake was divided into 4 basins. From northeast to southwest 14 lines were run in basin 1, 6 lines in basin 2, 12 lines in basin 3, and 16 lines in basin 4 (Fig. 3).

Because of the shallow water throughout the lake, several subbottom profiling systems with different acoustic characteristics were evaluated to determine which could achieve the best resolution of the shallow reflectors. These included a 3.5/200 kHz Datasonics SBT-220 pinger, a 1-10 kHz Datasonics CAP 6000A chirp acoustic profiler, and an Odem Echotrac 3200 dual frequency (24kHz/200 kHz) system.

The Echotrac provided the best bathymetric (200 kHz) and subbottom (24kHz) data and was used throughout the survey. A sidemount for the boat was constructed to support the transducer. Power was provided with a portable Honda generator. Differential GPS navigation provided

1-2 m accuracy. A local navigation network was established by tranferring a known benchmark position to a local site. From that site, GPS corrections were transmitted via VHF line-of-sight radio to the survey boat on the lake. This technique permitted the use of real-time differential GPS.

On the seismic records, the lake bottom and a subbottom interface between what we interpeted to be the original lake bottom were picked. The difference between these two horizons was a measure of the amount of sediment that has accumulated in the lake since the dam was built. These thickness values were recorded at 1-minute intervals along each track and are presented in Figure 4. They then were contoured at 2-foot intervals yielding an isopachous map of the accumulated lacustrine sediment thickness (Fig. 5).

Because of a discrepancy in some areas of the lake between the interpreted sediment thickness acquired with geophysics and the sediment thickness acquired previously with a probe (Fig. 2), another set of probe measurements was carried out in May, 1994 by the second author of this paper (U. S. Army Corps of Engineers) with a steel rod (3/8" or 0.95 cm diameter) at 13 locations in Basin 1, at 2 locations in Basin 2, at 12 locations in Basin 3, and at 17 locations in Basin 4 (Fig. 4; Table 1). Each probe measurement was located by compass bearing and by making an estimate of distance from shore. These locations, thus, are only approximate, whereas the error in geophysical data point locations is only 1-2 meters

RESULTS

The bathymetric data show that the lake is mostly flat-floored, but water depths decrease slightly upstream from the dam at the northern end of Basin 1 (Table 1). Based on geophysical data in Basin 1, closest to the dam, water depths measured acoustically ranged from 2 ft (0.6 m) to 7 ft (2.1 m) and probe depths averaged 6 ft (1.8 m). In Basin 2, geophysical depths ranged from 2 ft (0.6 m) to 5 ft (1.5 m) and probe depths averaged 5 ft (1.5 m). In Basin 3 geophysical depths ranged from 1.5 ft (0.5 m) to 6 ft (1.8 m) and probe depths averaged 3 ft (0.9 m). In Basin 4, farthest from the dam, water ranged from about 1 ft (0.3 m) deep to 4.6 ft (1.4 m) deep whereas probe depths averaged 2.3 ft (0.7

m). Ranges of water depth and sediment thickness values for each geophysical profile and for the second set of probe measurements carried out by the Corps of Engineers are shown in Table 1.

Basin 1, dredged of an unknown amount of sediment between 1980-84, appears to contain less than 2 ft (0.6 m) of sediment except in a few small areas. This is close to what the first probe study showed [0-2.1 ft (0.7 m)] along the one transect run through the basin. However, the second set of probe measurements recorded as much as 5.2 ft (1.6 m) of sediment. In fact, almost all the measurements exceeded those interpreted from the geophysical data most often by 1 ft (0.3 m) to 2 ft (0.6 m) but at one location by 5.3 ft (1.6 m).

In Basin 2 as much as 5 ft (1.5 m) of sediment were recorded on the seismic data in the northeast part, decreasing southward to 0 between Basins 2 and 3. Geophysical data and the two probe measurements in the Basin are within 0.5 ft (0.15 m) of each other.

Based on the geophysics, Basin 3 contains the thickest sediment of the four basins. In several areas near the north shore, sediments are as thick as 10 ft (3 m) and in much of this basin exceed 6 ft (1.8 m). Along the southern shore, values are as low as 3 ft (0.9 m) (Fig. 5). These geophysical measurements contrast sharply with the first set of probe measurements which all showed about 2 ft (0.6 m) of lacustrine sediment except in the southeasternmost corner of the basin where a value of 4 ft (1.2 m) was recorded. On most of probe transect B-B' in Basin 3 (Fig. 2), no sediment was measured, whereas geophysical results show sediment 5 ft (1.5 m) to 6 ft (1.8 m) thick. The new set of probe measurements are mostly within 1 ft (0.3) to 2 ft (0.6 m) of those observed with the seismic system in Basin 3. Comparisons of the base of the lacustrine sediment recorded on the long east-west profiles, tie lines that cross them, and the second set (COE) of probe measurements in Basin 3 are shown in Figure 6.

In Basin 4, geophysical measurements are similar to those in Basin 3 with much of the lacustrine fill 6 ft (1.8 m) thick. These values are greater than those recorded by both sets of probe measurements. However, the two profiles of the first set of probe measurements are located at the northern and southern ends of Basin 4 where geophysical data are sparse; thus, only limited comparisons can be made. Values from the second set of probe measurements range from 1 ft (0.3 m) to as much as 6.3 ft (1.9 m). At 7 of the 17 locations of the second set of probe measurements, values are within 2 ft (0.6 m) of the nearest geophysical results. The remainder are more than 2 ft (0.6 m) less than the geophysical measurements sometimes only 1/2 their value.

DISCUSSION AND CONCLUSIONS

In Basin 1 the discrepancy between the new probe measurements and the geophysical results is hard to resolve. Because the geophysical system was the same and was run at the same settings as in the other basins, the thinner lacustrine sediment recorded on the geophysical data than in the new probe data could be due to a change in the character of the acoustic reflectors such as a layer of sand or a gas-bearing horizon. Neither of these explanations seems likely considering the proximity of the other basins where such changes apparently did not occur. Another option is that the area was swampy or was a small pond before the dam was built and the sediments below those that have accumulated since the dam was built did not offer noticeable resistance to the probe. This explanation does not accounst for the discrepancy between the two sets of probe measurements. However, considering that the probes were simply pushed into the bottom manually with no control on the pressure applied, considerable variability can be expected. The assumption that if a subaerial soil zone had developed it would be sufficiently resistant to stop the probe would not apply if the area were swampy before the rising water covered it.

In Basin 3, the first set of probe measurements indicated that the lacustrine sediment was much thinner than was recorded either by the geophysical measurements or by the subsequent set of probe measurements. We do not have an explanation for this discrepancy but the compatability of the latter two data sets suggests that calculated sediment volumes based on them are close to what actually will need to be removed.

In Basin 4, geophysical measurement are most often greater than those made with the second set of probe measurements. The discrepancy could be due to a layer of organic material inhibiting probe penetration. Because the opening from Basin 4 into the eastern and northern part of the lake is very narrow, such material could have concentrated there during, for example, a flood. Only coring will resolve this question. The thickness of lacustrine sediment recorded on the geophysical records are consistent enough to suggest that they represent the best data on which to base an estimate of the volume of material that should be removed.

Based on the locus of thickest sediment, the isopach map suggests that the thalweg of Deep River, before it was dammed, was located closer to the southern margin of Basin 4, consistent with what would be expected in a mature, meandering stream, and was closer to the northern shore of Basin 3 except for the eastern narrower part where it lies closer to the southeastern shore.

TABLE 1

Geophysical Data

Basin 1

Line #	Water Depth ft/m Min	Water Depth ft/m Max	Sediment Thickness ft/m Min	Sediment Thickness ft/m Max
1	3/0.9	7/2.1	0	4/1.2
2	3/0.9	7/2.1	0	2/0.6
3	4/1.2	4/1.2	0	2/0.6
4	4/1.2	4/1.2	0	2/0.6
5	3/0.9	4/1.2	0	2/0.3
6	3/0.9	4/1.2	0	1/0.3
7	3/0.9	4/1.2	0	2/0.6
8	3/0.9	4/1.2	0	1/0.3
9	2/0.6	4/1.2	0	2/0.6
10	4/1.2	4/1.2	0	2/0.6
11	4/1.2	4/1.2	0	2/0.6
12	4/1.2	4/1.2	0	4/1.2
13	4/1.2	4/1.2	0	2/0.6
14	4/1.2	4/1.2	0	2/0.6
Mean	3.4/1.0	4.3/1.3	0	2/0.6

COE Probe

Station	Water Depth ft/m	Sed. Thickness ft/m
A1-1	6/1.8	3.5/1.1
A1-2	6.5/2.0	4/1.2
A1-3	6/1.8	4.3/1.3
B1-1	5.5/1.7	1.5/0.5
B1-2	5/1.5	4/1.2
B1-3	5/1.5	5.3/1.6
C1-1	7/2.1	5/1.5
C1-2	6/1.8	2.5/0.8

C1-3	7.5/2.3	2.8/0.8
C1-4	7/2.1	3/0.9
LL11-1	6.5/2.0	3/0.9
LL11-2	5/1.5	3.5/1.1
LL11-3	5/1.5	3.5/1.1
LL11-4	5.5/1.7	3.0.9
LL11-5	7/2.1	2.5/0.8
Mean	6/1.8	3.3/1.0

Geophysical Data
Basin 2

	Water Depth ft/m		Sediment Thickness ft/m	
Line #	Min	Max	Min	max
1	4/1.2	5/1.5	1/0.3	3/0.9
2	4/1.2	4/1.2	0	3/0.9
3	2/0.6	3/0.9	1/0.3	5/1.5
4	2/0.6	4/1.2	1/0.3	2/0.8
5	2/0.6	4/1.2	0	2/0.6
6	2/0.6	4/1.2	0	2/0.6
Mean	2.6/0.8	4/1.2	0.5/0.15	2.8/0.8

Probe depths

Station	Water Depth ft/m	Sed Thickness ft/m
2A-1	6.9/2.1	0.5/0.15
2A-1	3.6/1.1	2.5/0.8
Mean	5.2/1.6	1.5/0.5

Basin 3

Geophysical data

Line #	Water Depth ft/m Min	Max	Sediment Thickness ft/m Max	Min
1	2/0.6	2.5/0.7	4/1.2	6/1.8
2	2/0.6	4/1.2	5/1.5	9/2.7
3	2/0.6	3/0.9	4/1.2	10/3
4	2/0.6	6/1.8	5/1.5	6/1.8
5	2/0.6	2/0.6	6/1.8	8/2.4
6	2/0.6	2/0.6	6/1.8	8.2.4
7	2/0.6	2/0.6	6/1.8	8/2.4
8	5/1.5	2/0.6	5/1.5	8/2.4
9	2/0.6	2.5/0.7	3/0.9	6/1.8
10	2/0.6	3/0.9	3/0.6	4/1.8
11	2/0.6	3.5/1.1	4/1.2	6/1.8
12	2/0.6	4/1.2	0	6/1.8
Mean	2/0.6	3/0.9	4.2/1.3	6.5/2.0

Probe data

Station #	Water Depth ft/m	Sediment Thickness ft/m
LL1-11	3.6/1.1	5.5/1.7
LL2-11	3.6/1.1	3.4/1.1
LL2-10	2.9/0.9	7/2.1
LL1-9	2.9/0.9	4.5/1.4
LL2-9	2.9/0.9	3/0.9
LL1-8	2.9/0.9	7/2.1
LL2-8	2.9/0.9	3/0.9
LL3-8	2.9/0.9	5.5/1.7
LL3-6	2.9/0.9	6/1.8
LL3-5	3.6/1.1	3.5/1.1
LL1-128+80	2.9/0.9	8/2.4
LL2-128+80	2.9/0.9	9/2.7
Mean	3.1/0.95	5.4/1.6

Basin 4

Geophysical data

Line #		Water Depth ft/m Min	Water Depth ft/m Max	Sediment thickness ft/m Min	Sediment thickness ft/m Max
1		4/1.2	6/1.8	4/1.2	6/1.8
2		2/0.6	3/0.9	3/0.6	6/1.8
3		2/0.6	3/0.9	5/1.5	6/1.8
4		2/0.6	4/1.2	4/1.2	7/2.1
5		2/0.6	4/1.2	4/1.2	8/2.4
6		2/0.6	2/0.6	4/1.2	8/2.4
7		2/0.6	2/0.6	4/1.2	7/2.1
8		?	?	4/1.2	8/2.4
9		2/0.6	2/0.6	6/1.8	9/2.7
10		2/0.6	3/0.9	6/1.8	8/2.4
11		2/0.6	2/0.6	4/1.2	8/2.4
12		1/0.3	2/0.6	5/1.5	8/2.4
13		2/0.6	2/0.6	4/1.2	6/1.8
14		2/0.6	2/0.6	4/1.2	7/2.1
15		2/0.6	2/0.6	6/1.8	7/2.1
16		2/0.6	5/1.5	4/1.	8/2.4
	Mean	2/0.6	3/0.9	4.4/1.3	7.3/2.2

Probe data

Station #	Water Depth ft/m	Sediment Thickness ft/m
D4-1	7/2.3	5.5/1.7
D4-2	2.5/0.8	3.5/1.1
E4-1	2/0.6	4/1.2
E4-2	2/0.6	10/3
F4-1	2/0.6	2.3/0.7
F4-2	2.5/0.8	1.5/0.5
G4-1	2/0.6	3/0.9
G4-2	2/0.6	3/0.9
G4-3	2.5/0.8	4/1.2
G4-4	2.5/0.8	3.3/1

H4-1	2/0.6	2.1/0.6
H4-2	2.5/0.8	2/0.6
H4-3	2.7/0.8	6.3/1.9
LL14-1	2/0.6	3.5/1.1
LL14-2	2.3/0.7	3.1/1
LL14-3	2/0.6	3.5/1.1
LL14-4	2.3/0.7	4.7/1.4
LL14-5	2.5/0.8	1.5/0.5
LL14-6	2.8/0.9	3/0.9
LL14-7	5/1.5	4.3/1.3
	Mean 2.3/0.7	3.7/1.1

Acknowledgments

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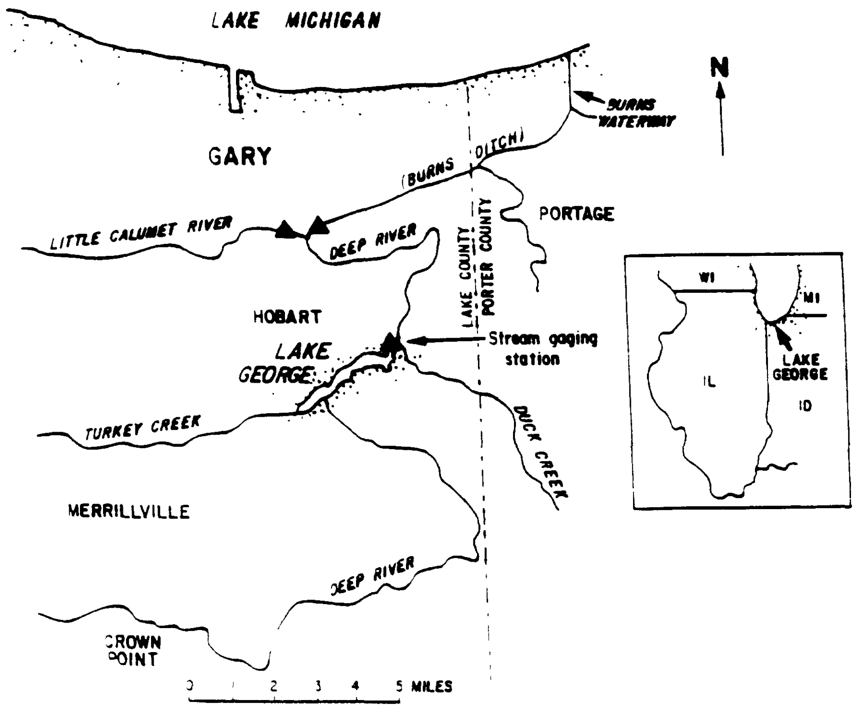
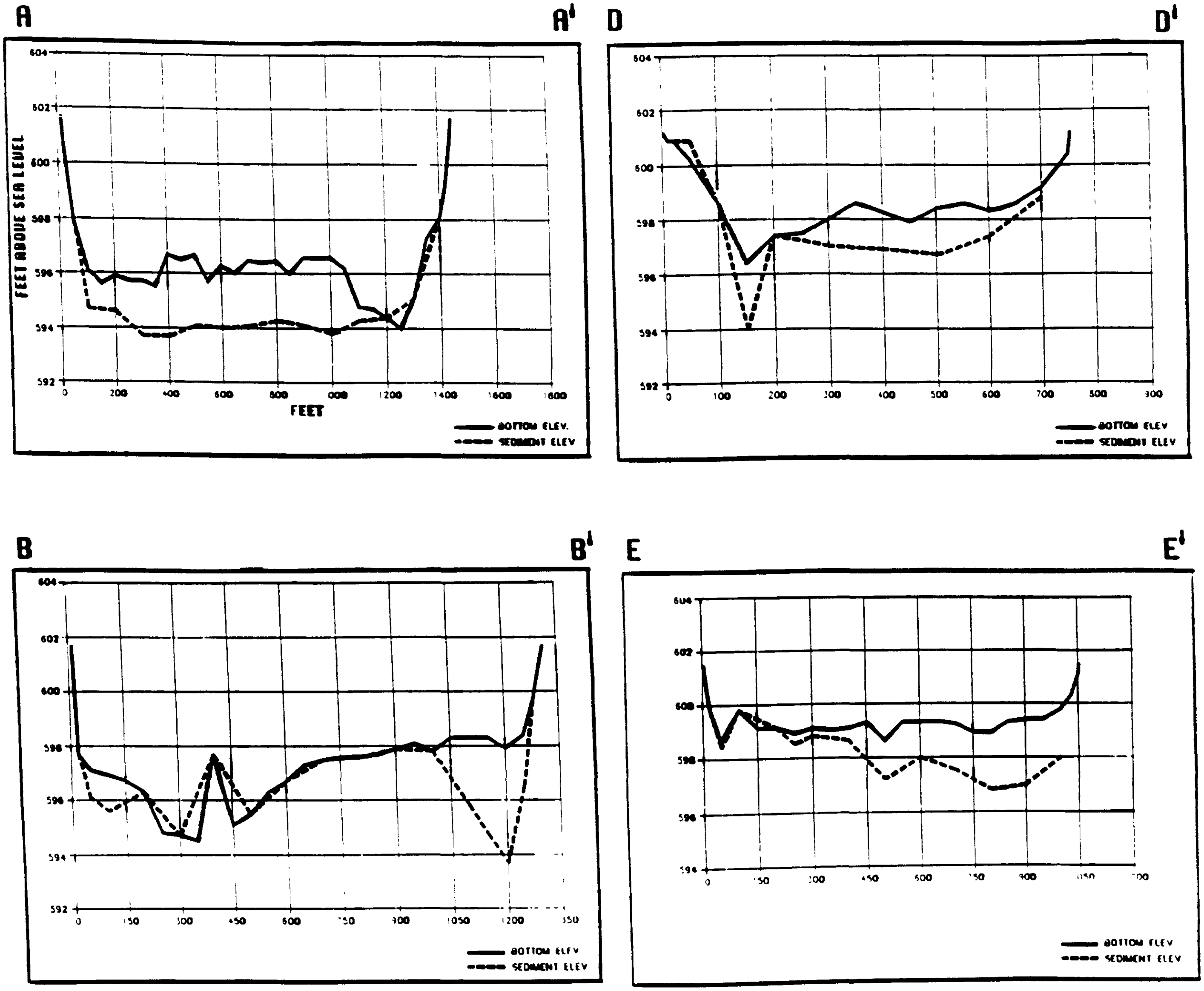


Figure 1. Location of study area.



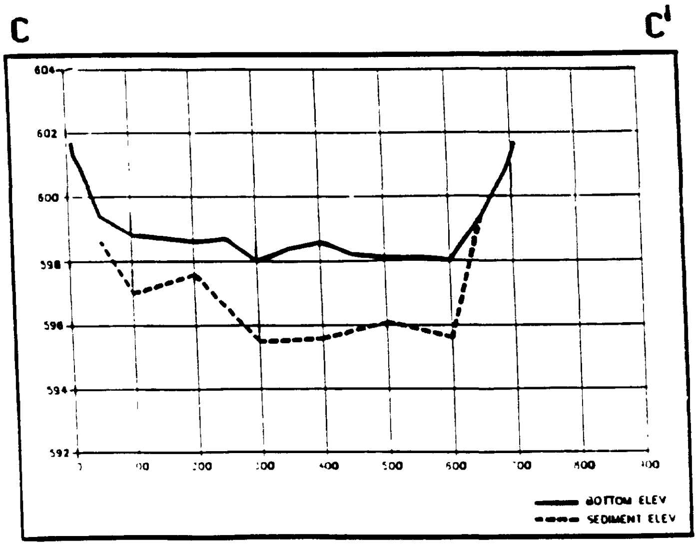


Figure 2. Profiles (see Fig. 4) in each basin along which accumulated lacustrine sediment thickness was measured with a probe prior to this study (U.S. Army Corps of Engineers, written commun.). Solid lines show the bottom of the lake; dashed lines show the bottom of the lacustrine sediment.

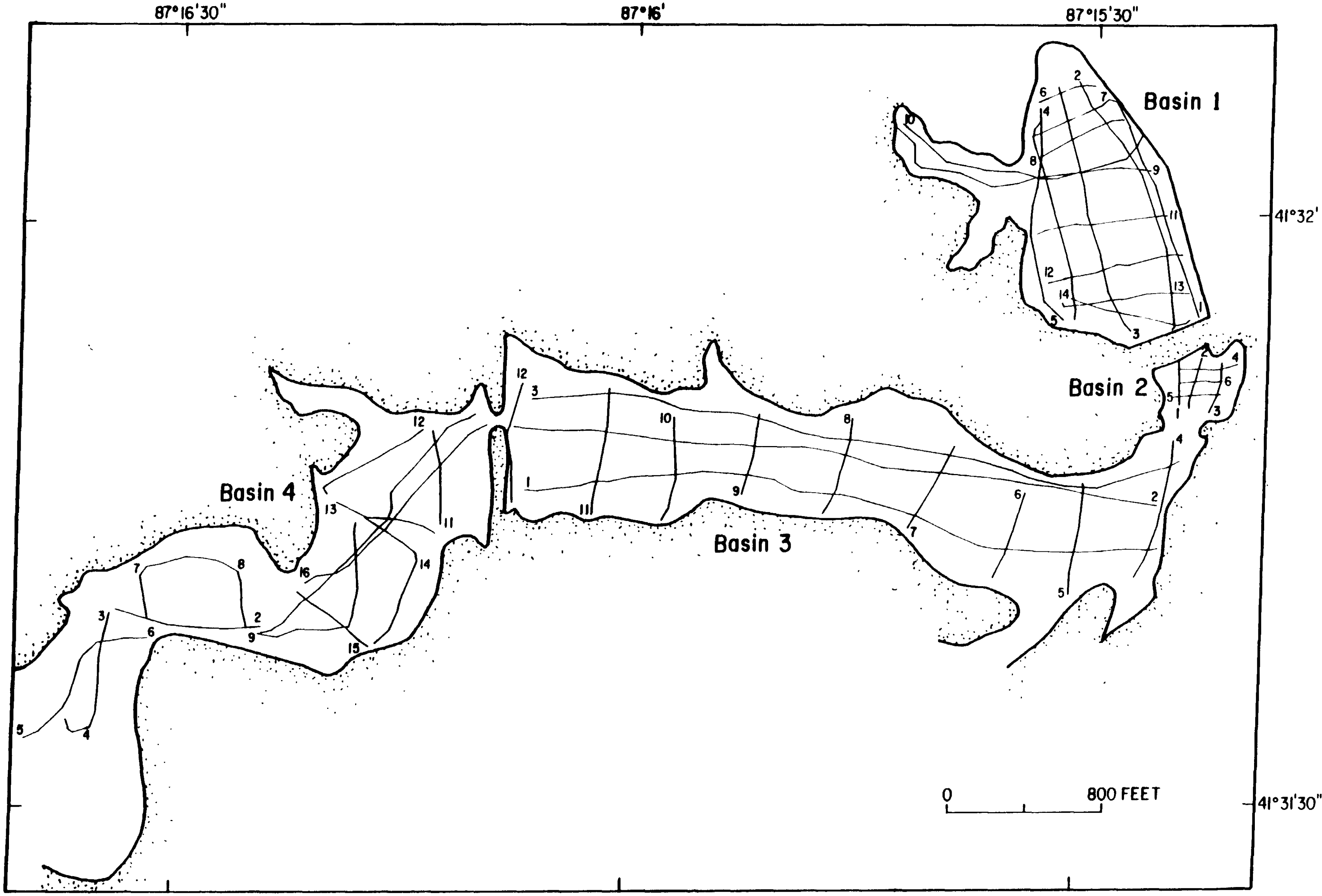


Figure 3. Location of single channel seismic profiles run as part of this study.

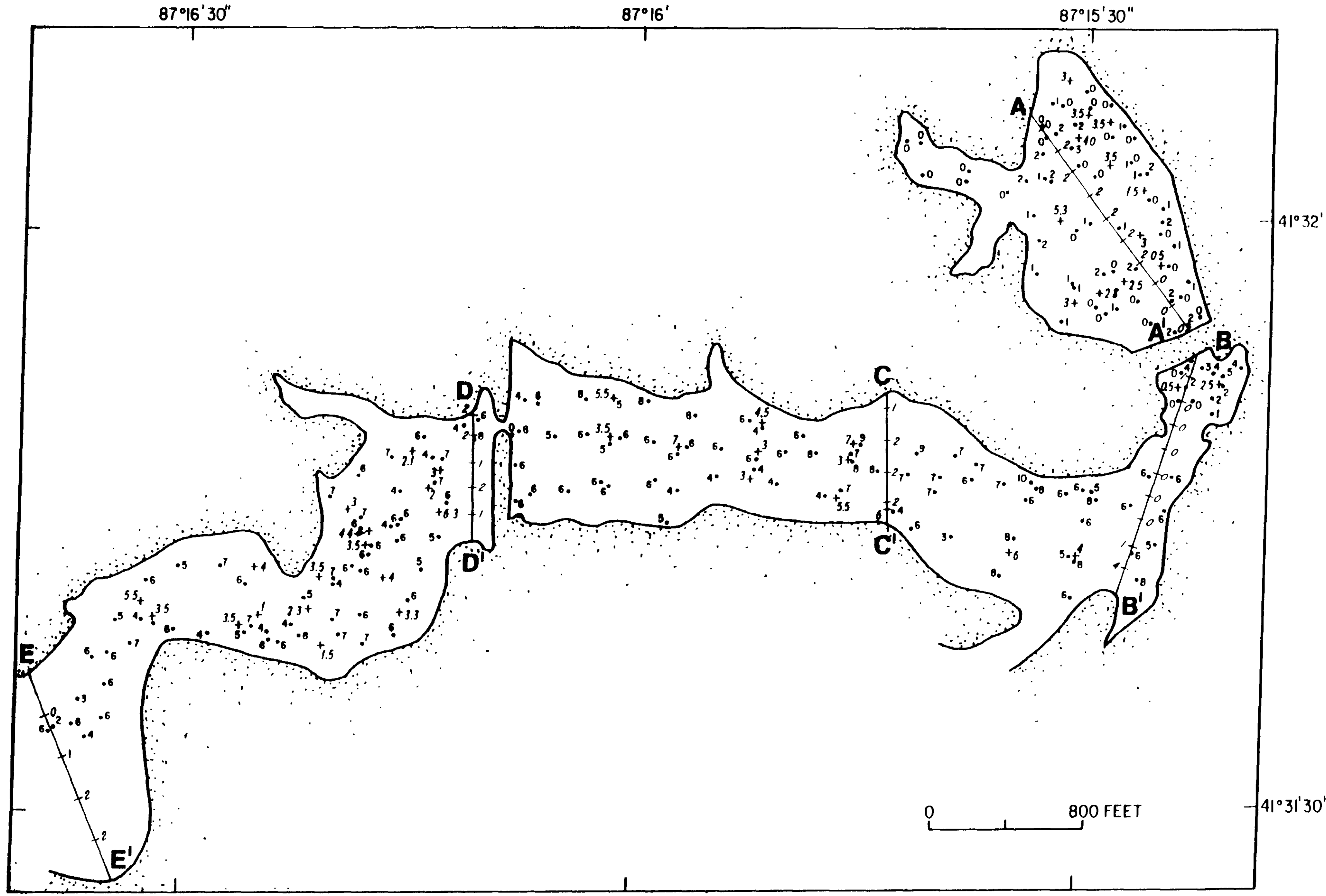


Figure 4. Black dots show the thickness of accumulated sediment recorded every minute along seismic profiles shown in Figure 3. Sections (A-A', B-B',etc.) show the thickness of accumulated sediment measured with a probe prior to this study. Crosses are sites where the thickness of accumulated sediment was measured with a probe as part of this study. All thickness values are in feet.

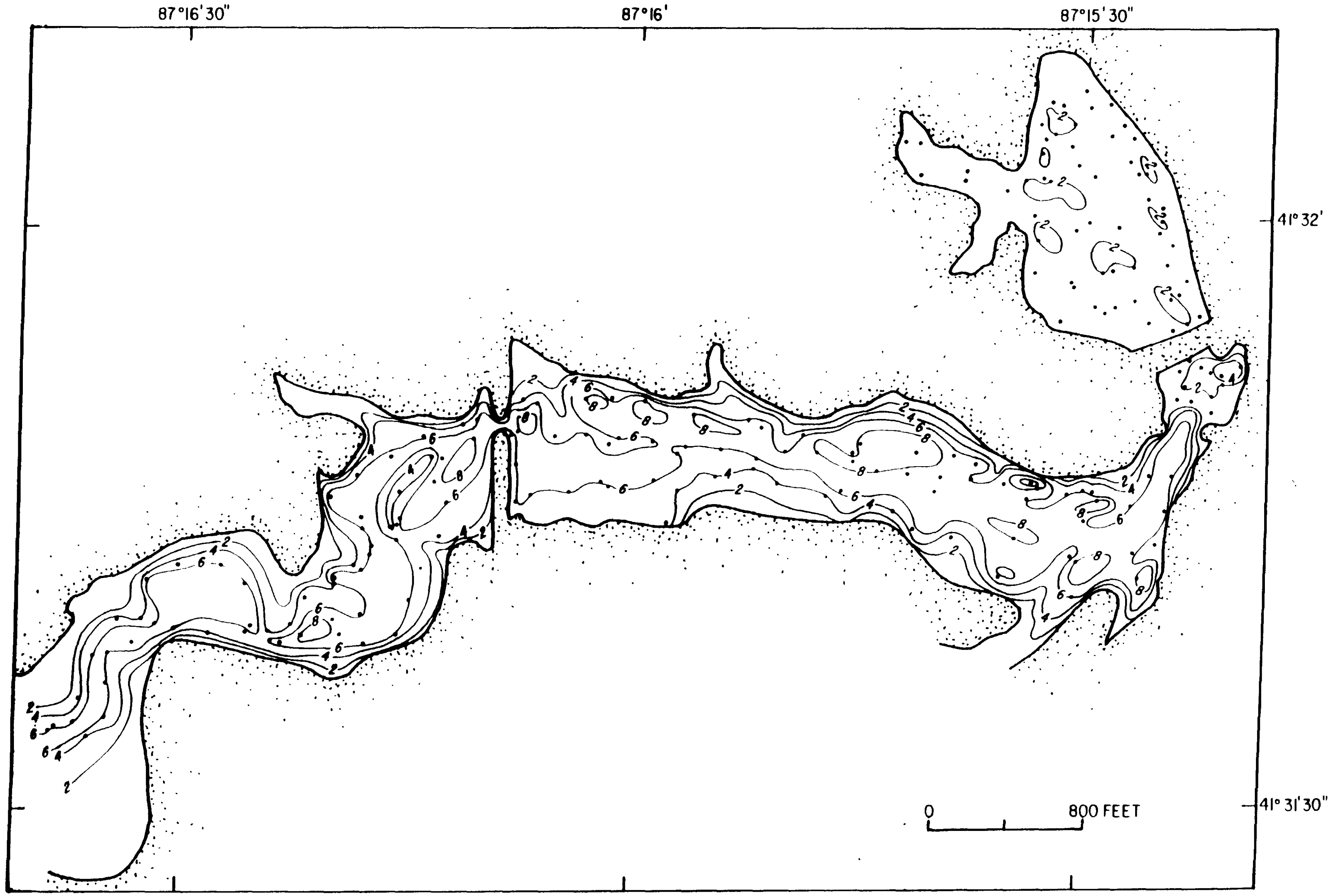


Figure 5. Isopach of accumulated sediment based on seismic reflection data only. Contour interval=2 feet.

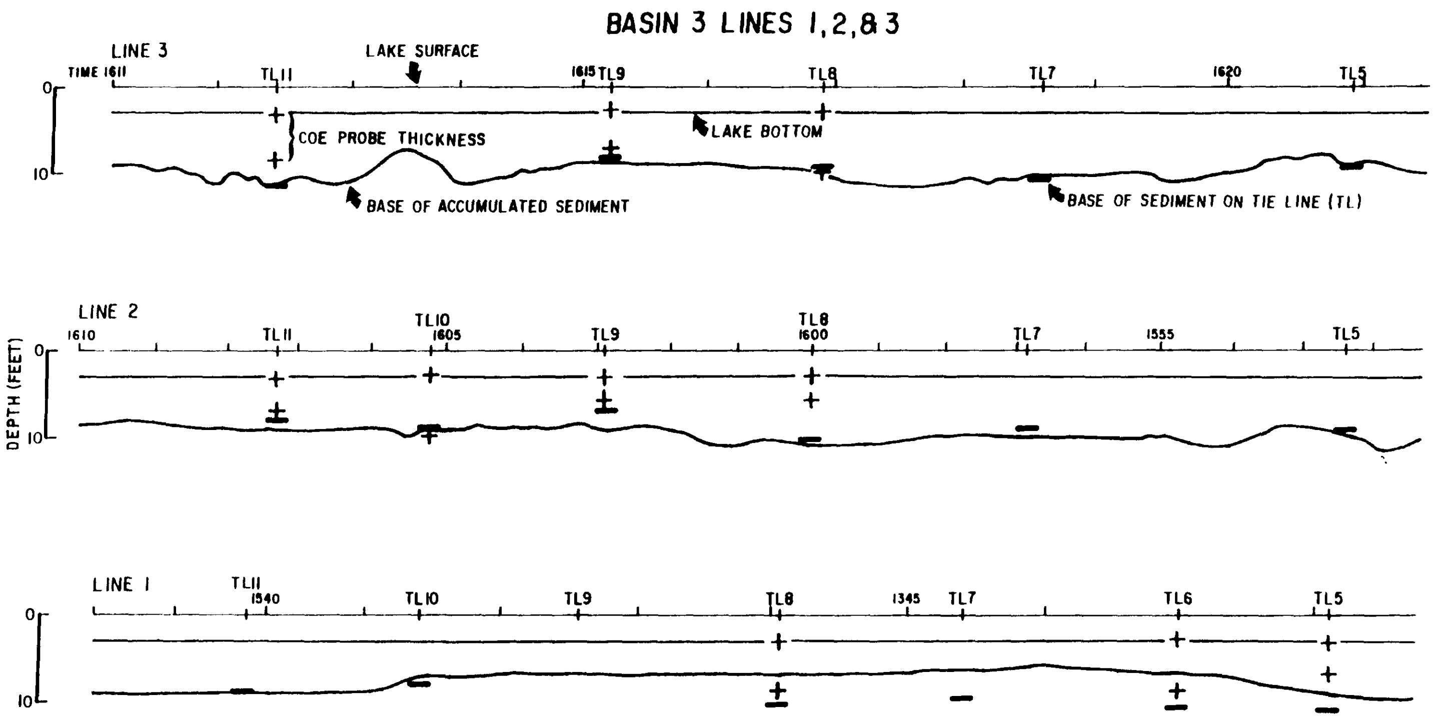


Figure 6. Three geophysical profiles run along the long axis of Basin 3 (see Figure 3) showing the lake bottom and the base of accumulated sediment. Short dark lines show the base of the accumulated sediment recorded on tie lines run orthogonally to the long profiles. Crosses show the lake bottom and base of accumulated sediment measured with a probe as part of this study.