SEDIMENTATION OF LAKE TANEYCOMO, MISSOURI, 1913-1987

By Wayne R. Berkas

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 89-4160

Prepared in cooperation with the

MISSOURI DEPARTMENT OF NATURAL RESOURCES,

DIVISION OF ENVIRONMENTAL QUALITY

Rolla, Missouri

1989

DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:
District Chief
U.S. Geological Survey
1400 Independence Road
Mail Stop 200
Rolla, Missouri 65401

Copies of this report can
be purchased from:
U.S. Geological Survey
Books and Open-File Reports
Federal Center, Bldg. 810
Box 25425
Denver, Colorado 80225

CONTENTS

	Page
Abstract	1
Introduction	1
Purpose and scope	3
Study area	3
Previous sedimentation study	4
Acknowledgments	6
Sedimentation survey	6
Volumetric survey	6
Method	7
Lake and sediment volume determinations	14
Factors affecting sediment accumulation and volume estimates	14
Cesium-137 measurements	18
Method	21
Results	21
Supporting information	23
Velocity	23
Particle-size distribution	24
Summary	29
References cited	31
Additional information	33

ILLUSTRATIONS

Page

Figures 1.-3. Maps showing:

1. Location of study area and part of the Lake Taneycomo drainage basin 2
2. Area draining to Lake Taneycomo after the completion of Table Rock Dam during 1958 5
3. Location of ranges and cesium-137 sampling sites 8

Figures 4.-22. Graphs or cross sections showing:

4. Relation between cross-sectional area and distance from Ozark Beach Dam at ranges 17
5. Changes in cross-sectional area at each range along Lake Taneycomo 19
6. Elevation of the thalweg in the 1913, 1935, and 1987 cross sections 20
7. Location, cesium-137 activity, and particle-size distribution at site CS1 34
8. Cesium-137 activity and particle-size distribution at site CS2 36
9. Location of site CS3 in range 25 cross section 37
10. Cesium-137 activity and particle-size distribution at site CS3 39
11. Location of site CS4 in range 26 cross section 40
12. Cesium-137 activity and particle-size distribution at site CS4 41
13. Location, cesium-137 activity, and particle-size distribution at site CS5 42
14. Location, cesium-137 activity, and particle-size distribution at site CS6 44
15. Location, cesium-137 activity, and particle-size distribution at site CS7 45
16. Cesium-137 activity and particle-size distribution at site CS8 47
17. Location, cesium-137 activity, and particle-size distribution at site CS9 48
18. Cesium-137 activity and particle-size distribution at site CS10 50
19. Location, cesium-137 activity, and particle-size distribution at site CS11 51
20. Location of site CS12 in range 33 cross section 53
21. Cesium-137 activity and particle-size distribution at site CS12 54
22. Location of site CS13 in range 34 cross section 55

ILLUSTRATIONS--Continued

Page

Figures 23.-41. Graphs or cross sections showing:

23. Cesium-137 activity and particle-size distribution at site CS13 57

24. Location of site CS14 in range 35 cross section 58

25. Cesium-137 activity and particle-size distribution at site CS14 60

26. Location, cesium-137 activity, and particle-size distribution at site CS15 61

27. Location of site CS16 in range 37 cross section 63

28. Cesium-137 activity and particle-size distribution at site CS16 65

29. Location of site CS17 in range 38 cross section 66

30. Cesium-137 activity and particle-size distribution at site CS17 68

31. Cesium-137 activity and particle-size distribution at site CS18 70

32. Cesium-137 activity and particle-size distribution at site CS19 71

33. Location of site CS20 in range 39 cross section 72

34. Cesium-137 activity and particle-size distribution at site CS20 74

35. Cesium-137 activity and particle-size distribution at site CS21 76

36. Location of site CS22 and CS23 in range 40 cross section 77

37. Cesium-137 activity and particle-size distribution at site CS22 79

38. Cesium-137 activity and particle-size distribution at site CS23 80

39. Detachment velocities for quartz sediment as a function of mean sediment size 26

40. Estimated water-channel interface velocities 27

41. Median particle size of bed material, May 1988 28

TABLES

			Page
Table	1.	Cross-sectional area of each range in 1913, 1935, and 1987	15
	2.	Sediment deposition after 1954 as determined from cesium-137 analyses	22
Tables	3-27.	Cesium-137 activity and particle-size distribution of depth increments in sediment profile at:	
	3.	Site CS1	35
	4.	Site CS2	35
	5.	Site CS3	38
	6.	Site CS4	38
	7.	Site CS5	43
	8.	Site CS6	43
	9.	Site CS7	46
	10.	Site CS8	46
	11.	Site CS9	49
	12.	Site CS10	49
	13.	Site CS11	52
	14.	Site CS12	52
	15.	Site CS13	56
	16.	Site CS14	59
	17.	Site CS15	62
	18.	Site CS16	64
	19.	Site CS17	67
	20.	Site CS18	69
	21.	Site CS19	69
	22.	Site CS20	73
	23.	Site CS21	75
	24.	Site CS22	78
	25.	Site CS23	78
	26.	Estimated average velocities in Lake Taneycomo from a step-backwater model (Shearman, 1976)	25
	27.	Particle-size distribution of bed material in Lake Taneycomo, May 12, 1988	30

CONVERSION FACTORS

For readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
foot	0.3048	meter
	30.48	centimeter
mile	1.609	kilometer
square foot	0.09294	square meter
square mile	2.590	square kilometer
cubic foot	0.02832	cubic meter
foot per second	0.3048	meter per second
cubic foot per second	0.02832	cubic meter per second
cubic foot per year	0.02832	cubic meter per year
ton, short	1.016	megagram
tons per year	1.016	megagrams per year

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

SEDIMENTATION OF LAKE TANEYCOMO, MISSOURI, 1913-1987

By
Wayne R. Berkas

ABSTRACT

On the basis of data from a sedimentation survey by the U.S. Department of Agriculture, Soil Conservation Service, during 1935 and data collected by the U.S. Geological Survey in cooperation with the Missouri Department of Natural Resources, Division of Environmental Quality, during 1987, the volumes of sediment accumulated in Lake Taneycomo by 1935 and by 1987 were determined. Table Rock Dam, built directly upstream from Lake Taneycomo in 1958, eliminated 92 percent of the 4,644-square-mile basin from contributing sediment directly to the lake. Cesium-137 isotope was used as a tracer in the sediment to determine the quantity of deposition in the lake after 1954.

The relation between cross-sectional area and distance upstream from the dam (curve method) was used to determine the 1913 (original), the 1935, and the 1987 water volumes of Lake Taneycomo. A total of 910,000,000 cubic feet of sediment accumulated between 1913 and 1935, 42 percent of the original volume in the lake. A total of 1,066,000,000 cubic feet of sediment accumulated between 1913 and 1987, 49 percent of the original volume. Lake Taneycomo seems to be functioning as an alluvial river, responding to the new energy gradient established by the spillway at Ozark Beach Dam and later to changes in sediment load. The upper two-thirds of the lake seems to have been scoured after Table Rock Dam greatly decreased the sediment load to the lake. The cesium-137 analyses indicated that sediment is still accumulating in the lower reaches of the lake; measured accumulations generally ranged from 0.2 to 2.6 feet. Estimated velocities and particle-size data of bed material indicate that scouring of the upstream reaches of the lake are possible.

INTRODUCTION

The area around Lake Taneycomo (fig. 1) is becoming an increasingly popular tourist attraction. The area's natural beauty, recreational lakes, and other tourist attractions have made this a favorite spot for vacations and retirement. The scenic beauty and folklore inspired Harold Bell Wright to write the book "Shepherd of the Hills," and the play adapted from the book is presented every summer weekend in a picturesque outdoor theater. A family fun park that celebrates the region's past with native folklore and pioneer crafts is located in this area. Water-sport recreation is enjoyed throughout the year on Lake Taneycomo, Table Rock Lake, and Bull Shoals Lake. Tourist activities and attractions, such as country music theaters, craft stores, and amusement parks, are common, especially near Branson.

The population of Taney County (fig. 1) dramatically increased in recent years primarily because of the popularity of the area. According to the U.S. Department of Commerce (1983), the population of Taney County increased 57 percent from 1970 to 1980, the largest percent increase in Missouri. The population increased from 13,023 in 1970, to 20,467 in 1980, to 24,700 in 1987 (Branson Area Chamber of Commerce, written commun., 1988). The population of the city of Branson increased from 2,175 in 1970, to 2,550 in 1980, to 3,070 in 1987 (City of Branson, written commun., 1988). These figures represent the permanent residents and do not reflect the transient tourist population. According to the Branson Area Chamber of Commerce (written commun., 1988), the number of motel and resort rooms in the Branson area increased from 6,100 in 1982 to 8,000 in 1987. The total number of campground sites increased from 3,300 in 1982 to 5,600 in 1987. An estimated 5 million people visited Branson during 1986. Most of the tourists visit the area between May and October.

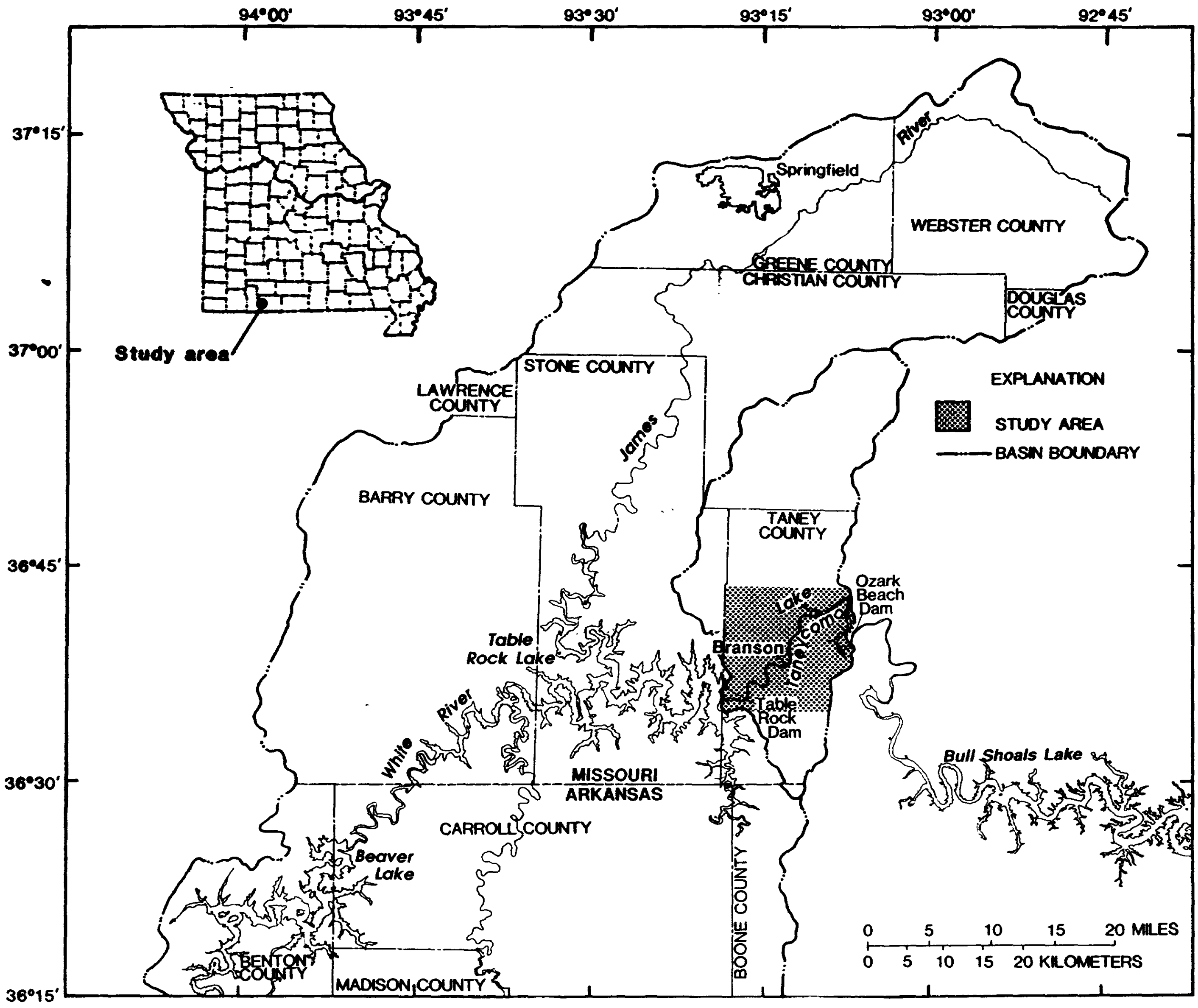


Figure 1.--Location of study area and part of the Lake Taneycomo drainage basin.

The popularity of the area has resulted in rapid commercial and domestic growth. In Taney County the number of building permits issued for new construction, additions, or demolition for 1986 and 1987 was 371 and 364 (Taney County Planning Commission, written commun., 1988). In Branson the number of building permits issued for new construction, additions, or demolition for 1986 and 1987 was 162 and 133, and averaged 139 from 1982 to 1987 (City of Branson, written commun., 1988).

Lake Taneycomo is considered by many to be the best trophy-trout lake in mid-America. When Table Rock Dam was completed during 1958 directly upstream from Lake Taneycomo, cold water was released from the bottom of Table Rock Lake during power generation. This cold water transformed Lake Taneycomo from the warm water lake that it had been since 1913 into a much cooler lake, suitable for a cold-water fishery. A State trout hatchery was built on the shore of Lake Taneycomo to maintain a supply of trout to the lake. During 1987, the Missouri Department of Conservation transplanted about 80,000 trout monthly into Lake Taneycomo (Shepherd of the Hills Fishery, oral commun., 1988). About 50 resorts are on Lake Taneycomo and most cater to trout fishermen.

Sedimentation of Lake Taneycomo is a major concern to area residents and State officials. The area is incised by many valleys with several hundred feet of relief. The soils are thin and highly erodible, especially during the land-clearing process while the land is being developed. The first areas to be developed were the ridge tops and areas along Lake Taneycomo where the slopes were relatively flat. Development recently has progressed into areas with steeper slopes that are more susceptible to erosion. Even if great care is taken during the development process, soil eroded from the land will increase. Converting the land from a forest environment to an urban environment will increase runoff during rainfall, which will increase the potential erosion of the land and the quality of soil transported from the land. Increased sediment transported to Lake Taneycomo may change the ecology of the lake, decreasing its suitability for trout fisheries. The study described in this report was done by the U.S. Geological Survey, in cooperation with the Missouri Department of Natural Resources, Division of Environmental Quality to determine the quantity of sediment accumulation in the lake.

Purpose and Scope

This report presents the results of a study made to determine the quantity of sediment accumulation in Lake Taneycomo from 1913 to 1987. The quantity of sediment that reached Lake Taneycomo has been affected by Table Rock Dam. Therefore, sediment accumulation was determined for both before and after 1958, when the dam was completed. Volumetric surveys were used to determine sediment accumulation. Cesium-137 activity was used to generalize the age of the sediment and determine sediment-accumulation patterns after 1954.

Study Area

Lake Taneycomo is on the White River about 50 miles south of Springfield, near the Missouri-Arkansas border. Lake Taneycomo was formed after Ozark Beach Dam was built during 1913 by the Ozark Power and Water Company to generate electricity. The dam is relatively small, rising 50 feet from the river channel and creating a 23-mile-long lake that covers less than 3 square miles. The drainage area upstream from Ozark Beach Dam is 4,644 square miles.

Ozark Beach Dam has an overall length of 1,220 feet. A power plant occupies 230 feet of the west end of the dam, a reinforced concrete spillway occupies 590 feet in the center, and earth fill constitutes the remaining 400 feet. The elevation of the spillway is 697.10 feet. Since 1924, the dam operators have used flashboards on the spillway, making the maximum lake surface elevation 700 feet. The flashboards usually are washed away during high-flow periods. The power plant contains 4 turbines capable of generating 5,000 kilovolt-amperes each. Water is discharged from the plant at 5,500 cubic feet per second under full operation.

The Lake Taneycomo basin is entirely within the Ozark Plateaus Province (Fenneman, 1938). Generally, the land surface elevation is between 1,000 and 1,500 feet, with the pool elevation of the lake at 700 feet. The intricate dissection of the upland has left much of the area unsuitable for agriculture. Most of the soil is thin, rocky, and highly susceptible to erosion. Alluvial soils are in the valleys, and most valleys are subject to flooding. Because of steep slopes and unproductive cherty soil, most of the area has remained in forests.

Table Rock Dam was completed on the White River during 1958, directly upstream from Lake Taneycomo. The drainage area upstream from Table Rock Dam is 4,280 square miles; therefore, Lake Taneycomo receives runoff directly from about 8 percent of its former drainage area. Only 364 square miles of drainage area directly contributes sediment to Lake Taneycomo.

The towns on Lake Taneycomo include Branson, Forsyth, Hollister, Ozark Beach, and Rockaway Beach (fig. 2). The tributaries draining directly into Lake Taneycomo are Bear, Bull, Coon, Fall, Roark, Short, and Turkey Creeks. The Bull Creek basin is the largest and drains forested land that not been extensively developed. Most of the development in the area has occurred along Highway 76, west of Branson in the Fall Creek and Roark Creek basins.

Previous Sedimentation Study

In 1935 the U.S. Department of Agriculture, Soil Conservation Service (SCS) made a survey on Lake Taneycomo to locate areas of sediment accumulation and measure the volume of sediment deposited from 1913 to 1935 (Kesler, 1936). This was to be accomplished by measuring the volume of water at the 700-foot level in 1935 and comparing this survey to the original lake volume.

Because Lake Taneycomo was not surveyed in 1913 the original lake bottom was estimated in 1935 by coring the sediment in the lake and subtracting the depth of accumulated sediment. Cross-sectional profiles were used to compute the 1913 and 1935 lake volumes and the difference was assumed to be the quantity of sediment.

Because of retention characteristics of Lake Taneycomo and Ozark Beach Dam, the SCS concluded that the lake was not trapping 100 percent of the sediment transported by the White River. Kesler (1936) states that, based on his experience, Ozark streams transported almost the entire annual sediment load during floods caused by intense rainfall in late winter and spring. If the flood was large enough, the flood would pass quickly through Lake Taneycomo and over the spillway, substantially decreasing the impounding effect of the dam.

Kesler (1936) stated that substantial sediment accumulation took place in Lake Taneycomo by 1935, but flushing occurred in upstream reaches of the lake. The original gravel bottom was free of silt from the upstream reaches of the lake to the mouth of Bull Creek. Silt had been deposited on the flooded terraces in the lake, but flood flows kept the main channel clear. Because the original gravel bottom was covered downstream from Bull Creek, this was considered the point where the transporting capacity of flood currents was critically altered.

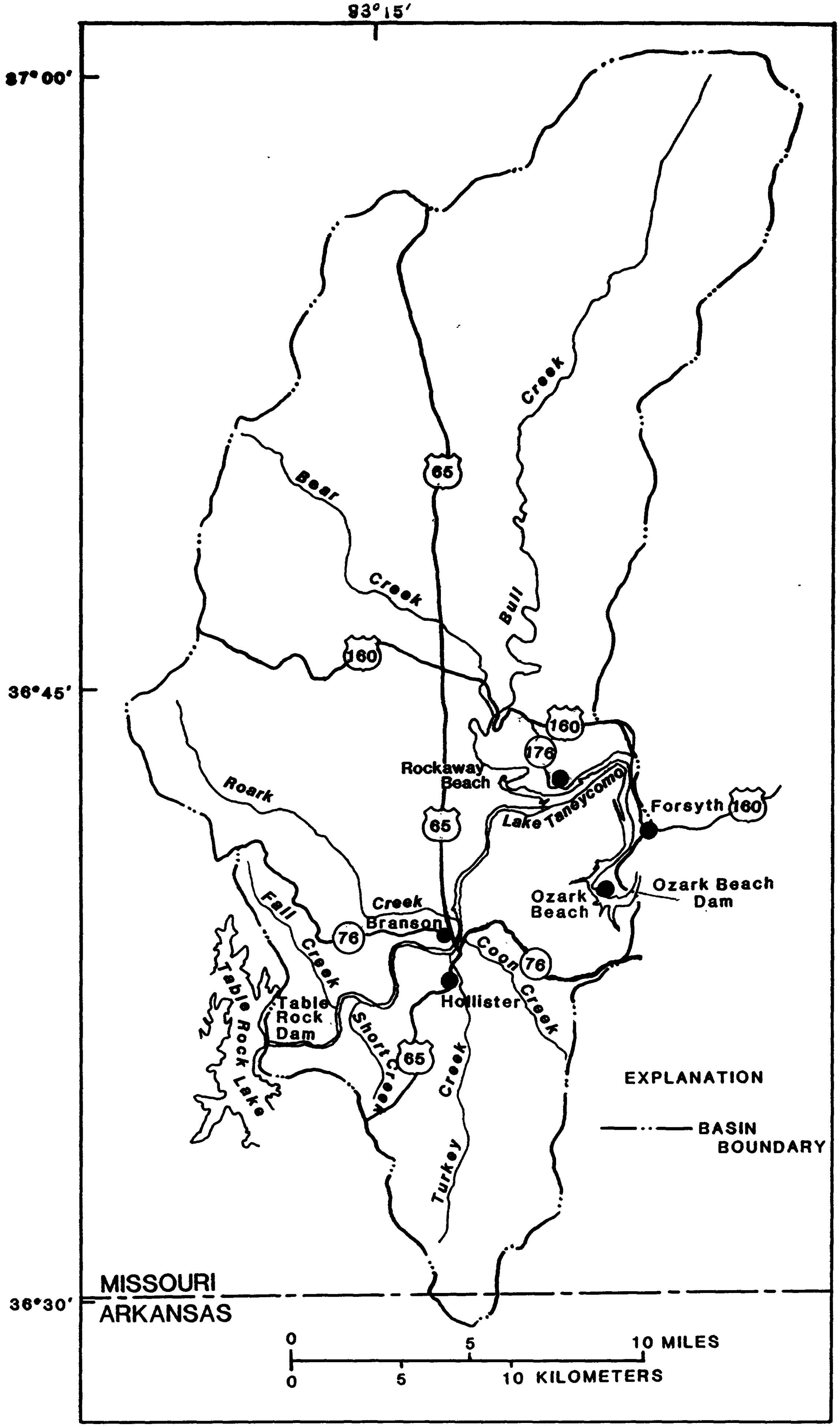


Figure 2.—Area draining to Lake Taneycomo after the completion of Table Rock Lake Dam during 1958.

The areas with the greatest depth of sediment accumulation are those downstream from bends in the lake. These locations coincide with the reversal of curvature from the bend and follow the general characteristics of natural alluvial river currents that maintain deep pools in bends and shoals in the intervening reaches between bends.

The SCS study indicated that 883,000,000 cubic feet of sediment were deposited in Lake Taneycomo during the 22 years from 1913 to 1935. This represents an average sediment accumulation of 40,100,000 cubic feet per year. The bulk density of the sediment was not determined, but by assuming a bulk density of 1.04 grams per cubic centimeter (65 pounds per cubic foot), about 28,700,000 tons of sediment were estimated to have accumulated between 1913 and 1935. This represents an average annual load of 1,300,000 tons per year or an average annual yield of 280 tons per year per square mile of drainage area.

Acknowledgments

The author thanks Dr. Sherwood C. McIntyre and Mr. James W. Naney of the U.S. Department of Agriculture, Agriculture Research Service at Durant, Oklahoma, who were instrumental in planning the sediment-profile sampling. Dr. McIntyre supervised the analysis of the sediment-profile samples for cesium and particle-size distribution at the Water Quality and Watershed Research Laboratory at Durant. Mr. Naney, along with Dr. McIntyre, provided experience in obtaining the sediment profiles from Lake Taneycomo. The author also thanks the Agriculture Research Service for providing the boat and sampling equipment used for core sampling.

The author thanks Dr. Glendon T. Stevens, Jr., of the University of Missouri-Rolla and Mr. Kenneth Anderson of the U.S. Army Corps of Engineers, at St. Louis, Missouri, for their expertise in surveying Lake Taneycomo.

SEDIMENTATION SURVEY

Two sedimentation surveys were made by the U.S. Geological Survey on Lake Taneycomo in 1987. The first of these was a volumetric survey in which the volume of water retained behind Ozark Beach Dam during 1987 was determined. This survey replicated much of the work done by the SCS in 1935. These two surveys were used to determine the volume of sediment deposited between 1913 and 1935 and between 1913 and 1987.

The second survey by the U.S. Geological Survey involved determining sediment accumulation at selected points in the lake using the cesium-137 isotope. After Table Rock Dam was completed during 1958, sediment transport into Lake Taneycomo was greatly disrupted. The presence of the cesium-137 isotope is useful for determining the quantity of sedimentation that has occurred since 1954, when cesium-137 first appeared in the environment.

Volumetric Survey

A volumetric sedimentation survey involves measuring the volume of a lake at one time, and subtracting that volume from a volume measured at an earlier time. The difference is the volume of accumulated sediment. This study includes three lake volumes; the original volume determined from sediment corings made by the SCS in 1935, the volume in 1935 determined by the SCS, and the volume determined by the U.S. Geological Survey in 1987. By using this information, the volume of sediment accumulated in Lake Taneycomo between 1913 and 1935 and between 1913 and 1987 was determined.

Sand and gravel have been removed from Lake Taneycomo from 1961 to the present (1987) by Table Rock Asphalt Construction Company (Robert Simmons, Table Rock Asphalt Construction Company, oral commun., 1987). Material has been removed from the lake bottom at many locations using a "clam shell" dredge. Those locations that showed signs of disturbance by dredging when measured in 1987 were not used in volume computations and elevation comparisons.

Method

A number of methods can be used to compute the volume of sediment that has accumulated in a lake. Heinemann and Dvorak (1965) looked at 21 different computations using 6 methods. All methods use the same basic approach: calculate the volume of the lake at two different dates and the sediment accumulation is the difference between the two lake volumes. They concluded that all methods are adequate for calculating lake volumes, but some methods are preferable, depending on lake configuration and resources available for the study.

The computation method used by the SCS in the 1935 study is unknown. The method used for the 1987 survey is a curve method (relation between cross-sectional area and distance upstream from the dam). This method was chosen because Lake Taneycomo is long and narrow, and it would be extremely difficult to determine contours of the lake bottom without expending tremendous effort and resources. Also, the data collected during the 1935 survey would be most suitable for the curve method.

The curve method involves determining the volume of a lake using cross sections in the lake (Vanoni, 1975, p. 379). Ranges are established along the reservoir and cross sections of the lake are obtained at those locations. The ranges are located in such a manner that major changes in lake cross sections are defined. The cross-sectional areas of the ranges and the distance the ranges are upstream from the dam are plotted on a graph and a line is fitted to the points. The area under the line is the volume of the lake. It is assumed that the changes in cross-sectional area between consecutive ranges are uniform.

In 1935 the SCS determined the 1913 volume and the 1935 volume of Lake Taneycomo. Bench marks that were established in 1927 for the Empire District Electric Company, who purchased the Ozark Power and Water Company, were used to determine most of the cross-section elevations. In 1935 differences were determined in the benchmark elevations. Therefore, all of the 1913 and 1935 elevations were adjusted and volumes were recomputed before comparisons could be made to the 1987 volume.

Because of development around the lake, the exact location of the ranges used during 1935 could not be found. By using the range-location map provided in Kesler (1936), an attempt was made to locate the 1987 ranges in the same location as the 1935 ranges. The author believes the 1987 ranges (fig. 3) are within 100 feet of the 1935 ranges. No permanent markings were left after the 1987 survey.

Cross-sectional elevations were determined by using electronic distance measuring (EDM) equipment and a fathometer. The sending unit of the EDM was set at the edge of the water on one end of the range, and a boat with the receiving unit of the EDM and a fathometer started at the other end of the range and moved across the lake. As the boat traveled along the range line, distances to the nearest foot were marked on the fathometer graph and depths of the lake were read to the nearest 0.1 foot. Additional elevations were obtained on both banks along the range. All elevations were referenced to the water surface of the lake. Water-level recorders were installed along the lake to note any changes in water-surface elevation during the range surveys. Water was not released from Table Rock Dam during the range survey and no change in water-surface elevation was recorded.

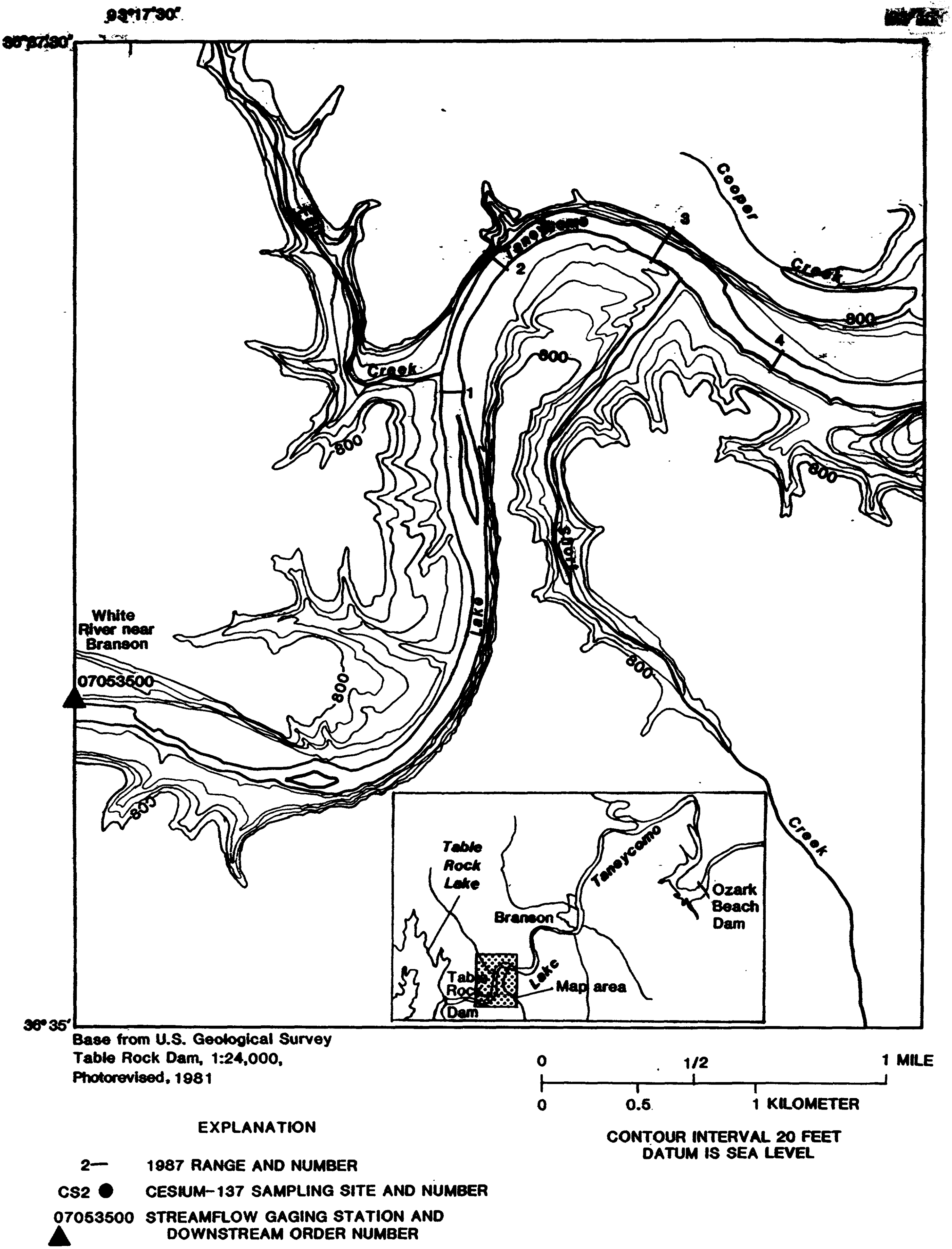
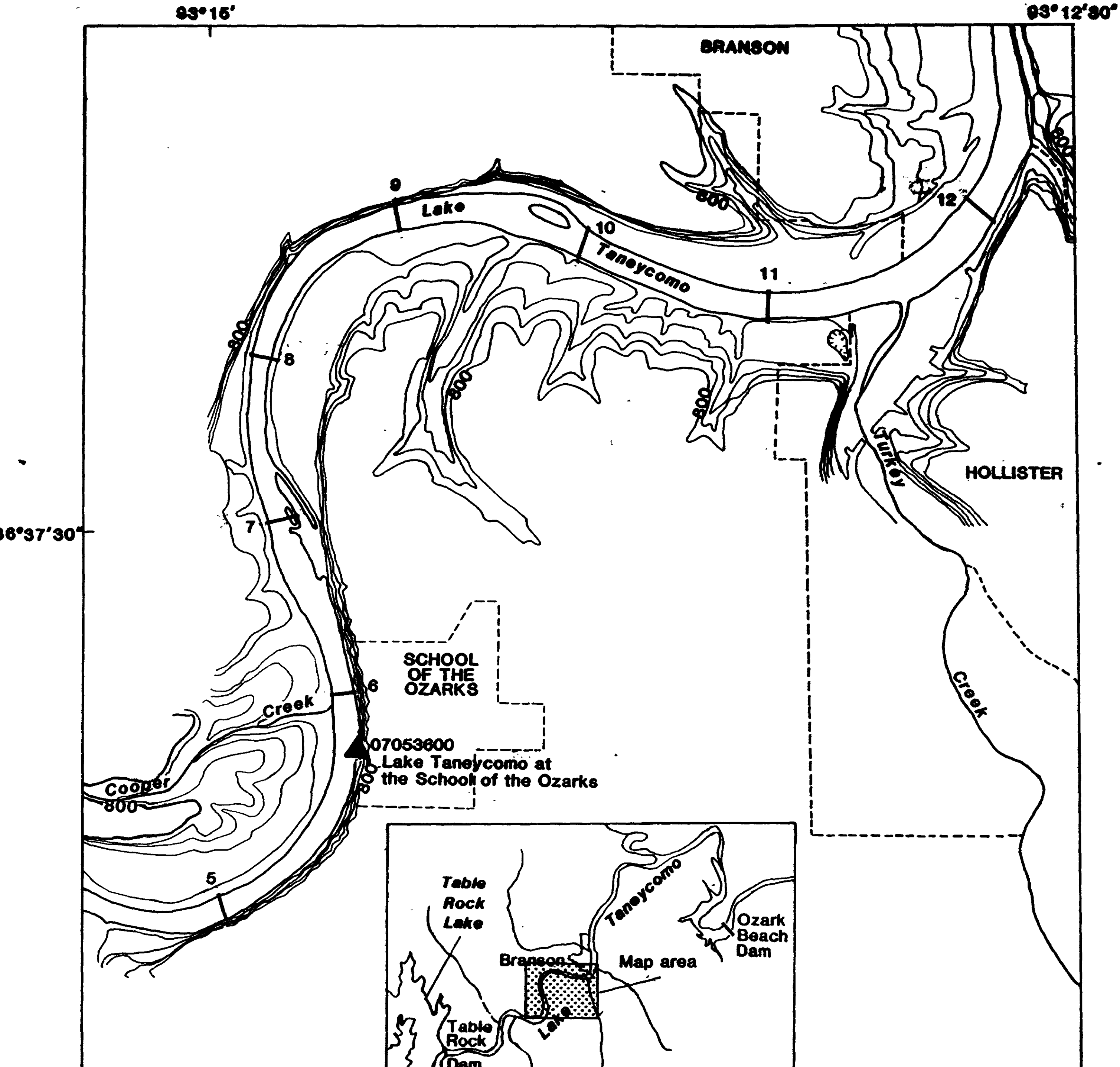


Figure 3.--Location of ranges and cesium-137 sampling sites.



Base from U.S. Geological Survey
Branson, 1:24,000, photorevisd 1981,
Hollister, 1:24,000, photorevisd 1978,
Table Rock Dam, 1:24,000,
photorevisd 1981

0 1/2 1 MILE
0 0.5 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DATUM IS SEA LEVEL

Figure 3.--Location of ranges and cesium-137 sampling sites--Continued.

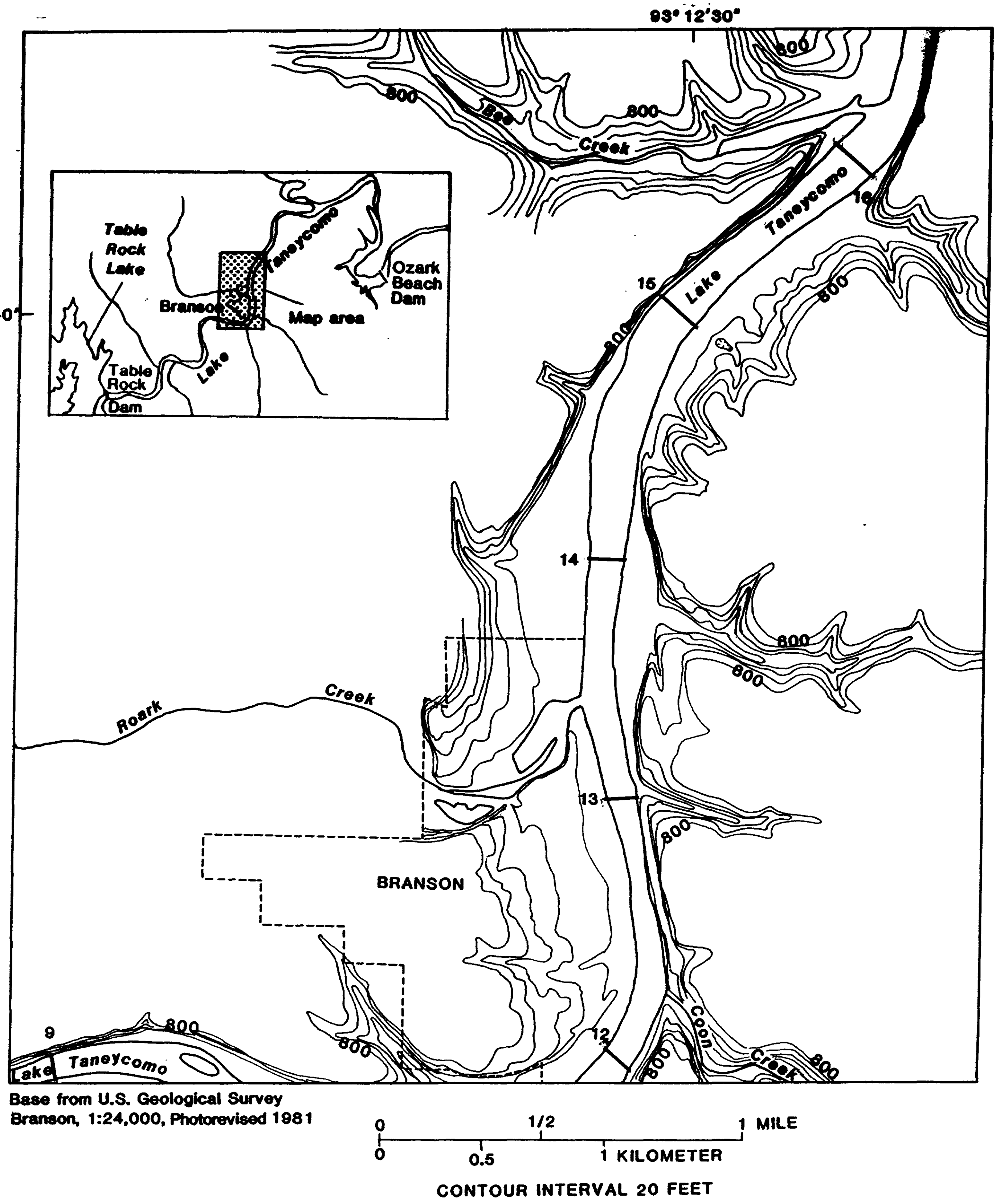


Figure 3.--Location of ranges and cesium-137 sampling sites-- Continued.

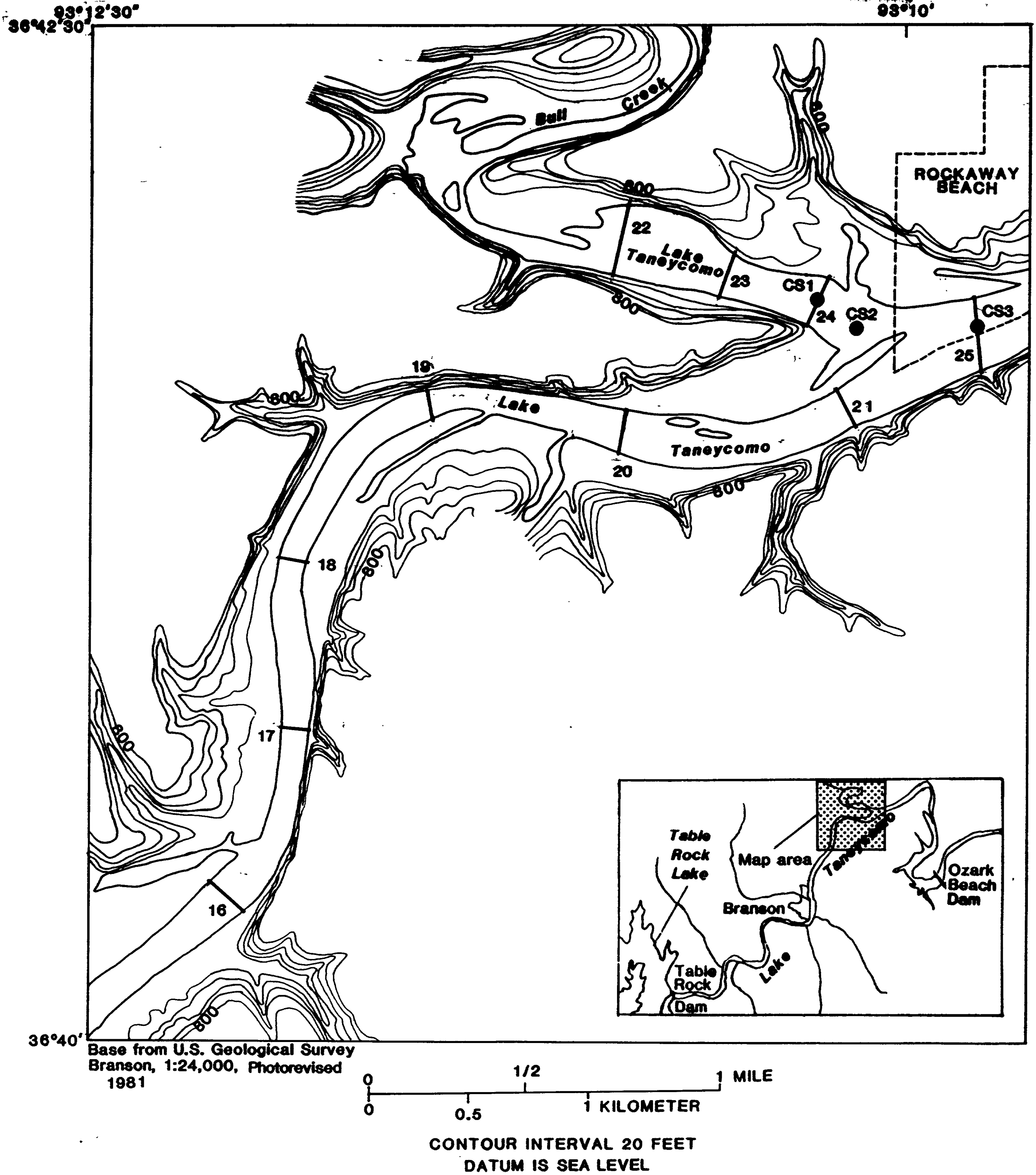


Figure 3.--Location of ranges and cesium-137 sampling sites-- Continued.

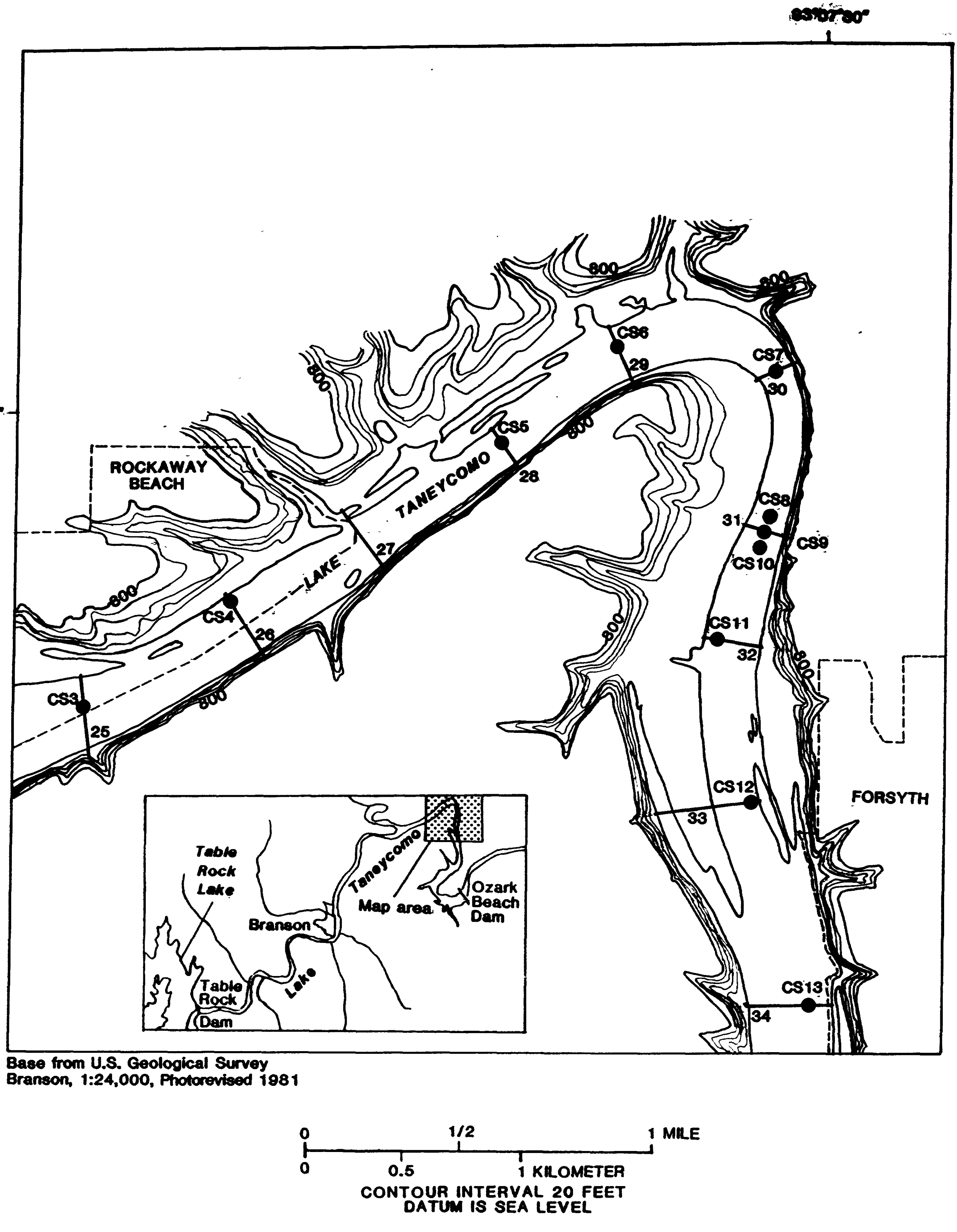
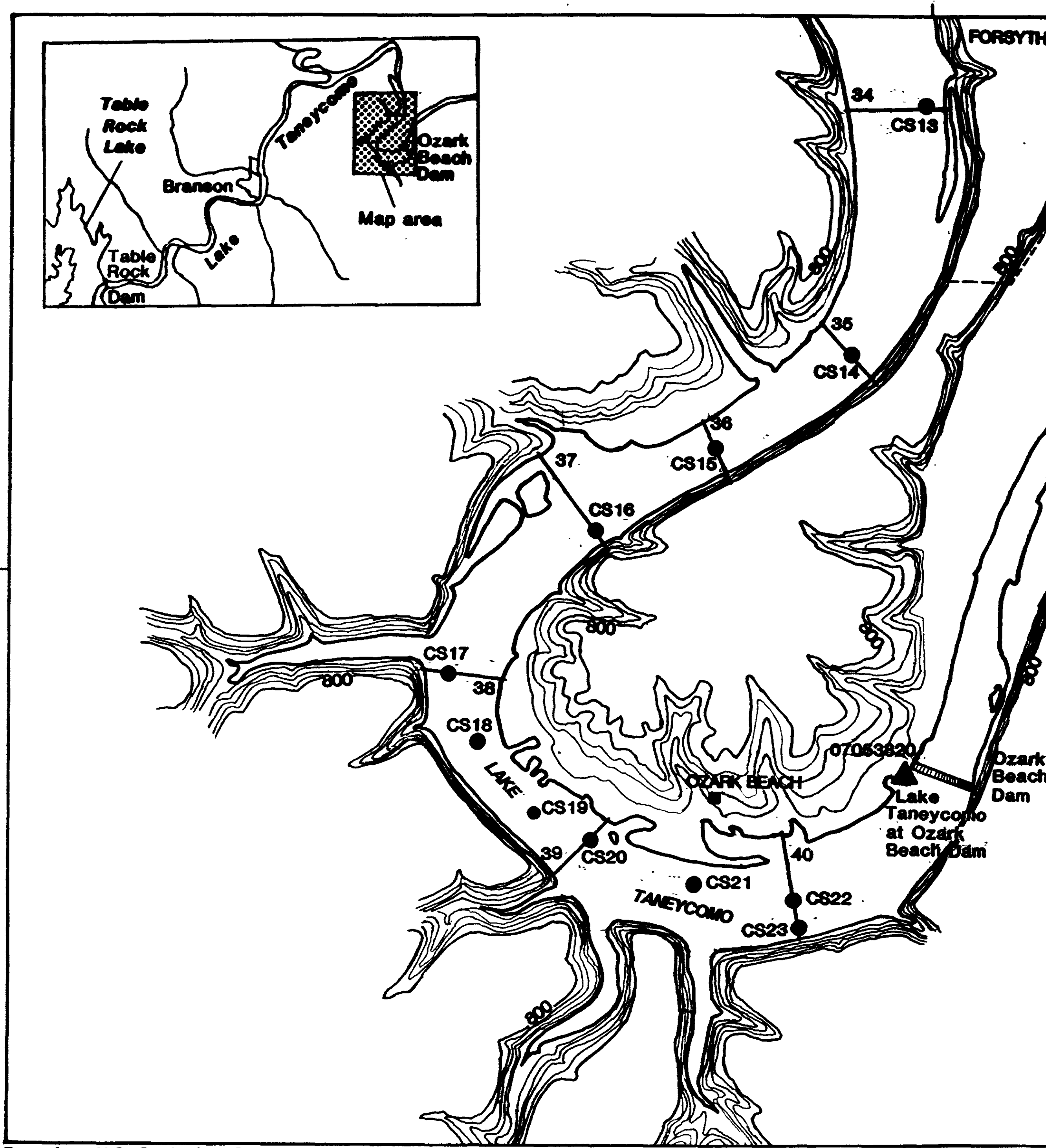


Figure 3.--Location of ranges and cesium-137 sampling sites--Continued.



Base from U.S. Geological Survey
Branson, 1:24,000, photorevised 1981,
Forsythe, 1:24,000, photorevised 1975

0 1/2 1 MILE

0 0.5 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DATUM IS SEA LEVEL

Figure 3.--Location of ranges and cesium-137 sampling sites--Continued.

Lake and Sediment Volume Determinations

The cross-sectional area of each range was determined assuming a water-surface elevation of 700 feet (table 1). A graph of the relation between cross-sectional area and distance from the dam was plotted (fig. 4). The following lake volumes were determined:

Year	Lake volume, in cubic feet		
	Main channel	Bull Creek	Total
1913[a]	2,069,000,000	86,000,000	2,155,000,000
1935[a]	1,196,000,000	49,000,000	1,245,000,000
1987	1,066,000,000	23,000,000	1,089,000,000

[a]Data from SCS files.

The following volumes of accumulated sediment were determined:

Date	Accumulated sediment, in cubic feet			Percentage of original volume
	Main channel	Bull Creek	Total	
1913 to 1935[a]	873,000,000	37,000,000	910,000,000	42
1913 to 1987[a]	1,003,000,000	63,000,000	1,066,000,000	49

[a]1913 and 1935 data from SCS files.

Factors Affecting Sediment Accumulation and Volume Estimates

Compaction of sediment could cause the volume of sediment accumulated between 1935 and 1987 to be underestimated. When sediment is deposited in a lake, a large percentage of a given volume is water. As more sediment is deposited, it is compacted together and water is forced from spaces between the sediment. The quantity of sediment compaction will depend on the materials comprising the sediment. Sand undergoes little compaction, whereas clay can undergo substantial compaction. As a result, the sediment deposited between 1913 and 1935 will have compacted; therefore, the true elevation of the 1935 lake bottom will have been lowered by the time the lake is measured again in 1987. The true volume of sediment deposited from 1935 to 1987 is larger than the measured volume and the sediment accumulation rate between these surveys would not be truly representative if computed solely on differences in volumes. Compaction could not be accounted for, so only sediment volumes accumulated betweem 1913 and 1935, and between 1913 and 1987 were determined.

Other factors that could affect sediment accumulation include: (1) the effectiveness of the lake to trap sediment is lessened as lake volume is decreased and some suspended sediment is transported downstream past Ozark Beach Dam; (2) water released from Table Rock Dam is scouring the upstream reaches of Lake Taneycomo; and (3) the drainage area and, therefore, the source area for sediment was decreased by the completion of Table Rock Dam.

Table 1.--Cross-sectional area of each range in 1913, 1935, and 1987

Range number 1987 (fig. 3)	Range number 1935	Distance upstream from Ozark Beach Dam, in feet	Cross-sectional area, in square feet 1913[a]	1935[a]	1987
1	134-133	106,200	1,900	2,000	1,800
2	131-130	103,800	1,600	1,600	1,700
3	129-128	101,200	2,300	2,300	2,300
4	127-126	98,700	3,000	3,000	2,500
5	125-124	95,600	2,800	2,800	3,700
6	123-122	91,900	3,100	3,200	4,200
7	121-120	90,000	4,700	2,800	4,300
8	119-118	87,500	4,600	4,600	[b]4,800
9	117-116	83,700	4,500	4,800	[b]5,500
10	115-114	80,600	8,200	5,300	5,100
11	113-112	78,100	9,800	5,500	5,200
12	107-106	74,400	9,800	6,000	6,600
13	105-104	70,600	8,600	7,100	[b]8,700
14	99-98	67,500	22,000	8,200	8,300
15	97-96	63,700	15,500	8,600	9,400
16	92-91	60,000	17,600	9,100	[b]11,100
17	90-89	56,900	16,000	9,400	8,300
18	88-87	54,400	21,600	9,800	10,900
19	86-85	51,300	19,000	9,100	10,200
20	80-79	47,500	18,800	9,700	9,800
21	63-62	45,000	29,000	11,600	10,700
22	68-67	48,400	16,400	9,700	5,000
23	66-65	46,400	12,400	7,900	4,300
24	64-63	44,700	18,500	10,800	3,300
25	59-58	42,500	33,400	13,100	11,300
26	57-56	39,400	25,800	11,500	10,700
27	54-53	37,500	27,300	14,100	12,900
28	50-49	35,000	24,600	13,000	12,800
29	48-47	32,500	27,300	16,800	14,700
30	46-45	30,000	25,000	16,000	14,500

Table 1.--Cross-sectional area of each range in 1913, 1935, and 1987--Continued

Range number 1987 (fig. 3)	Range number 1935	Distance upstream from Ozark Beach Dam, in feet	Cross-sectional area, in square feet 1913[a]	1935[a]	1987
31	44-43	26,900	25,000	15,500	13,600
32	42-41	25,600	34,600	16,500	14,900
33	40-39	22,500	38,100	16,800	14,700
34	38-37	20,000	40,000	20,200	17,100
35	36-35	16,300	31,600	19,300	15,800
36	30-29	13,700	30,200	19,300	14,700
37	28-27	11,900	39,000	28,900	23,500
38	23-22	8,800	43,600	33,000	23,300
39	19-18	5,600	39,600	28,300	21,800
40	4-3	2,500	49,500	32,600	21,600

[a] Data from SCS files.

[b]Cross section distributed by dredging.

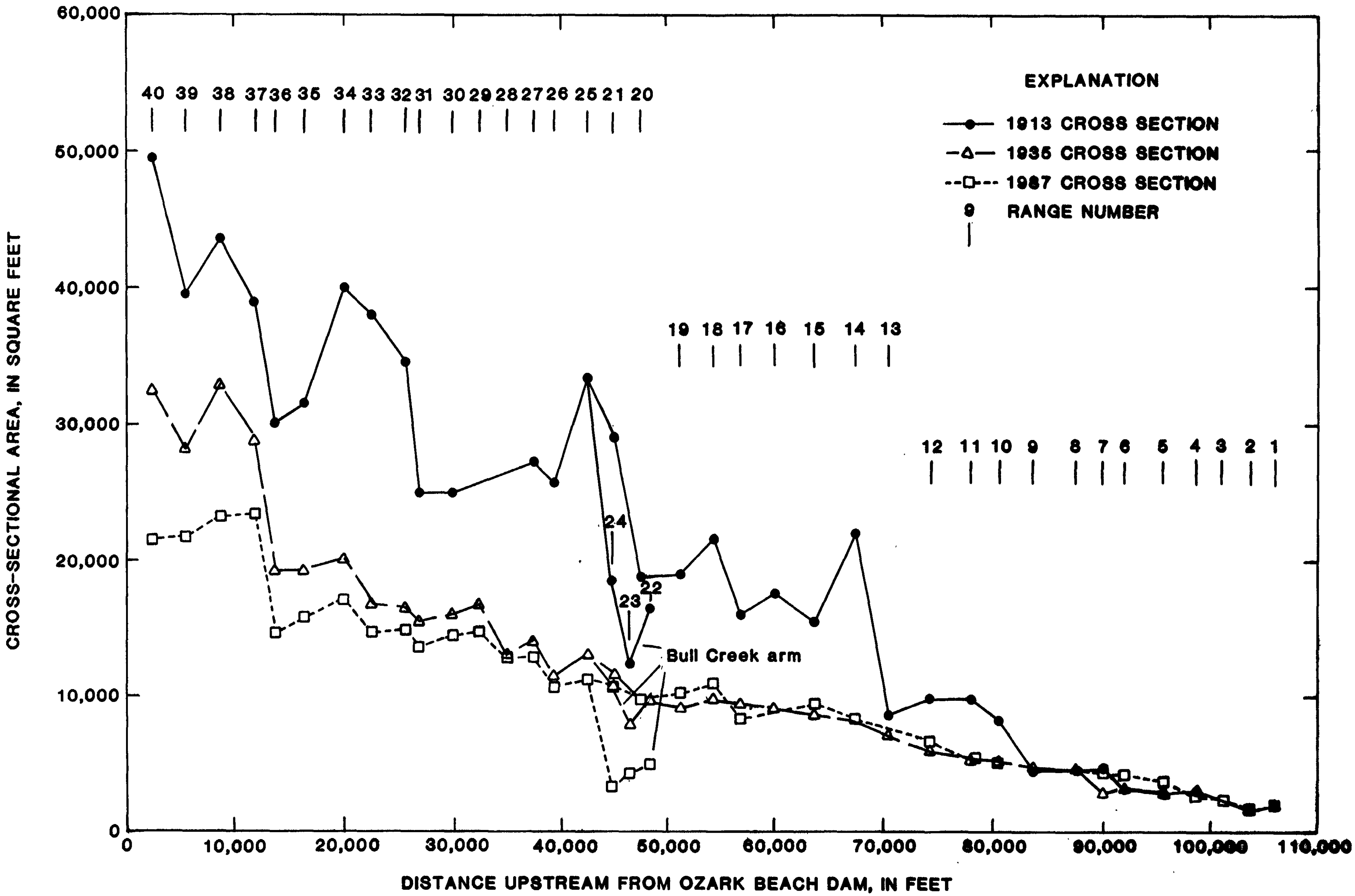


Figure 4.--Relation between cross-sectional area and distance from Ozark Beach Dam at ranges.

Virtually all of the sediment transported into Lake Taneycomo comes during flood flows (Kesler, 1936). When the impounded water decreases flow velocities sufficiently, sediment deposition begins. In an effort to locate where deposition begins in the lake, the changes in cross-sectional area at the ranges were compared for the 1913 to 1935 period and for the 1935 to 1987 period (fig. 5). Between 1913 and 1935 the flood water began depositing sediment at about range 7 (90,000 feet upstream from the dam). Plots of the channel thalweg (the deepest part of the channel cross section) for 1913 and 1935 (fig. 6) indicate that little accumulation occurred in the channel until range 20 (47,500 feet upstream from the dam). Although flood velocities were slowed sufficiently to allow deposition at range 7, velocities in the old river channel apparently were strong enough to prevent deposition upstream from range 21. Upstream from range 20, the original channel was maintained and sediment was deposited on the former flood plains. Downstream from range 20, the original channel bottom has built up to form an alluvial channel throughout its length, adjusted to the new base level or energy gradient established by the spillway at the Ozark Beach Dam.

Table Rock Dam disrupted the movement of sediment into Lake Taneycomo. Before Table Rock Dam was completed, flood flows transported sediment into Lake Taneycomo. After 1958, flood flows were retained behind Table Rock Dam and most of the transported material settled out into Table Rock Lake. Assuming Table Rock Dam traps almost 100 percent of sediment, the water entering Lake Taneycomo from Table Rock Dam has no sediment. Only sediment transported by the tributaries draining directly into Lake Taneycomo contributed sediment to the lake. The area contributing sediment to the lake after 1958 is only 8 percent of the total area that was contributing sediment to the lake before 1958. Flood volumes coming into Lake Taneycomo after 1958 are much smaller than before, and the impounded water of the lake has greater effect on the velocity of the incoming water. If no water enters Lake Taneycomo from Table Rock Dam, the incoming flood water from tributaries will deposit most of its sediment in the lake. On the other hand, if water is entering Lake Taneycomo from Table Rock Dam, most of the sediment transported into the main channel of Lake Taneycomo by tributaries will be caught by the current in the lake and transported further down the lake or out of Lake Taneycomo.

Partly in response to Table Rock Dam cutting off practically all the sediment transported to Lake Taneycomo, the channel present in 1935 has changed. Generally, the cross-sectional areas increased between 1935 and 1987 (fig. 5) for those ranges that were not dredged from range 1 to range 20 (106,200 to 47,500 feet upstream from Ozark Beach Dam). Downstream from range 21 the cross-sectional areas decreased, with the largest decreases occurring near Ozark Beach Dam. The thalweg elevations during 1987 generally are less than the 1935 thalweg elevations from range 1 to range 31 (106,200 to 26,900 feet upstream from the dam, fig. 6). Downstream from range 31 sediment deposition continues to increase the lake bottom elevation. Upstream from range 31 the lake channel is eroding, and downstream the lake channel is filling in response to the changes in the energy gradient (water-surface slope) and to the relatively sediment-free water discharged from Table Rock Dam.

Cesium-137 Measurements

Lake Taneycomo was not surveyed when Table Rock Dam was completed during 1958, so the volume of sediment accumulated after 1958 cannot be calculated using volumetric methods. An alternative method was used to date the sediment using a tracer element to determine accumulation from a specified time. The presence of the cesium-137 isotope in a sediment column can be used to determine the sediment accumulation after 1954. Cesium-137, a radioactive fallout product of atmospheric nuclear testing, first appeared in the environment during 1954 (McHenry and others, 1975). The isotope is tightly adsorbed onto fine soil particles and can be used to trace soil as it is

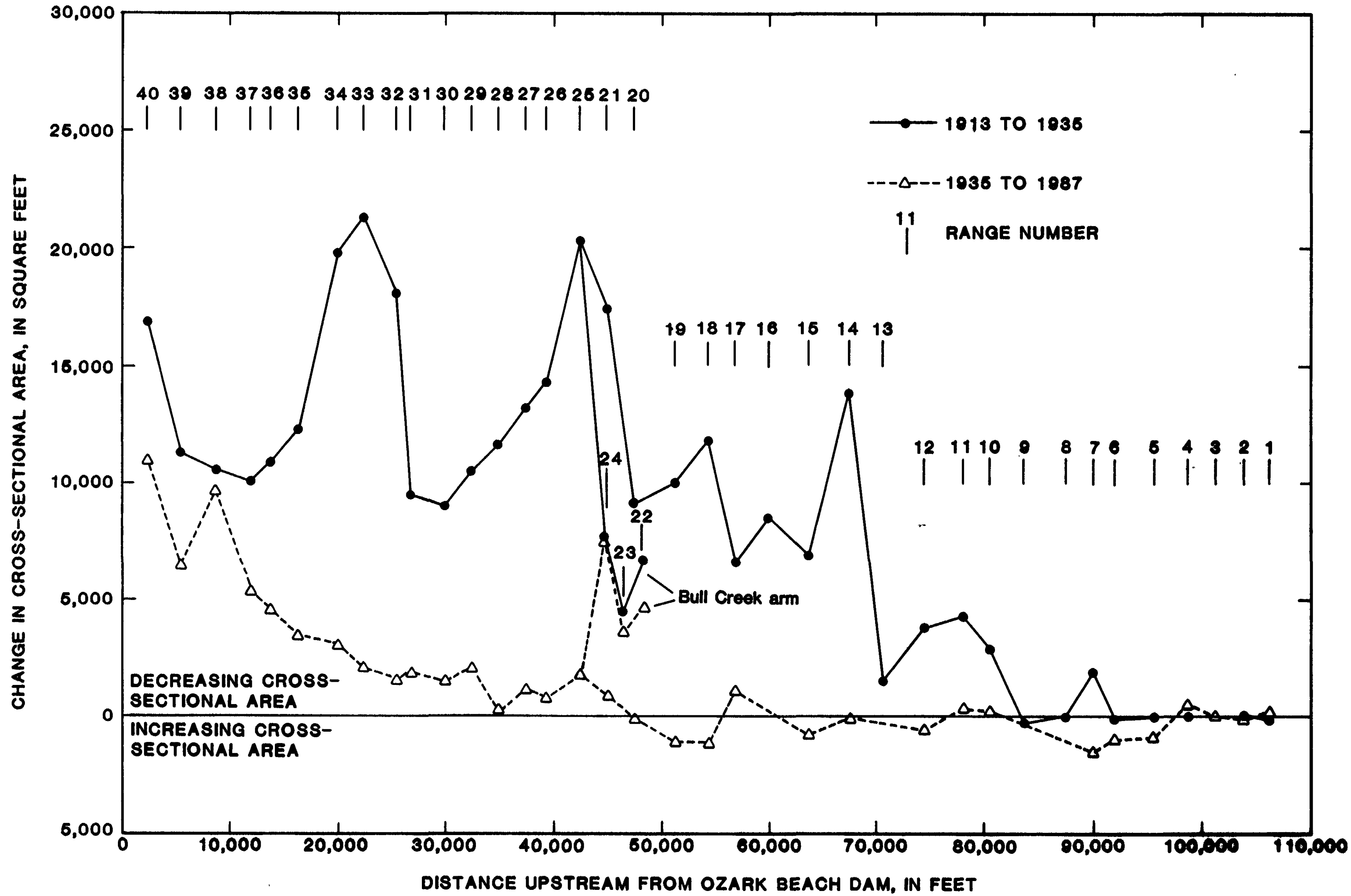


Figure 5.--Changes in cross-sectional area at each range along Lake Taneycomo.

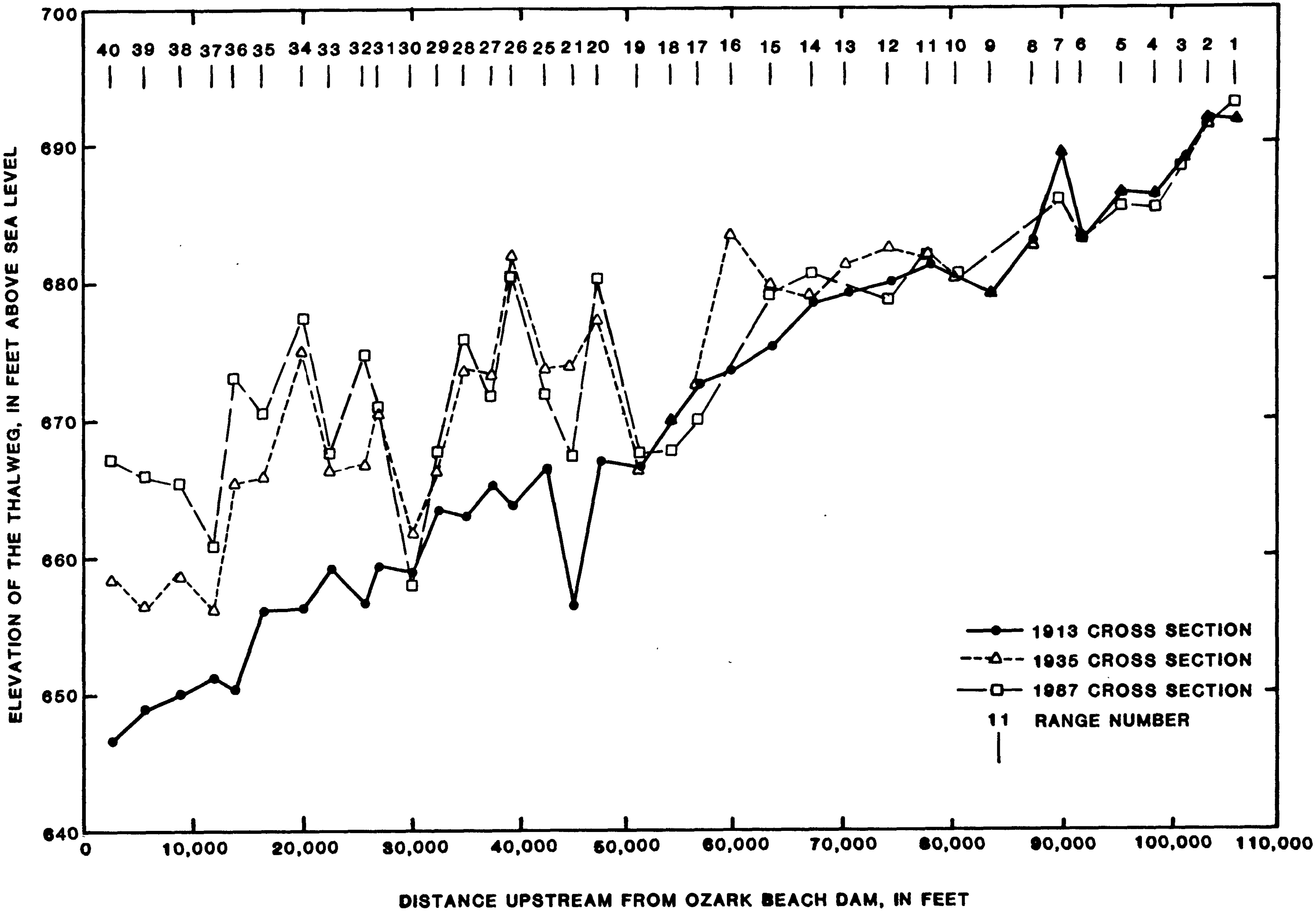


Figure 6.--Elevation of the thalweg in the 1913, 1935, and 1987 cross sections.

redistributed by erosion and deposited in lakes as sediment. Cesium-137 is not present in undisturbed sediment deposited before 1954. Sediment at the location in the profile where the presence of the cesium-137 isotope is first detected is assumed to have been deposited in 1954, which was 4 years before the completion of Table Rock Dam.

Dating sediment using cesium-137 only provides one elevation per sample site. A volumetric survey of a lake requires a large number of elevations. Because cesium-137 determinations are expensive, it was beyond the scope of this study to sample sufficient sites to determine adequately the volume of Lake Taneycomo during 1954. Cesium-137 analyses were used to determine the quantity of sediment accumulation after 1954 at a point. These accumulations were then compared to see if lateral and longitudinal patterns exist in the lake.

Method

Sediment profiles were obtained at 23 locations in Lake Taneycomo (fig. 3) during October 1987. Generally, samples were collected at each range downstream from Bull Creek, but sample sites were more closely spaced near Ozark Beach Dam because of greater sediment accumulation. Samples were collected using a modified 6-inch-diameter piston corer. The corer was forced into the bottom sediment about 2 feet and then removed. The sediment core was extruded. Three sediment cores were obtained at each site. The cores were measured and cut into 5-centimeter layers beginning with the top (the water-sediment interface). Corresponding layers from the three cores were composited and sent to the Water Quality and Watershed Research Laboratory operated by the U.S. Department of Agriculture, Agricultural Research Service at Durant, Oklahoma.

All samples were dried at 50 degrees Celsius and passed through a 6-millimeter mesh screen. The screened samples were weighed, and a 1,000-gram subsample was used to determine cesium-137 activity. The analysis was made using a multichannel analyzer with a germanium lithium-drifter solid-state crystal detector (McHenry and others, 1980). The sediment samples were then analyzed using the hydrometer method (Gee and Bauder, 1986) for particle-size distribution. A total of 188 samples were analyzed.

Calculations of sediment deposition were made by using the midpoint of the deepest sediment layer containing detectable cesium-137 activity. The minimum detectable level of cesium-137 activity was considered to be 0.03 picocuries per gram. Downward movement of cesium-137 into the lake sediment after deposition was assumed to be negligible.

Results

The quantity of sediment deposited after 1954 calculated from cesium-137 analysis is shown for each sample site in table 2. Samples in the lake upstream from Bull Creek were not obtained because the sediment would not remain in the sampler long enough to be retrieved from the lake. This was attributed to a lack of the cohesive finer silt and clay in the sediment profile. The location of the sample site in the cross section, the cesium-137 profile, and the particle-size distribution of the sediment profile are included in the Additional Information section, by site number, in the back of this report (tables 3-25 and figs. 7-38).

At CS1 (range 24 at the mouth of Bull Creek) the cesium-137 analyses indicate more than 1.5 feet of sediment accumulation between 1954 and 1987, or an average accumulation rate of more than 0.04 foot per year (1.5 feet divided by 33 years) from 1954 to 1987. The 1987 sedimentation survey indicated an 8-feet accumulation of sediment at CS1 between 1935 and 1987. Therefore, the average accumulation rate from 1935 to 1954 was less than 0.32 foot per year (about 6 feet divided by 19 years). The smaller accumulation rate from 1954 to 1987 is because of the removal of a large sediment source when Table Rock Dam was completed. Before the completion of this dam, sediment-laden floodwater from the White River entered Lake Taneycomo. Part of the floodwater traveled up the Bull Creek arm of the lake while the flood passed into the lake. The small flow velocities in the Bull Creek arm probably allowed large quantities of sediment to accumulate in that part of the lake. After Table Rock Dam was completed, sediment-laden floodwater from the main channel of Lake Taneycomo was eliminated. Therefore, practically all of the more than 1.5 feet of sediment accumulated at CS1 after 1954 probably came from the Bull Creek basin.

The volumetric survey indicated that after 1935, between ranges 25 and 31, scouring or small sediment accumulation occurred in the thalweg of the lake and most of the sediment accumulated away from the main channel. The cesium-137 analyses indicate that this pattern of accumulation also was present between 1954 and 1987. The least quantity of sediment accumulation noted between sample sites CS3 and CS10 occurred at site CS7 (0.2 foot), which is located in the thalweg of range 30. Site CS8 also had a small sediment accumulation (0.4 foot). This site is not located on a range, but the map location (fig. 3) indicates it probably is near the thalweg. The largest sediment accumulation in the thalweg (greater than 2.0 feet) occurred at site CS4, the site farthest from the main channel of the lake.

Table 2.--Sediment deposition after 1954 as determined from cesium-137 analyses

[>; greater than]

Site number (fig. 3)	Sediment deposition after 1954	
	Feet	Centimeters
CS1	>1.5	>45.0
CS2	1.6	47.5
CS3	.9	27.5
CS4	>2.0	>60.0
CS5	1.5	45.0
CS6	.8	25.0
CS7	.2	7.5
CS8	.4	12.5
CS9	2.1	62.5
CS10	1.1	32.5
CS11	>2.0	>61.0
CS12	1.6	47.5
CS13	.9	27.5
CS14	1.4	42.5
CS15	1.1	32.5
CS16	1.7	52.5
CS17	1.1	32.5
CS18	1.4	42.5
CS19	>1.8	>55.0
CS20	>2.6	>80.0
CS21	>2.0	>60.0
CS22	1.4	42.5
CS23	.2	7.5

After 1935, sediment consistently began to accumulate in the main channel downstream from range 31. The cesium-137 analyses also indicate larger quantities of sediment accumulated in the main channel downstream from range 31 than upstream from this range. Sample sites in or close to the thalweg of the lake downstream from range 31 include CS11 (range 32) with more than 2 feet of accumulation, CS14 (range 35) with 1.4 feet of accumulation, CS15 (range 36) with 1.1 feet of accumulation, CS17 (range 38) with 1.1 feet of accumulation, and CS22 (range 40) with 1.4 feet of accumulation. Generally, the other sites had greater quantities of accumulation, but the differences between deposits in the thalweg and deposits away from the thalweg do not appear to be as large as the differences upstream from range 31.

The cesium-137 analyses indicated that downstream from range 25 (site CS3) sediment accumulated in Lake Taneycomo from 1954 to 1987 followed the sediment accumulation pattern indicated by the volumetric survey for the period 1935 to 1987. Although the quantity of sediment transported into Lake Taneycomo has been reduced by the completion of Table Rock Dam, the largest quantity of sediment accumulation in a cross section continues to be away from the thalweg, and the quantities of sediment accumulated in the longitudinal axis of the lake continue to increase downstream. Sediment is being deposited in a manner characteristic of an alluvial river whose base level has been elevated.

SUPPORTING INFORMATION

During this study it became apparent that the upper reaches of Lake Taneycomo had become scoured by outflow from Table Rock Dam. Therefore, some additional data were collected to explain the occurence of scouring in the lake. Two types of supporting information included in this report are water velocities in the lake and particle size of lake bottom material. The velocity information indicates that velocities can occur in the lake that will detach bottom materials and transport them farther down the lake or out of the lake. The particle-size information documents conditions in 1988, and may indicate areas where scouring took place.

Velocity

Scouring in Lake Taneycomo was expected because large volumes of water are released during power generation at Table Rock Dam. When the velocity of flowing water is sufficient to detach a particle from the channel, that particle will become suspended and transported away. When the velocity decreases the forces suspending the particle diminish and sediment particles are deposited. The reason that scouring can occur directly downstream from Table Rock Dam is that water released from the dam, which has no suspended material for sediment deposition, has sufficient velocity to detach particles from the channel.

While doing onsite work on Lake Taneycomo, velocities were observed in all parts of the main lake. It was beyond the scope of this study to develop velocity profiles in the lake. Velocities in the lake were estimated using a step-backwater model (Shearman, 1976), which routes a given flow through the cross sections of the lake. The model was calibrated using gage-height data from three gaging stations: 07053500, White River near Branson; 07053600, Lake Taneycomo at the School of the Ozarks; and 07053820, Lake Taneycomo at Ozark Beach Dam (fig. 3). Velocities were estimated for sustained flows of 7,500 and 17,500 cubic feet per second. These two flows were used because they had been maintained at station 07053500 (fig. 3) for at least 3 days. This is a necessary criterion because the assumption is made that the discharge entering the lake is equal to the discharge leaving the lake and that water-surface elevations have reached equilibrium.

The frequency of occurrence for the two flows were calculated based on the average daily discharge record for station 07053500 from October 1958 to September 1987. These data indicate that 15 percent of the time flows entering Lake Taneycomo were less than 7,500 cubic feet per second, and 1 percent of the time flows were greater than 17,500 cubic feet per second. The average velocities calculated at each range for the two flows are shown in table 26.

Many investigators have attempted to determine the velocity necessary to detach and suspend a channel particle. Their investigations indicated that the detachment velocity is dependent on the mass of the particle and the cohesion of the particle to the channel. The relation between detachment velocity and particle size, which was based upon work done by Hjulstrom (1935) using quartz grain, is shown in figure 39 (Vanoni, 1975). The easiest particles to detach are sand particles, about 0.25 millimeter in diameter. As the particles become smaller than 0.25 millimeter, the cohesion between the particles increases as does the velocity needed to detach them. As the particles become larger than 0.25 millimeter, the mass increases, as does the velocity needed to detach them. Generally, if the detachment velocity is greater than 0.6 foot per second, particles may be removed from the channel.

The detachment velocity is that velocity measured at the water-channel interface. A number of studies has been done relating average channel velocity to the velocity measured at various locations in the channel cross section. The general rule is the bottom velocity, or the velocity measured at the water-channel interface, is one-half the average channel velocity (Rantz and others, 1982). Water-channel interface velocities for discharges of 7,500 and 17,500 cubic feet per second were estimated from the average channel velocities (fig. 40).

Based on estimated water-channel interface velocities (fig. 40), scouring of Lake Taneycomo is possible during both discharges. For a discharge of 7,500 cubic feet per second, scouring may be possible upstream from range 11. For the 17,500 cubic feet per second discharge, scouring may be possible upstream from range 21. In the upper reaches of the lake removal of material from 0.01 to 4 millimeter in diameter is possible. This includes material in the silt (0.002 to 0.05 millimeter), sand (0.05 to 2 millimeters), and gravel (greater than 2 millimeters) classes. The velocity data indicate that scouring in Lake Taneycomo is possible from Table Rock Dam to range 21, particularly during high flows.

Particle-Size Distribution

Material from the surface of the lake bed was collected at approximately every other range on May 12, 1988, and analyzed for particle-size distribution. A US BM-54 sampler or a pipe-dredge sampler was used to obtain the samples. The US BM-54 is a 100-pound cast-steel sampler suspended from a cable. A scoop bucket mounted in the center of the sampler obtains a bottom-material sample when the sampler touches the surface of the bottom material. The scoop penetrates about 1.7 inches into the bottom material. When the bottom material was too large to fit into the scoop bucket, a pipe-dredge sampler was used. The pipe dredge consists of a 4-inch inside-diameter pipe that is closed on one end and flared to a 6-inch inside-diameter opening at the other end. The overall length is 16 inches. The sampler is lowered to the lake bottom and dragged across the bottom until sufficient sample is obtained.

The samples were analyzed by the U.S. Geological Survey Sediment Laboratory in Iowa City, Iowa, using the sieve-pipet method (Guy, 1969). The median particle size was determined for each sample and plotted against the distance of the sample site from Ozark Beach Dam (fig. 41). The median particle size decreased from about 20 millimeters in the upper reaches of the lake to about 0.015 millimeter near the dam. Because no previous information about the particle size of the lake bottom was available, the effect of the discharge from Table Rock Dam cannot be determined on composition of the bottom material in the lake. However, these data may be useful in future surveys to determine particle-size changes because of water releases from Table Rock Dam.

Table 26.--Estimated average velocities in Lake Taneycomo from a step-backwater model (Shearman, 1976)

[ft, feet; ft/s, feet per second; ft^3/s, cubic feet per second]

Range (fig. 3)	Distance upstream from Ozark Beach Dam, in ft	Average velocity, in ft/s: Discharge equal to 7,500 ft^3/s	Average velocity, in ft/s: Discharge equal to 17,500 ft^3/s
1	106,200	2.57	3.77
2	103,800	2.88	4.17
3	101,200	2.39	3.71
4	98,700	2.36	3.96
5	95,600	1.67	2.88
6	91,900	1.57	2.81
7	90,000	1.47	2.56
8	87,500	1.38	2.51
9	83,700	1.20	2.23
10	80,600	1.45	2.61
11	78,100	1.33	2.49
12	74,400	.92	1.68
13	70,600	.78	1.52
14	67,500	.81	1.55
15	63,700	.71	1.35
16	60,000	.62	1.19
17	56,900	.73	1.44
18	4,400	.64	1.30
19	51,300	.68	1.37
20	47,500	.69	1.31
21	45,000	.64	1.24
25	42,500	.57	1.01
26	39,400	.61	1.09
27	37,500	.52	.96
28	35,000	.54	1.10
29	32,500	.46	.92
30	30,000	.49	1.01
31	26,900	.51	1.03
32	25,600	.46	.91
33	22,500	.41	.73
34	20,000	.38	.70
35	16,300	.43	.84
36	13,700	.46	.88
38	8,800	.30	.62
39	5,600	.32	.65
40	2,500	.32	.62

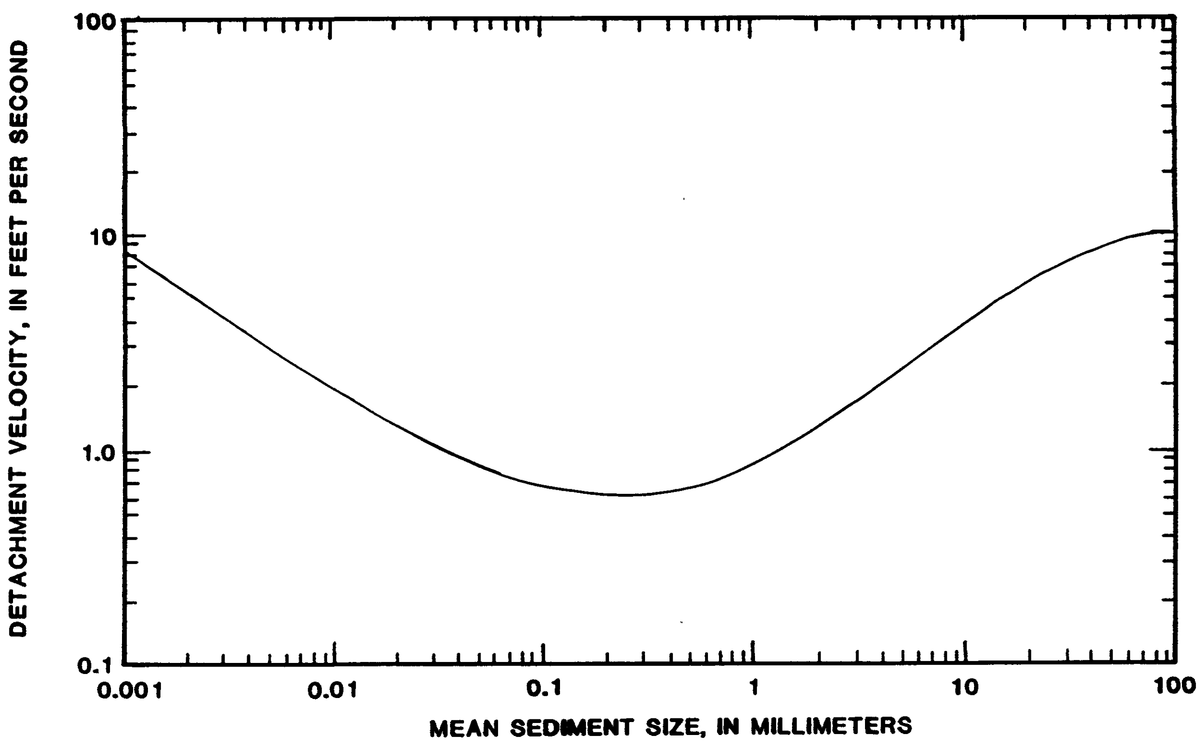


Figure 39.—Detachment velocities for quartz sediment as a function of mean sediment size (modified from Vanoni, 1975, p.102).

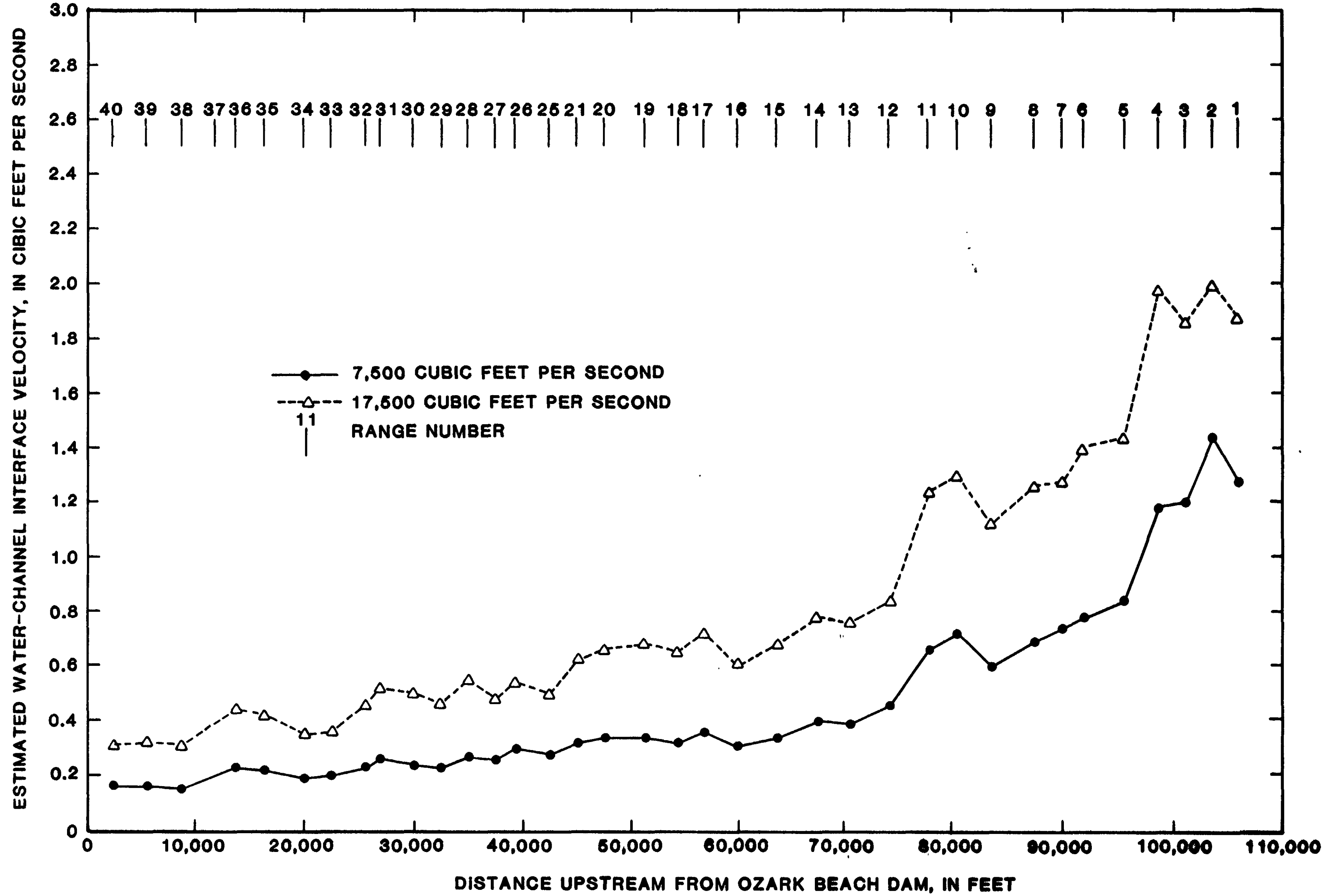


Figure 40.--Estimated water-channel interface velocities.

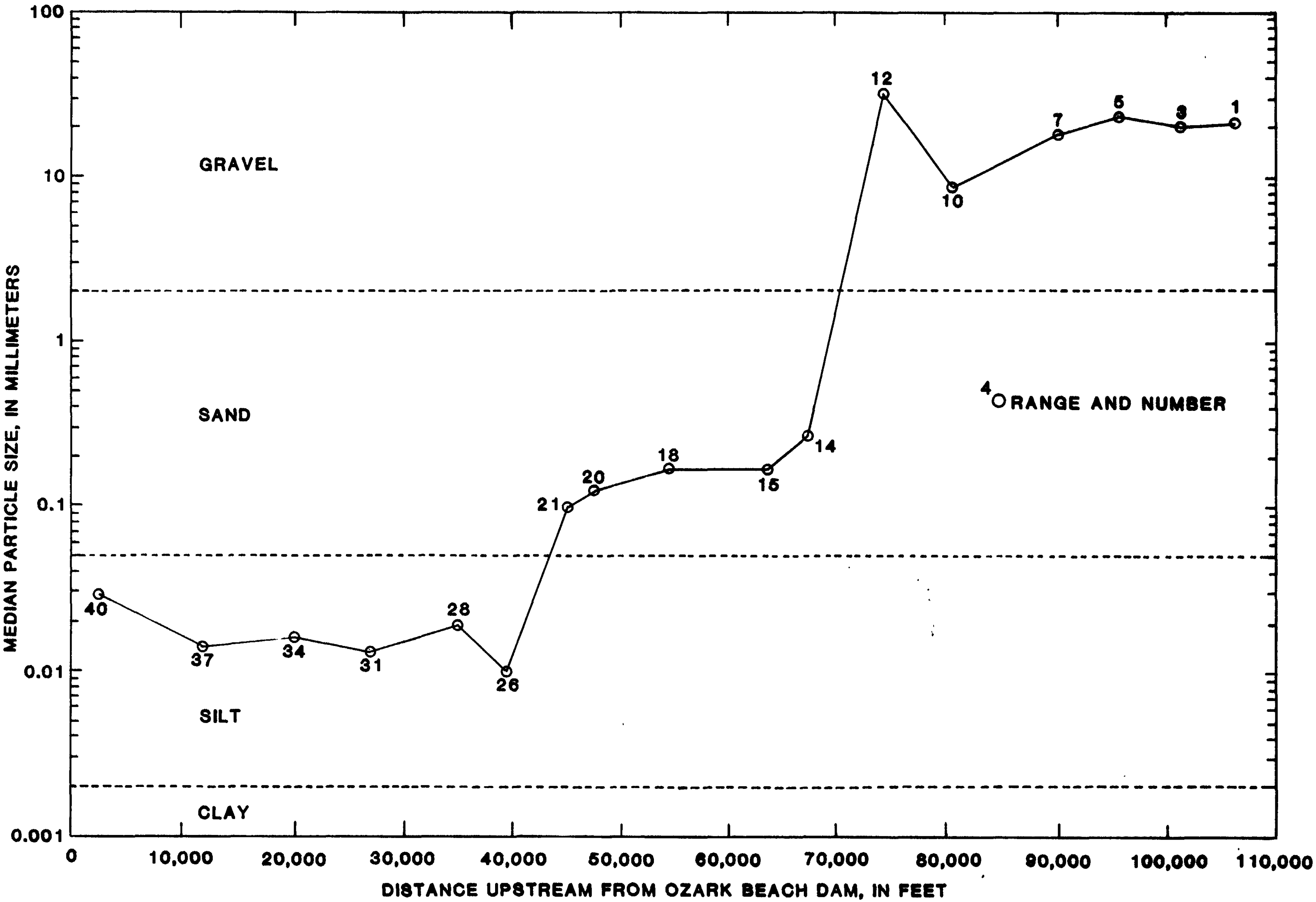


Figure 41.—Median particle size of bed material, May 1988.

Almost all of the sediment particles in the samples upstream from range 12 were larger than 5 millimeters in diameter (table 27), which coincides with the largest water-channel interface velocities (fig. 40). The lack of particles (13 percent or less) in the 0.01- to 4-millimeter diameter-range probably is because of discharges from Table Rock Dam removing them upstream from range 12.

SUMMARY

The water volume of Lake Taneycomo in 1913, 1935, and 1987 was calculated using the curve method from data collected in a sedimentation survey by the U.S. Department of Agriculture, Soil Conservation Service during 1935 and data collected by the U.S. Geological Survey, in cooperation with the Missouri Department of Natural Resources, Division of Environmental Quality, during 1987. The volume of sediment accumulated in the lake from 1913 to 1935 was calculated to be 910,000,000 cubic feet, or 42 percent of the original lake volume. The volume of sediment accumulated in the lake from 1913 to 1987 was calculated to be 1,066,000,000 cubic feet, or 49 percent of the original lake volume.

The cross-sectional information indicated that until 1935, sediment began accumulating in Lake Taneycomo at about range 7, but that current velocities in the lake did not allow sediment to accumulate in the main channel upstream from range 20. The ranges surveyed during 1987 indicated that generally the cross-sectional areas upstream from range 21 were larger than those measured in 1935, indicating a net scouring in the upper part of the lake. Downstream from range 21, the 1987 data indicated a net accumulation of sediment, but the thalweg elevations were all generally less than the 1935 thalweg elevations downstream to range 31, indicating scouring occurred in the lake upstream from range 31 after Table Rock Dam was completed.

The quantity of sediment accumulated in Lake Taneycomo downstream from range 24, as measured by cesium-137 analyses, ranged from 0.2 feet to more than 2.6 feet. Generally, the cesium-137 data indicate the quantity of accumulation was dependent on the location in the lake laterally and longitudinally. The least quantity of accumulation occurred in the thalweg farthest upstream from Ozark Beach Dam. The greatest accumulation occurred away from the thalweg near Ozark Beach Dam. The data indicated that although accumulated sediment has been reduced by the completion of Table Rock Dam, sediment continues to be deposited in a manner characteristic of an alluvial stream whose base level has been elevated by the spillway at Ozark Beach Dam and responds to changes in slope and sediment load.

Before Table Rock Dam was built, the sediment transported into the lake by the White River filled the slackwater areas, starting at the upstream end of the lake. Eventually, the original bottom of the lake would have been elevated in response to the energy gradient established by the Ozark Beach Dam spillway. During 1958 Table Rock Dam was built, which eliminated most of the sediment transported into Lake Taneycomo. As a result the upstream reaches of the lake were scoured and deposition continued in the downstream reaches in an attempt to reach an equilibrium between energy gradient and sediment load.

Channel velocities were estimated in the lake using a step-backwater model and the 1987 cross-sectional data. The estimated velocities indicated that scouring of the channel is possible downstream to range 21 (8 river miles upstream from Ozark Beach Dam). Particle size of bed material in the lake thalweg were obtained. The data were not sufficient to determine if scouring occurred. In the reach upstream from range 12 bed material generally was larger than 5 millimeters in diameter, indicating that scouring of fine material has occurred.

Table 27.--Particle-size distribution of bed material in Lake Taneycomo, May 12, 1988

[--, no data available]

	Percentage of sample smaller than particle diameter Particle diameter, in millimeters														
Range	64	32	16	8	4	2	1	0.5	0.25	0.12	0.062	.016	0.008	0.004	0.002
1	100	85	35	3	3	2	2	1	0	0	0	0	0	0	0
3	100	100	21	0	0	0	0	0	0	0	0	0	0	0	0
5	100	82	21	4	3	2	2	2	2	1	0	0	0	0	0
7	100	89	42	11	5	3	3	2	2	1	0	0	0	0	0
10	100	81	47	24	13	8	5	3	1	0	0	0	0	0	0
12	100	48	27	17	13	11	10	10	9	6	4	0	0	0	0
14	100	100	100	90	77	71	67	44	7	1	0	0	0	0	0
15	100	100	100	99	97	94	90	86	67	34	10	--	--	1	--
18	100	100	100	100	100	100	100	98	84	27	5	0	0	0	0
20	100	100	86	72	62	59	58	57	57	51	31	15	10	8	6
21	100	100	100	100	100	100	100	100	97	60	32	18	14	11	9
26	100	100	100	100	100	100	100	100	100	98	93	64	48	34	27
28	100	100	100	100	100	100	100	100	100	98	88	45	32	24	18
31	100	100	100	100	100	100	100	100	100	100	96	56	38	27	22
34	100	100	100	100	100	100	100	100	100	97	89	50	33	26	20
37	100	100	100	100	100	100	100	100	100	100	97	55	39	28	24
40	100	100	100	100	100	100	100	100	99	86	67	39	27	20	15

REFERENCES CITED

Fenneman, N.M., 1938, Physiography of Eastern United States: New York, McGraw Hill, 714 p.

Gee, G.W. and Bauder, J.W., 1986, Particle-size analysis in Klute, A. and others eds., Methods of Soil Analysis: Agronomy, v. 9, Part 1, p. 383-409.

Guy, H.P., 1969, Laboratory theory methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter C1, 58 p.

Heinemann, H.G. and Dvorak, V.I., 1965, Improved volumetric survey and computation procedures for small reservoirs in Proceeding of the Federal Interagency Sedimentation Conference, 1963, Miscellaneous Publication No. 970: Washington, D.C., U.S. Department of Agriculture, p. 845-856.

Hjulstrom, F., 1935, Studies of the morphological activity of rivers as illustrated by the River Fyris: Upsala, Sweden, Geological Institute of Upsala Bulletin, v. XXV.

Kesler, T.L., 1936, Advance report on the sedimentation survey of Lake Taneycomo, Taney County, Missouri: U.S. Department of Agriculture, Soil Conservation Service, Division of Research, Section of Hydrodynamic Studies: SCS-SS-8, 8 p.

McHenry, J.R., Ritchie, J.C., and Cooper, L.M., 1980, Rates of recent sedimentation in Lake Pepin: Water Resources Bulletin 6, p. 1,049-1,056.

McHenry, J.R., Ritchie, J.C., and May, J., 1975, Recent sedimentation rates in the lower Mississippi River Valley: Lake Verret-Lake Palondre, Louisiana: Proceedings Mississippi Water Resources Conference, Water Resources Research Institute, Mississippi State University, p. 13-23.

Rantz, S. E. and other, 1982, Measurement and computation of streamflow--Volume 1--Measurement of Stage and Discharge: U.S. Geological Survey Water-Supply Paper 2175, 284 p.

Shearman, J.O., 1976, Computer applications for step-backwater and floodway analysis: U.S. Geological Survey Open-File Report 76-499, 103 p.

Vanoni, V.A., ed., 1975, Sedimentation engineering: American Society of Civil Engineerings--Manuals and Reports on Engineering Practice No. 54, 745 p.

U.S. Department of Commerce, 1983, 1980 census of population: Washington, D.C., Bureau of the Census, 269 p., 4 appendices.

pg 33 follows

ADDITIONAL INFORMATION

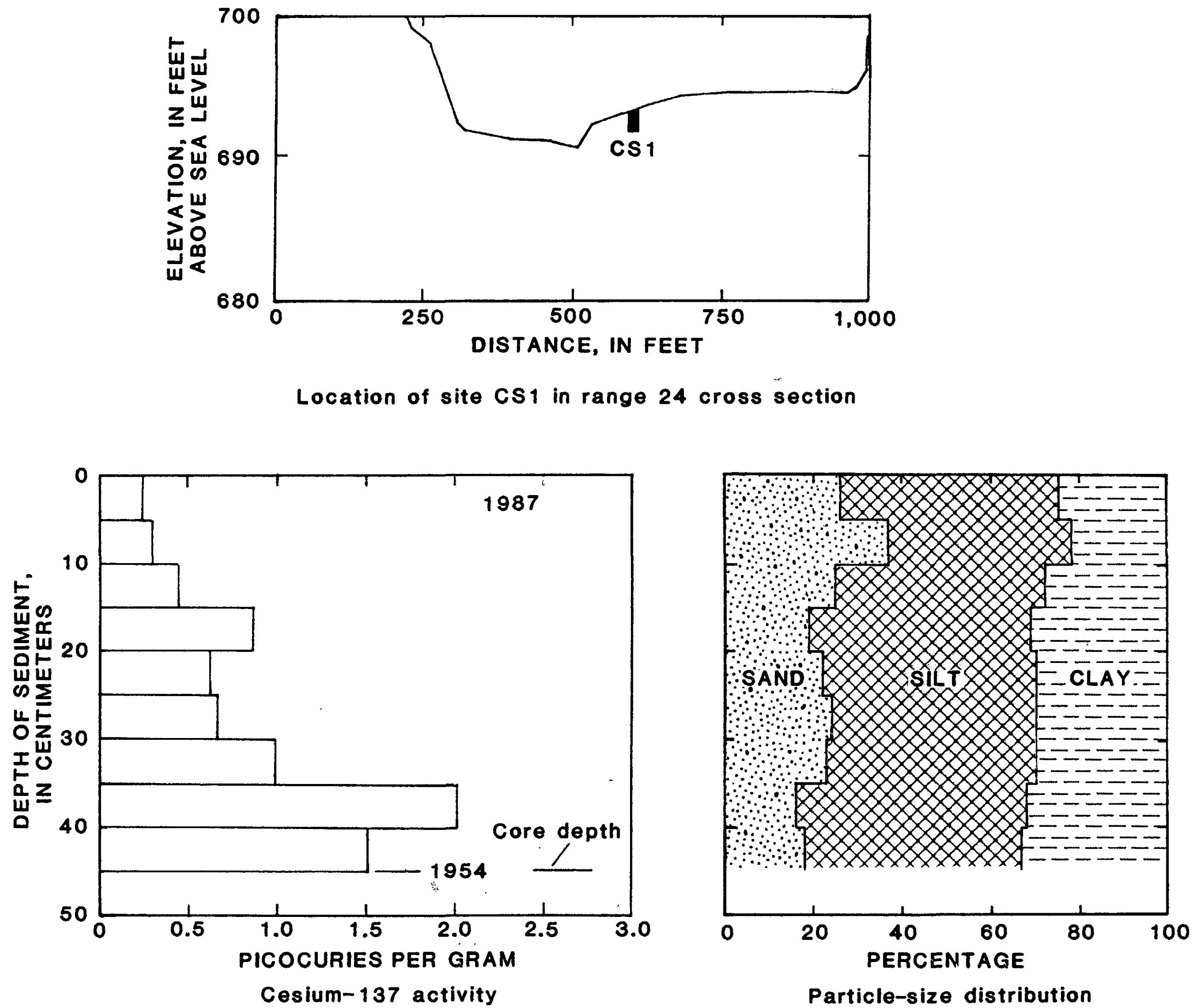


Figure 7.--Location, cesium-137 activity, and particle-size distribution at site CS1.

Table 3.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS1

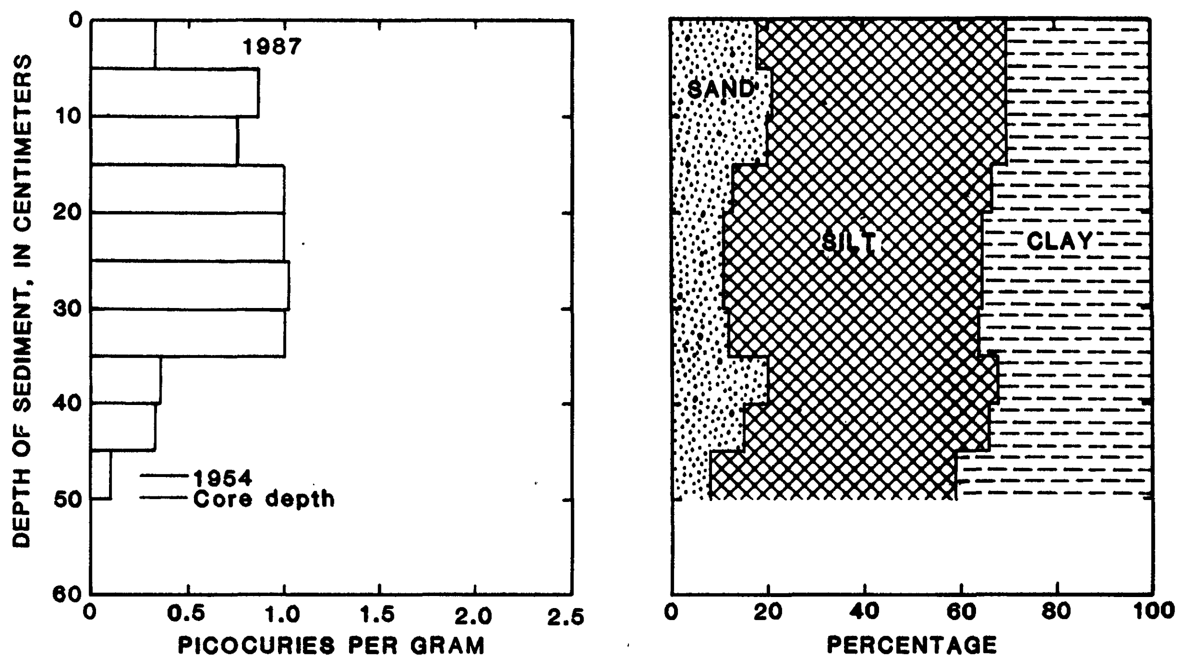
[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.24	26	49	25
5 to 10	.30	37	41	22
10 to 15	.46	25	47	28
15 to 20	.86	19	50	31
20 to 25	.62	22	48	30
25 to 30	.65	24	46	30
30 to 35	1.0	23	47	30
35 to 40	2.0	16	52	32
40 to 45	1.5	18	49	23

Table 4.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS2

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.35	18	52	30
5 to 10	.89	21	49	30
10 to 15	.76	20	50	30
15 to 20	1.1	13	54	33
20 to 25	1.1	11	54	35
25 to 30	1.2	11	54	35
30 to 35	1.1	12	52	36
35 to 40	.35	20	48	32
40 to 45	.32	15	51	34
45 to 50	.05	8	51	41



Cesium-137 activity

Particle-size distribution

Figure 8.--Cesium-137 activity and particle-size distribution at site CS2.

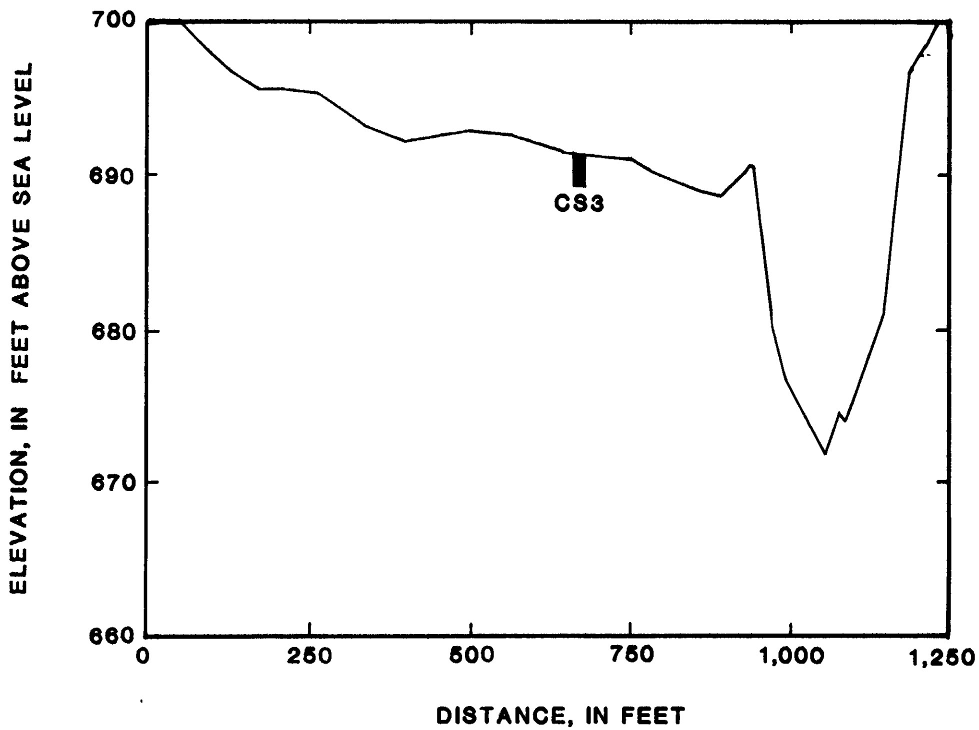


Figure 9.--Location of site CS3 in range 25 cross section.

Table 5.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS3

[cm, centimeter; pCi/g, picocuries per gram;
>, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	1.2	20	53	27
5 to 10	1.9	14	56	30
10 to 15	.60	28	45	27
15 to 20	.03	48	34	18
20 to 25	.03	63	23	14
25 to 30	.05	23	48	29
30 to 35	<.03	11	58	31
35 to 40	.03	7	61	32
40 to 45	<.03	5	56	39
45 to 50	<.03	9	53	38
50 to 55	<.03	11	53	36
55 to 60	.03	15	50	35
60 to 65	<.03	19	46	35

Table 6.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS4

[cm, centimeter; pCi/g, picocuries per gram;
>, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.65	12	63	25
5 to 10	1.2	8	59	33
10 to 15	1.8	7	57	36
15 to 20	1.5	9	62	29
20 to 25	1.2	11	61	28
25 to 30	.70	12	58	30
30 to 35	.84	8	56	36
35 to 40	.81	10	55	35
40 to 45	.57	23	54	23
45 to 50	.40	18	52	30
50 to 55	.22	17	52	31
55 to 60	.08	23	51	26

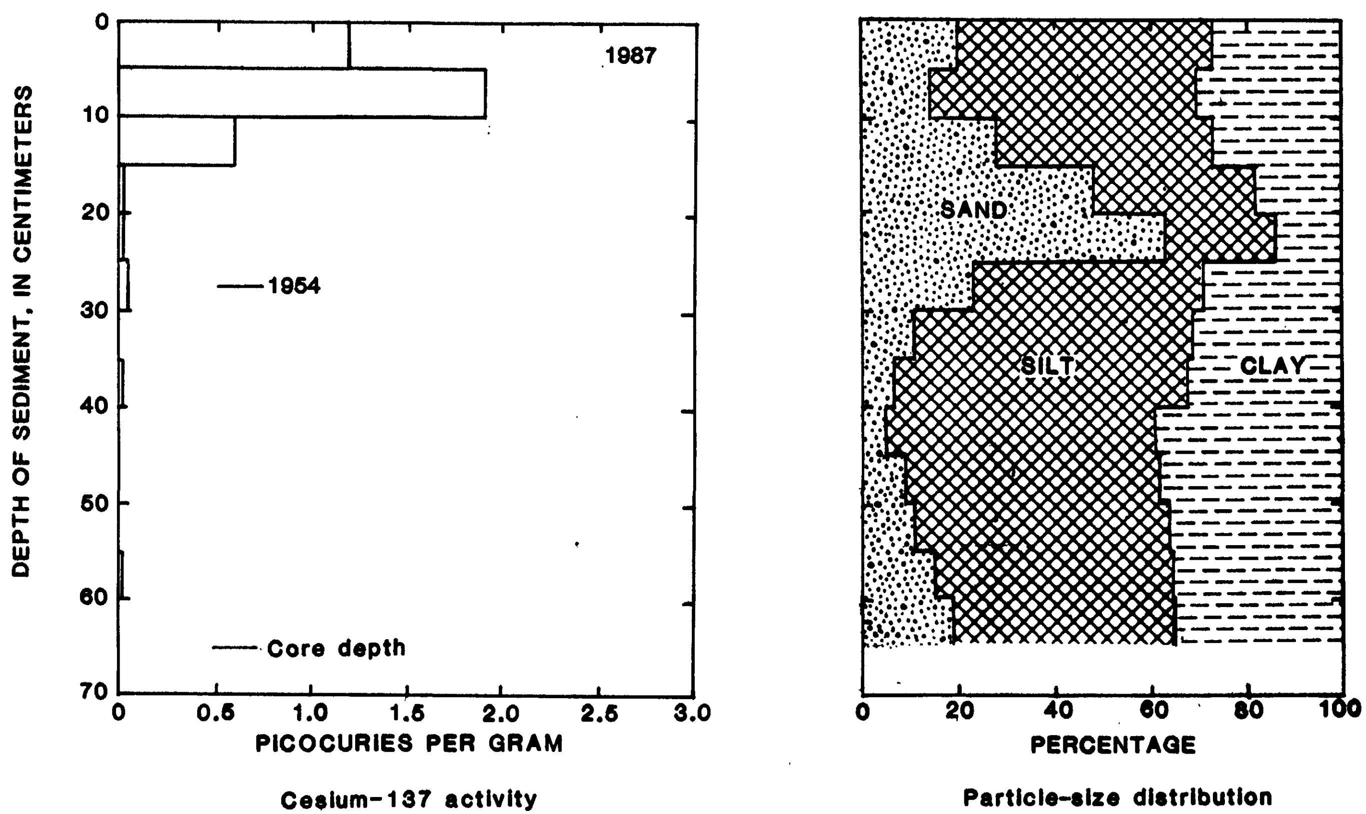


Figure 10.--Cesium-137 activity and particle-size distribution at site CS3.

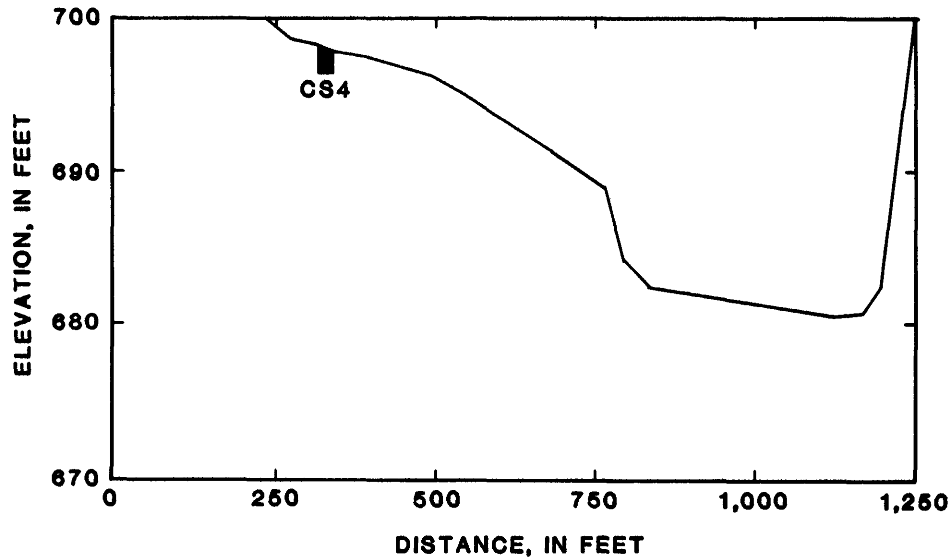


Figure 11.--Location of site CS4 in range 26 cross section.

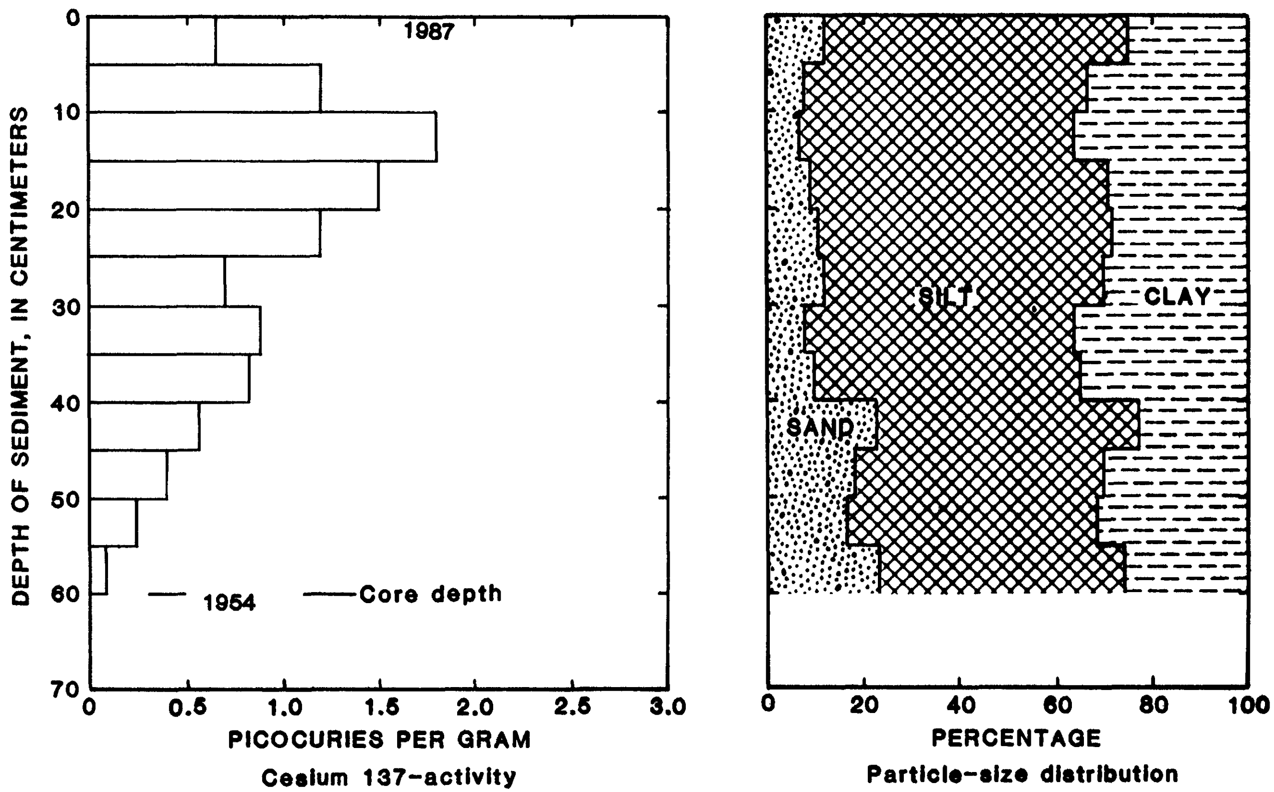
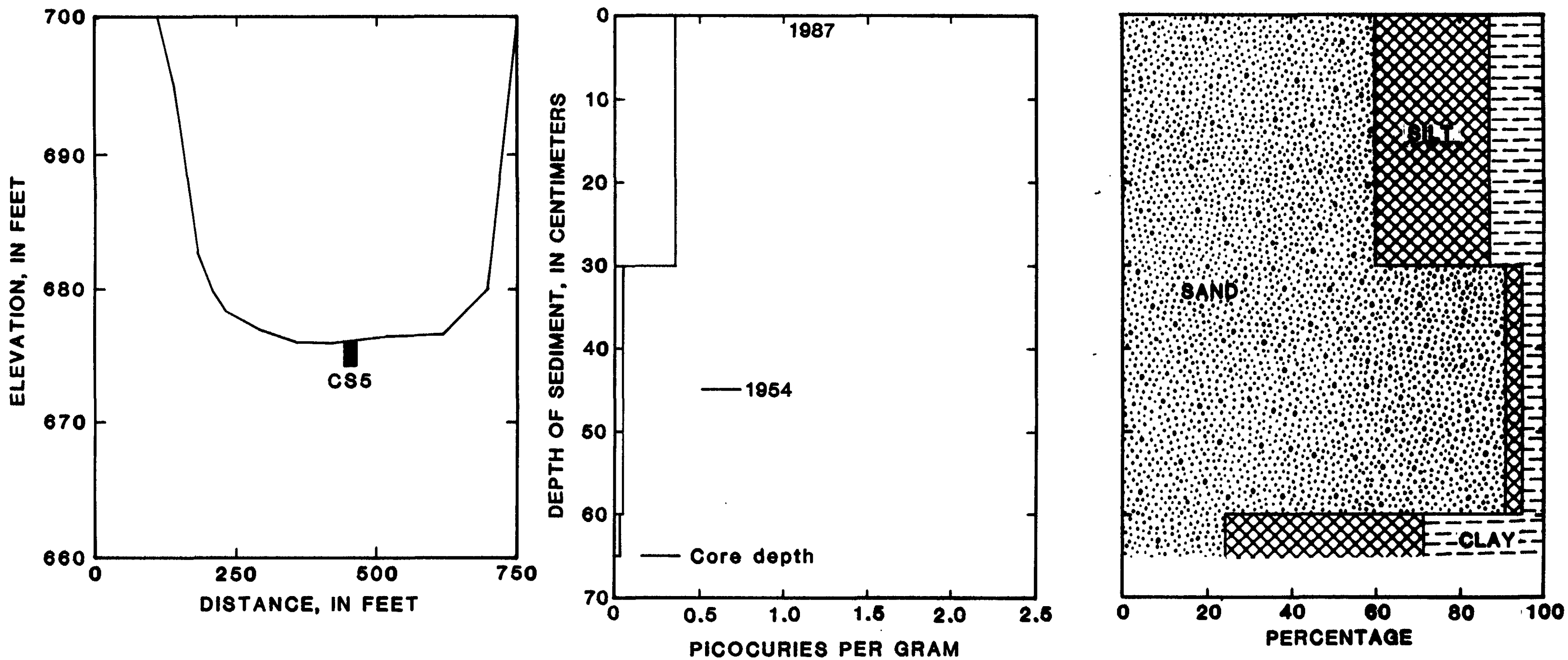


Figure 12.--Cesium-137 activity and particle-size distribution at site CS4.



Location of site CS5 in range 28 cross section.

Cesium-137 activity

Particle-size distribution

Figure 13.--Location, cesium-137 activity, and particle-size distribution at site CS5.

Table 7.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS5

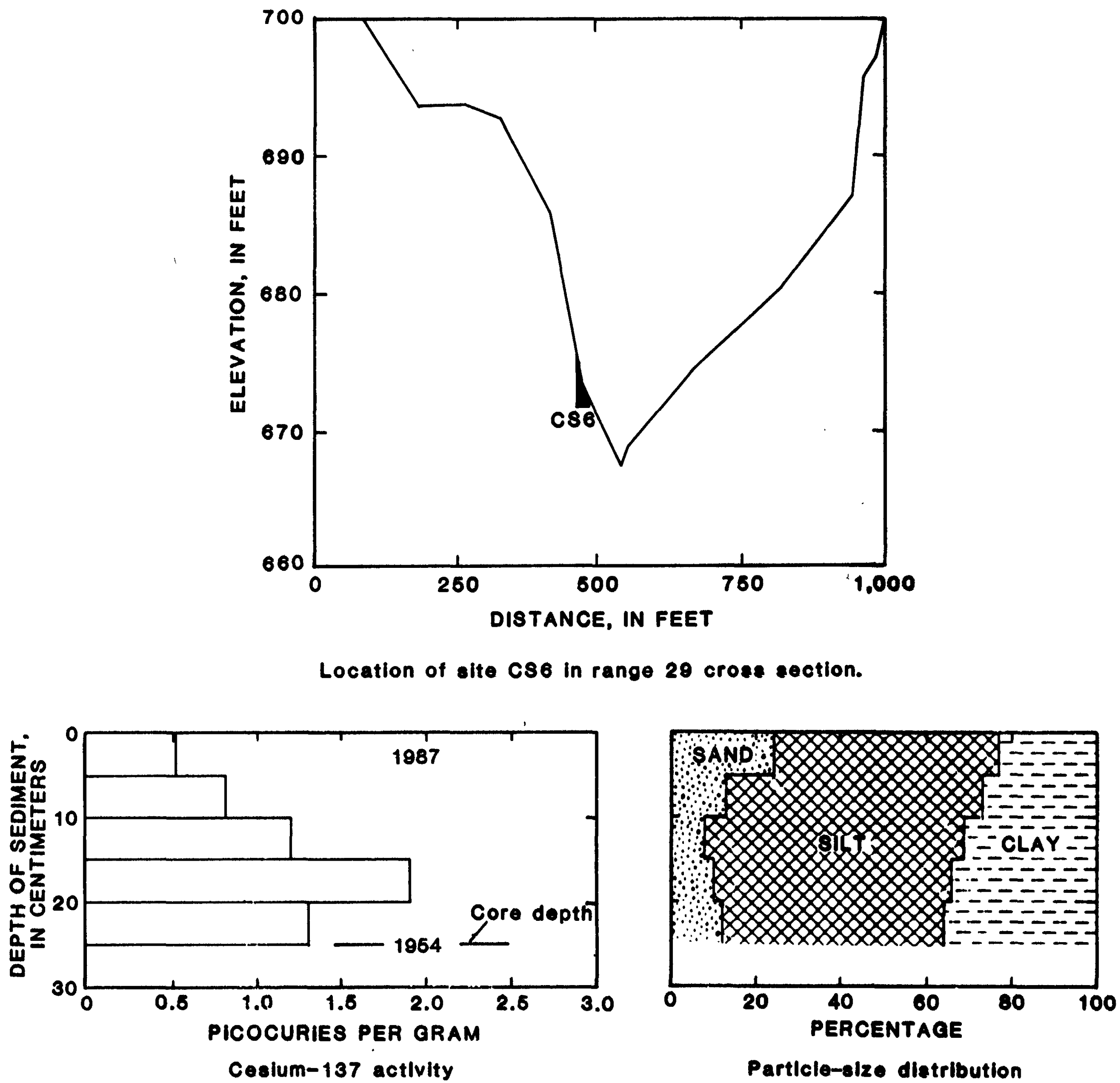
[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 30	0.35	60	27	13
30 to 60	.05	91	4	5
60 to 65	<.03	24	47	29

Table 8.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS6

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.51	24	53	23
5 to 10	.81	13	60	27
10 to 15	1.2	8	61	31
15 to 20	1.9	10	56	34
20 to 25	1.3	12	52	36

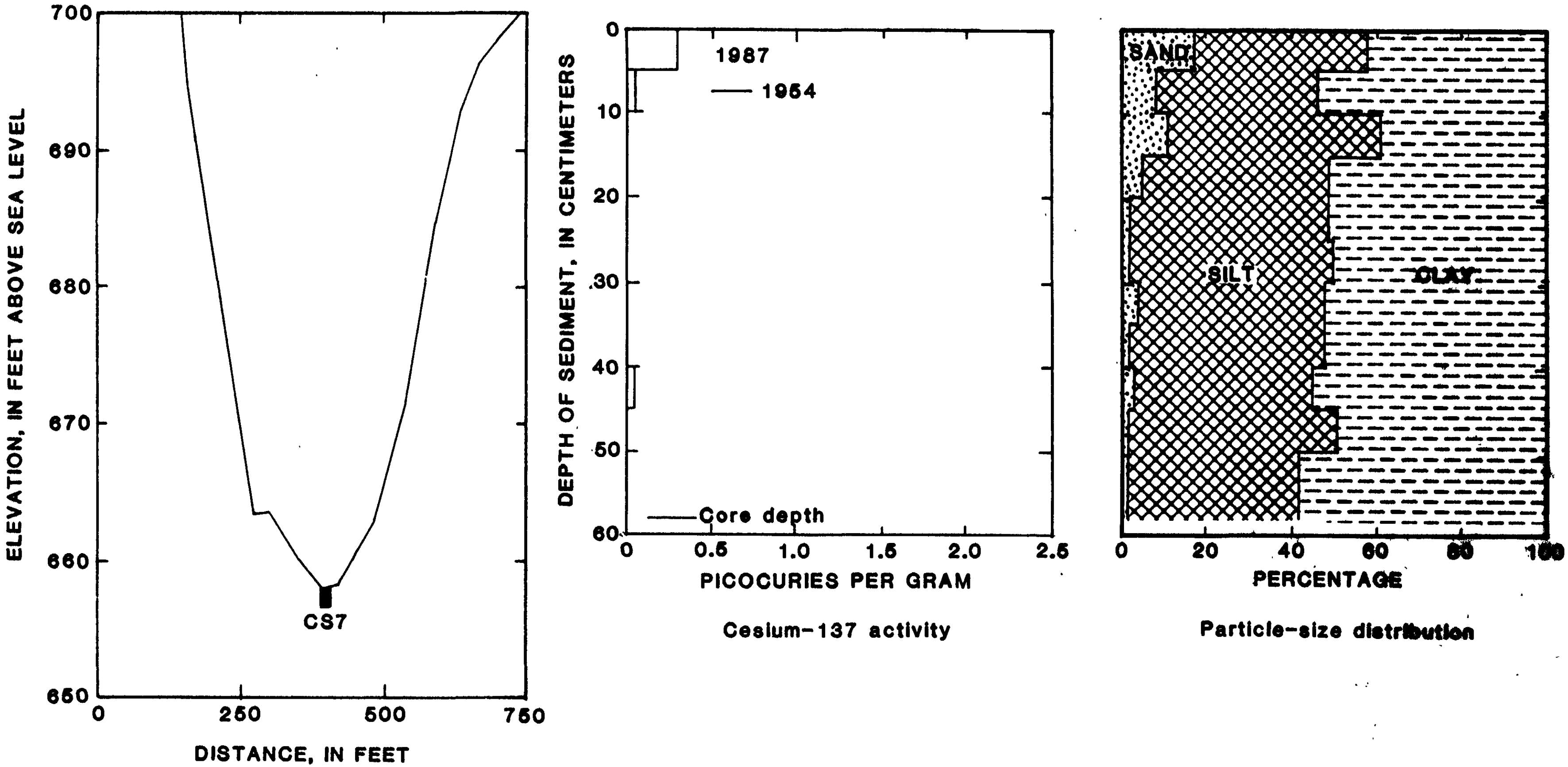


Location of site CS6 in range 29 cross section.

Cesium-137 activity

Particle-size distribution

Figure 14.--Location, cesium-137 activity, and particle-size distribution at site CS6.



Location of site CS7 in the range 30 cross section.

Figure 15.--Location, cesium-137 activity, and particle-size distribution at site CS7.

Table 9.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS7

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.30	17	41	42
5 to 10	.05	8	38	54
10 to 15	<.03	11	50	39
15 to 20	<.03	5	44	51
20 to 25	<.03	2	47	51
25 to 30	<.03	2	48	50
30 to 35	<.03	4	44	52
35 to 40	<.03	2	46	52
40 to 45	.05	3	42	55
45 to 50	<.03	2	49	49
50 to 58	<.03	2	40	58

Table 10.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS8

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.76	8	51	41
5 to 10	.38	9	50	41
10 to 15	.14	11	50	39
15 to 20	.03	10	50	40
20 to 25	<.03	9	51	40
25 to 30	.03	12	51	37
30 to 35	<.03	12	52	36
35 to 40	<.03	10	53	37
40 to 45	<.03	8	50	42
45 to 50	<.03	4	53	43
50 to 55	<.03	6	48	46
55 to 60	<.03	13	53	34
60 to 65	.05	13	53	34
65 to 70	.03	3	56	41

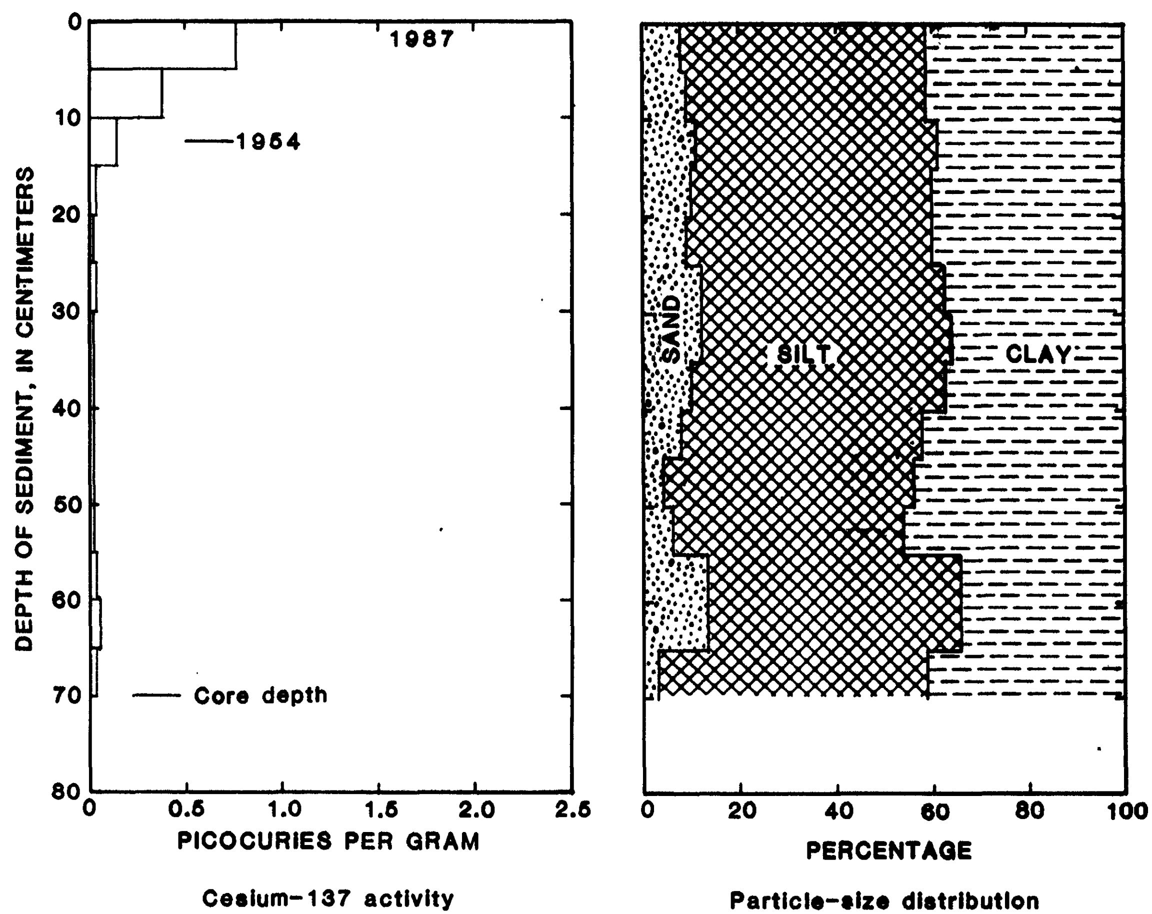
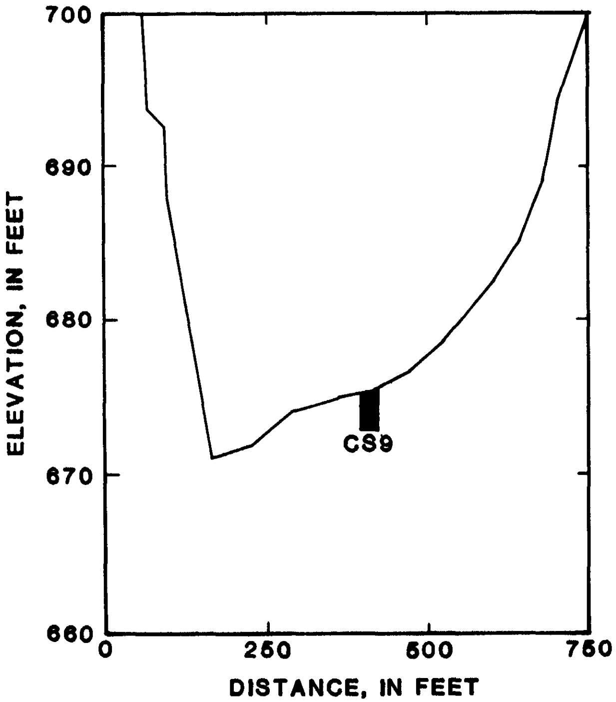
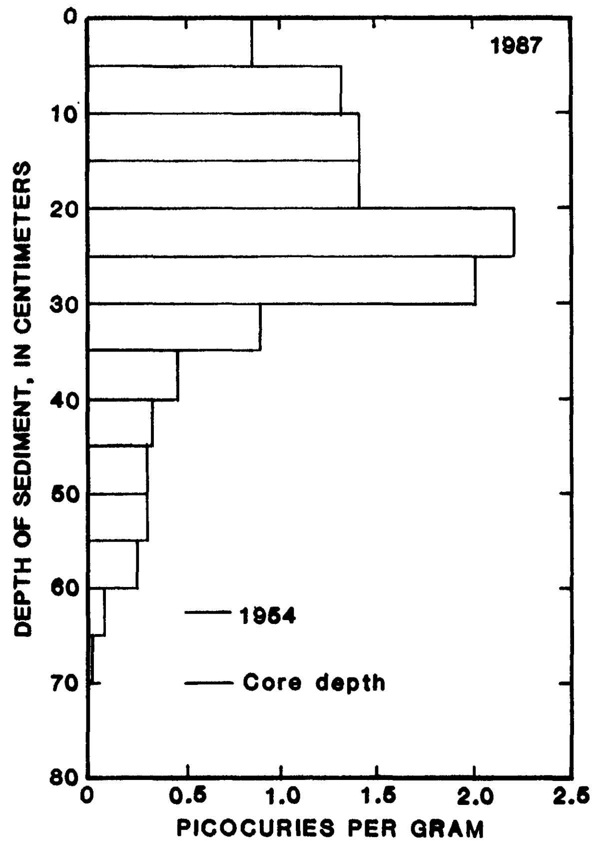


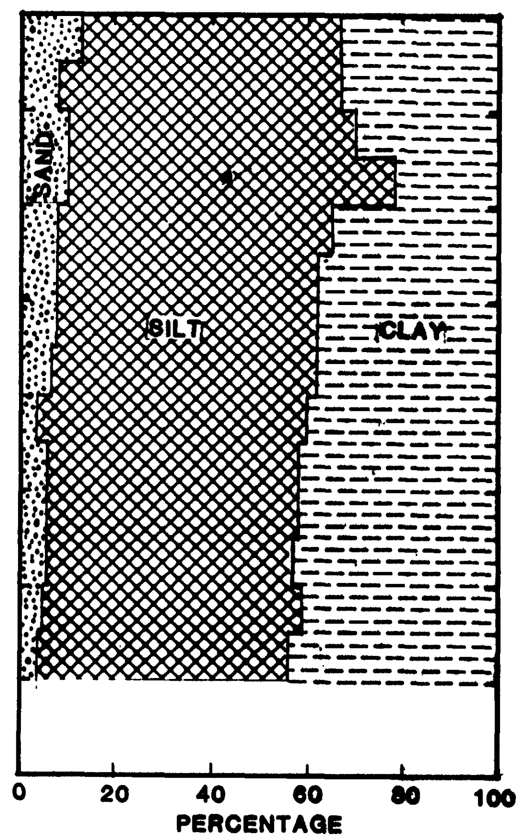
Figure 16.--Cesium-137 activity and particle-size distribution at site CS8.



Location of site CS9 in the range 31 cross section.



Cesium-137 activity



Particle-size distribution

Figure 17.--Location, cesium-137 activity, and particle-size distribution at site CS9.

Table 11.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS9

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.84	13	54	33
5 to 10	1.3	8	59	33
10 to 15	1.4	10	60	30
15 to 20	1.4	10	58	32
20 to 25	2.2	8	57	35
25 to 30	2.0	8	54	38
30 to 35	.89	8	54	38
35 to 40	.46	7	55	38
40 to 45	.32	4	56	40
45 to 50	.30	6	52	42
50 to 55	.30	6	52	42
55 to 60	.24	6	51	43
60 to 65	.08	5	54	41
65 to 70	<.03	4	52	44

Table 12.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS10

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	1.3	30	41	29
5 to 10	1.4	16	49	35
10 to 15	.94	12	51	37
15 to 20	.68	11	47	42
20 to 25	.38	11	49	40
25 to 30	.19	9	51	40
30 to 35	.11	8	51	41
35 to 40	<.03	13	51	36
40 to 45	<.03	13	51	36
45 to 50	<.03	11	51	38
50 to 55	<.03	10	52	38
55 to 60	<.03	4	50	46
60 to 65	<.03	2	50	48
65 to 70	<.03	5	46	49

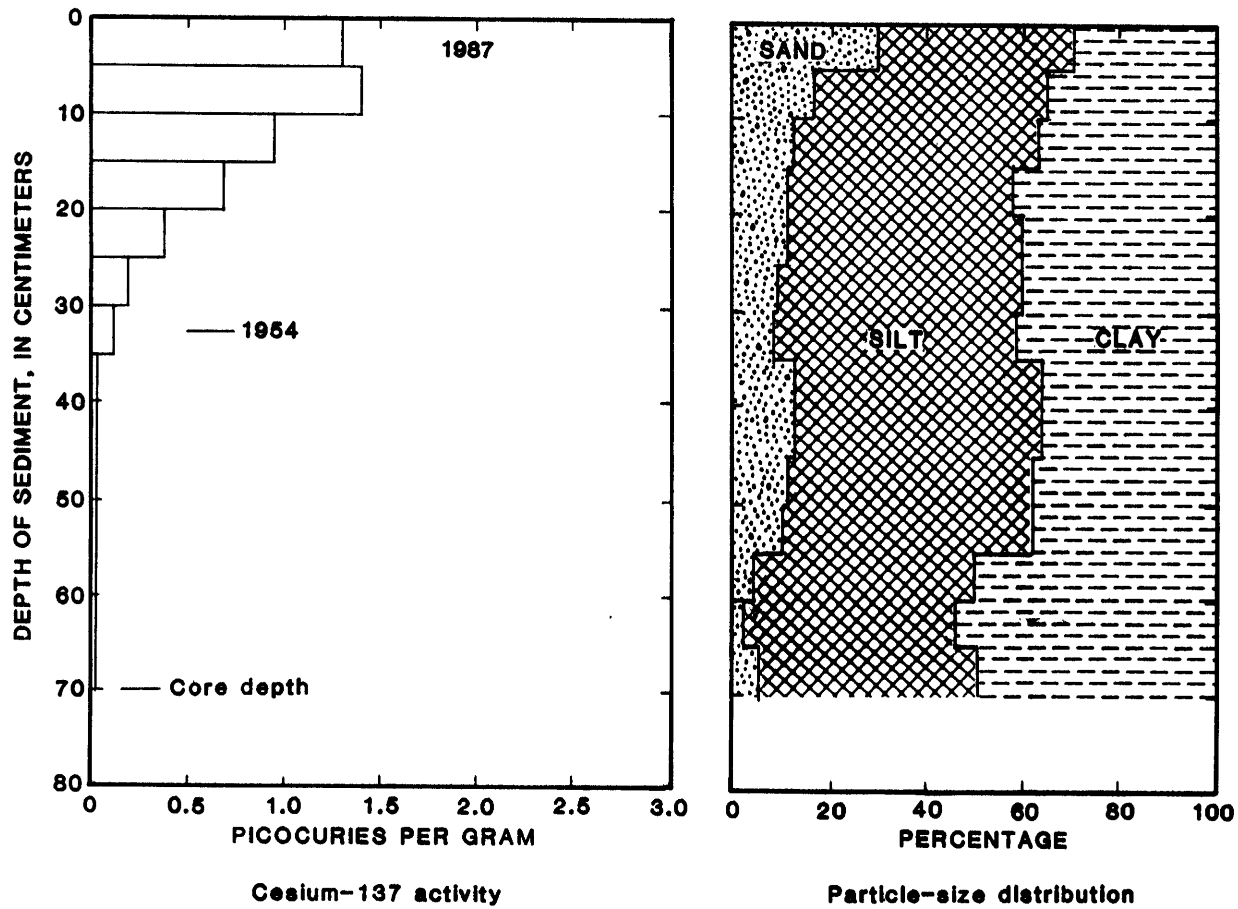
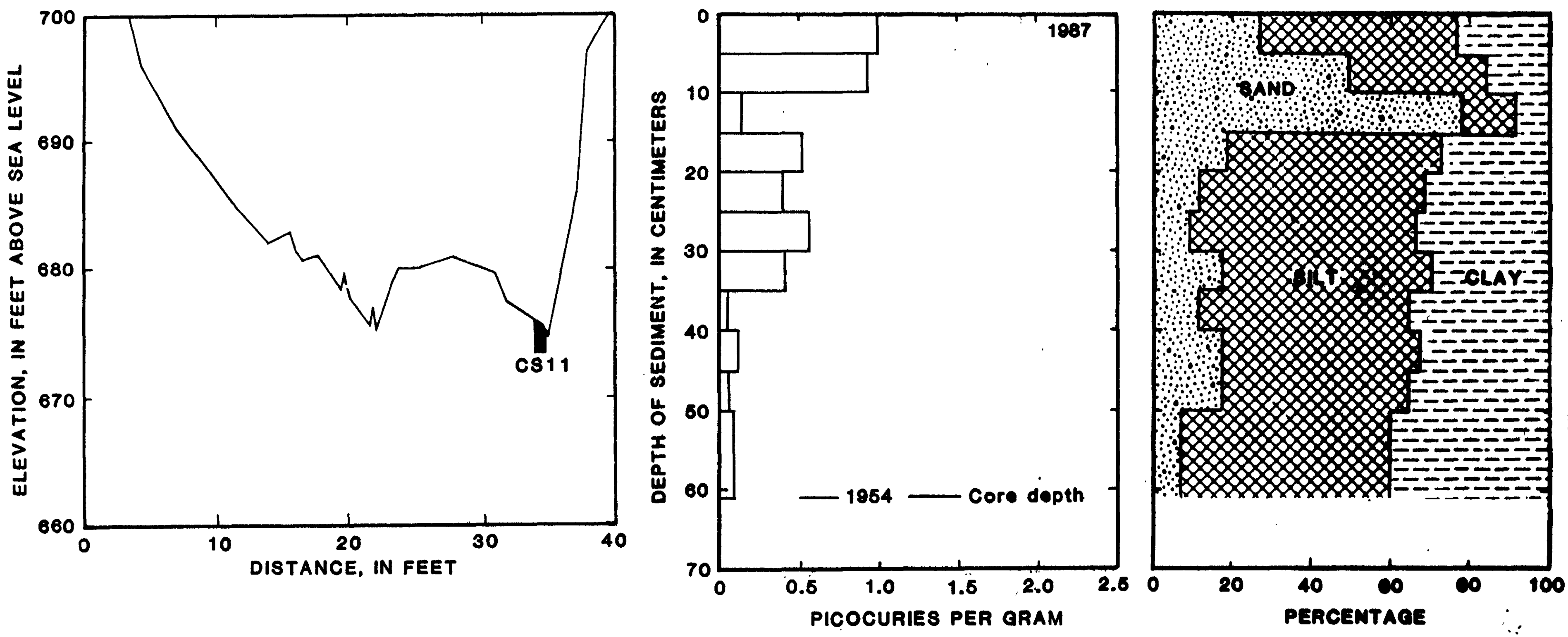


Figure 18.--Cesium-137 activity and particle-size distribution at site CS10.



Location of site CS11 in the range 32 cross section

Cesium-137 activity

Particle-size distribution

Figure 19.--Location, cesium-137 activity and particle-size distribution at site CS11.

Table 13.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS11

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	1.0	26	50	24
5 to 10	.92	49	34	17
10 to 15	.22	77	14	9
15 to 20	.51	18	54	28
20 to 25	.40	11	57	32
25 to 30	.54	9	57	34
30 to 35	.43	17	48	35
35 to 40	.05	11	53	36
40 to 45	.11	17	50	33
45 to 50	.05	17	47	36
50 to 61	.08	7	52	41

Table 14.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS12

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.76	7	62	31
5 to 10	.86	8	61	31
10 to 15	1.2	6	62	32
15 to 20	1.6	6	61	33
20 to 25	1.9	7	58	35
25 to 30	1.7	8	57	35
30 to 35	.70	10	55	35
35 to 40	.30	7	57	36
40 to 45	.16	6	56	38
45 to 50	.14	6	52	42
50 to 55	.03	6	54	40
55 to 60	<.03	7	54	39
60 to 65	<.03	5	56	39
65 to 70	<.03	5	57	38

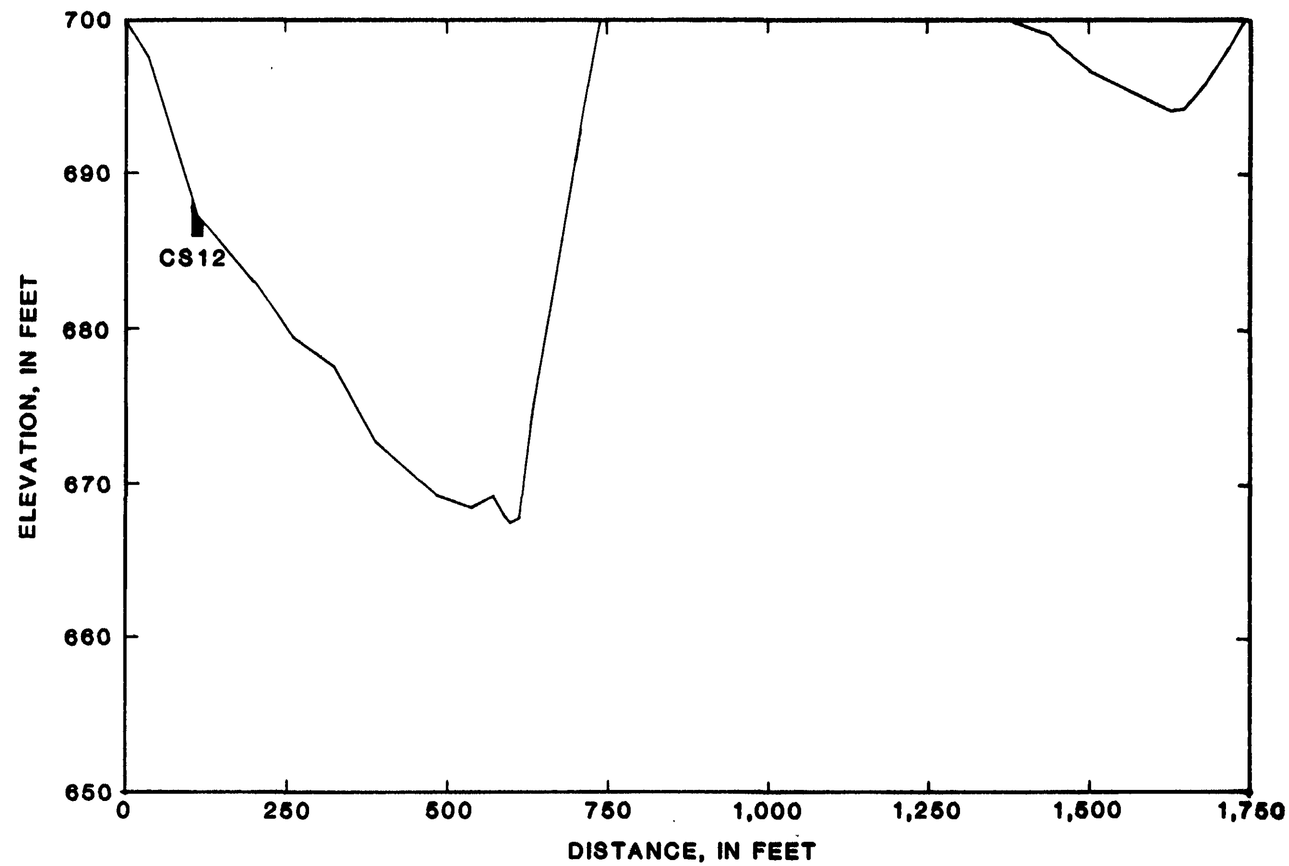


Figure 20.--Location of site CS12 in range 33 cross section.

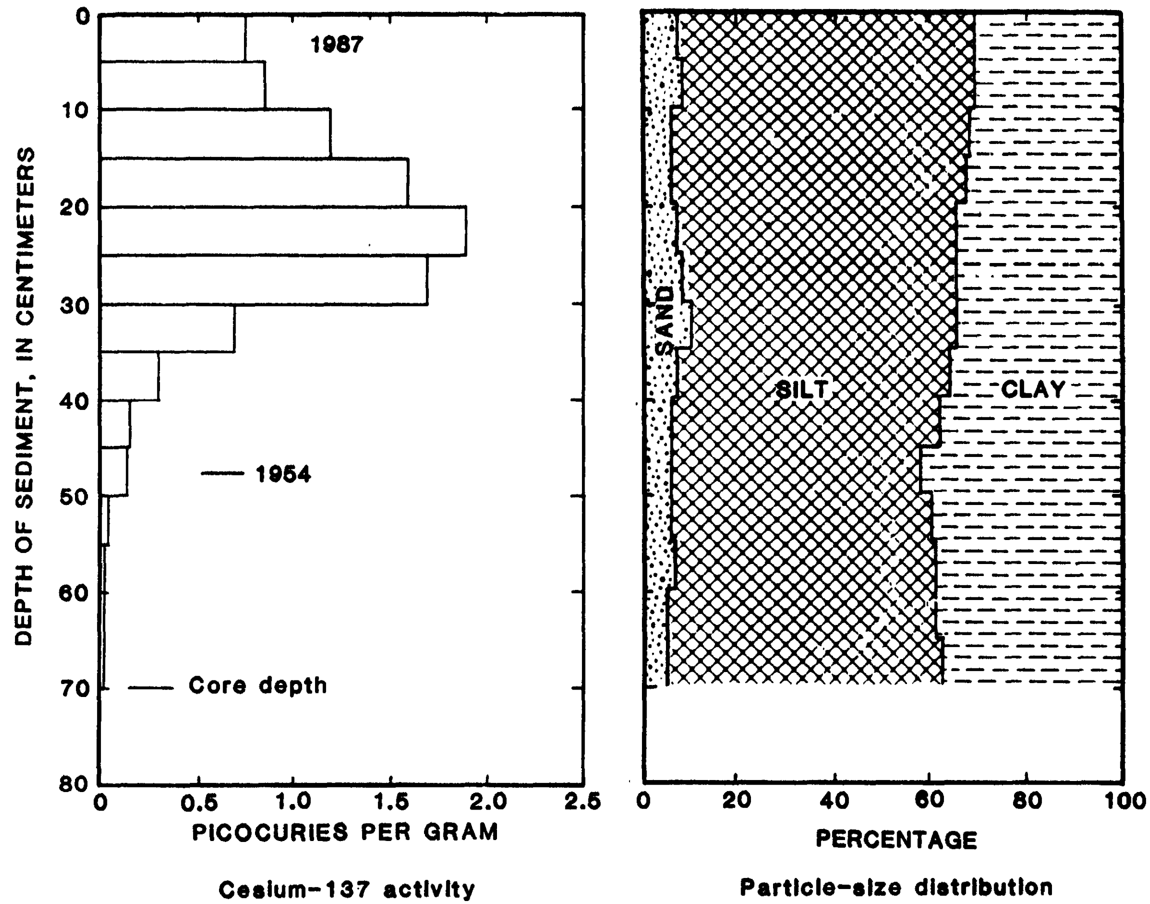


Figure 21.--Cesium-137 activity and particle-size distribution at site CS12.

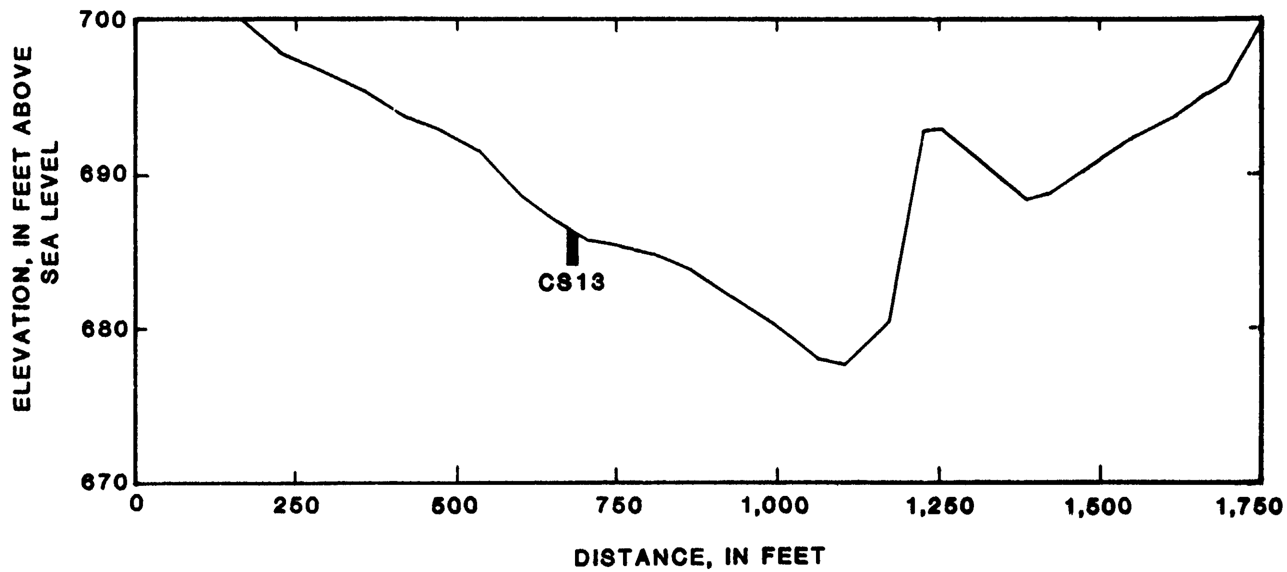


Figure 22.--Location of site CS13 in range 34 cross section.

Table 15.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS13

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.70	15	61	24
5 to 10	.92	14	58	28
10 to 15	.84	20	52	28
15 to 20	.46	17	53	30
20 to 25	.19	23	50	27
25 to 30	.08	15	54	31
30 to 35	.03	12	55	33
35 to 40	.03	8	60	32
40 to 45	<.03	7	58	35
45 to 50	<.03	13	52	35
50 to 55	<.03	14	52	34
55 to 60	<.03	9	57	34
60 to 65	<.03	15	52	33
65 to 70	<.03	21	50	29

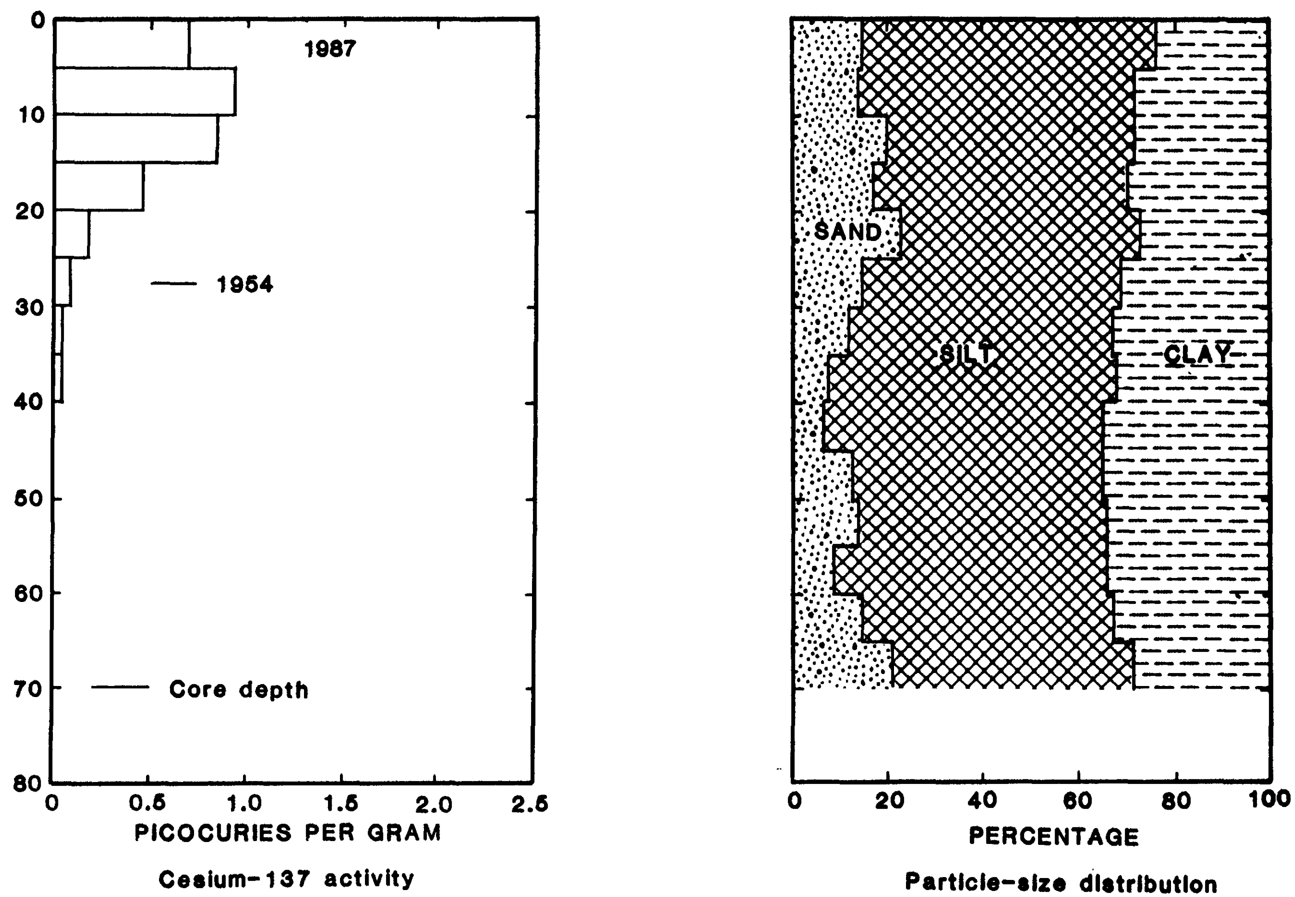


Figure 23.--Cesium-137 activity and particle-size distribution at site CS13.

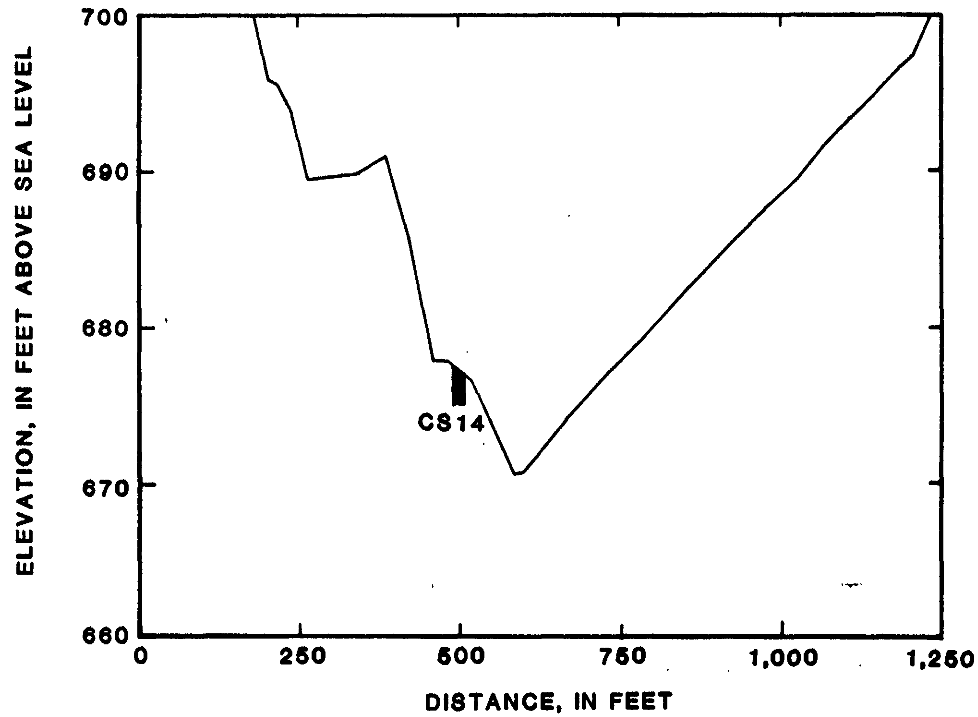
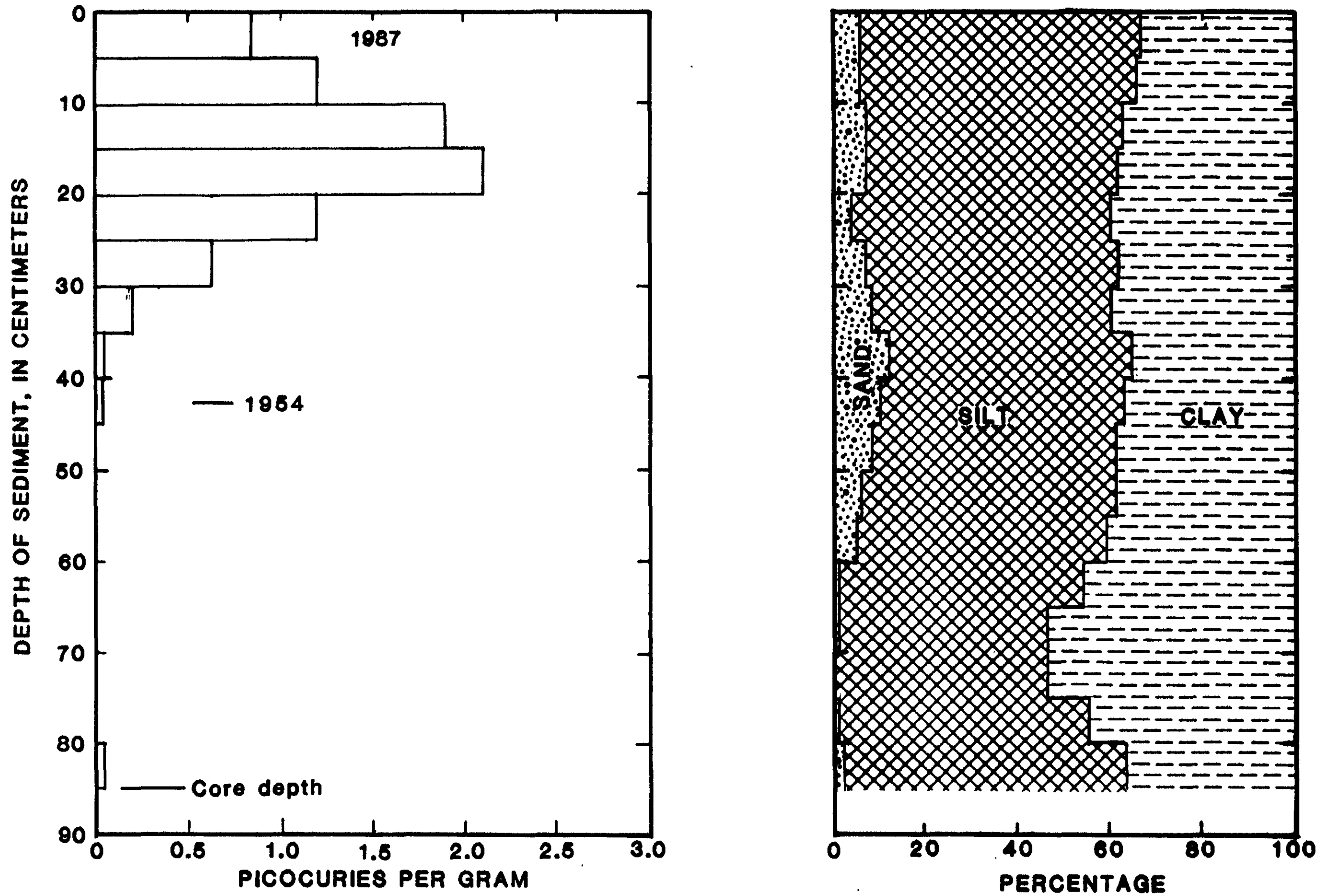


Figure 24.--Location of site CS14 in range 35 cross section.

Table 16.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS14

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

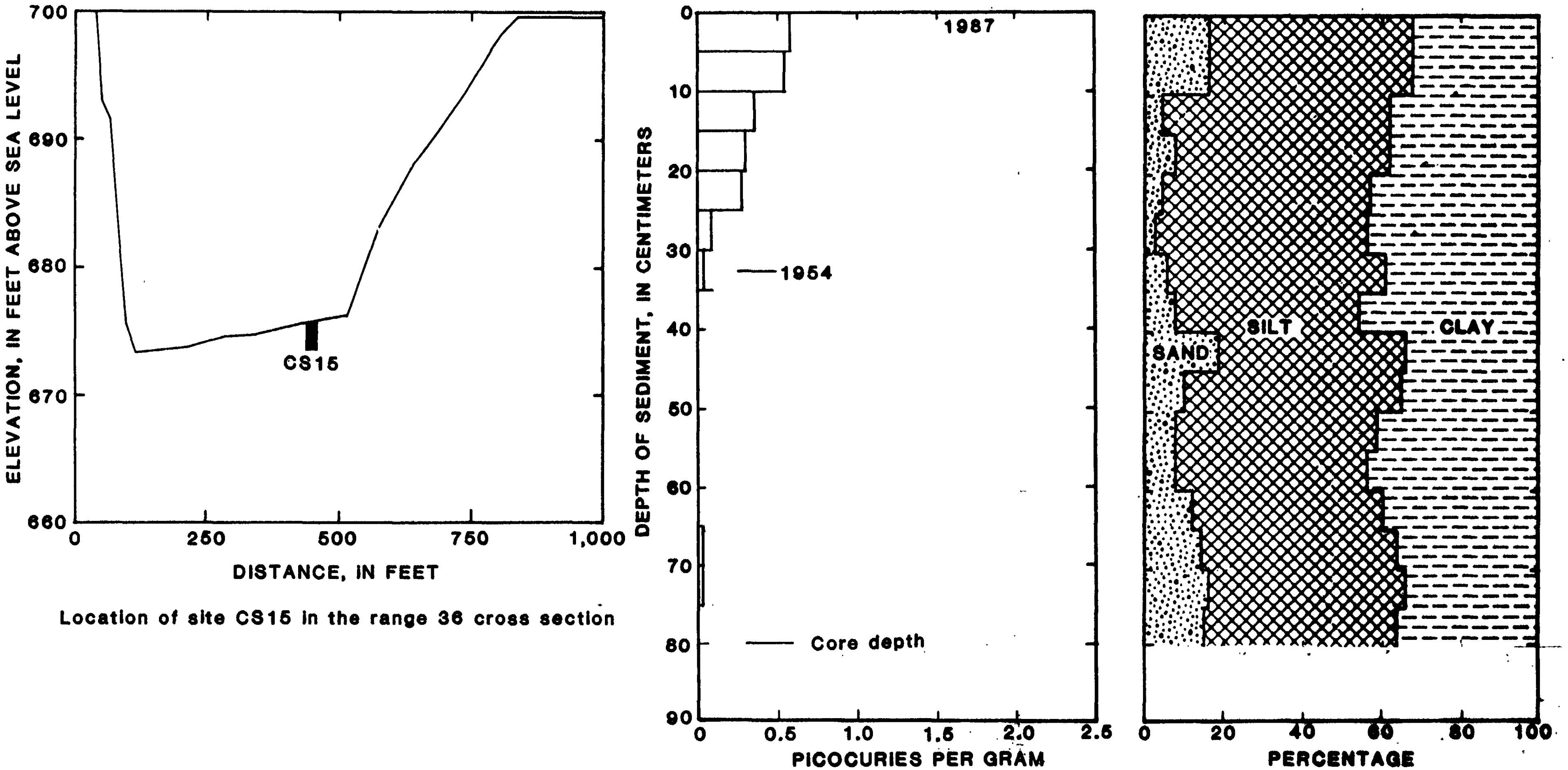
Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.84	6	61	33
5 to 10	1.2	6	60	34
10 to 15	1.9	7	56	37
15 to 20	2.1	7	55	38
20 to 25	1.2	4	56	40
25 to 30	.62	7	55	38
30 to 35	.19	8	52	40
35 to 40	.05	12	53	35
40 to 45	.03	10	53	37
45 to 50	<.03	8	53	39
50 to 55	<.03	6	55	39
55 to 60	<.03	5	54	41
60 to 65	<.03	1	53	46
65 to 70	<.03	1	45	54
70 to 75	<.03	0	46	54
75 to 80	<.03	1	54	45
80 to 85	.03	2	61	37



Cesium-137 activity

Particle-size distribution

Figure 25.--Cesium-137 activity and particle-size distribution at site CS14.



Location of site CS15 in the range 36 cross section

Cesium-137 activity

Particle-size distribution

Figure 26.--Location, cesium-137 activity and particle-size distribution at site CS15.

Table 17.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS15

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction: Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.68	16	52	32
5 to 10	.54	16	52	32
10 to 15	.35	5	57	38
15 to 20	.30	8	54	38
20 to 25	.16	5	52	43
25 to 30	.08	3	53	44
30 to 35	.05	6	55	39
35 to 40	<.03	8	54	38
40 to 45	<.03	19	47	34
45 to 50	<.03	10	55	35
50 to 55	<.03	8	51	41
55 to 60	<.03	8	48	44
60 to 65	<.03	12	48	40
65 to 70	.03	14	50	36
70 to 75	.03	16	50	34
75 to 80	<.03	15	49	36

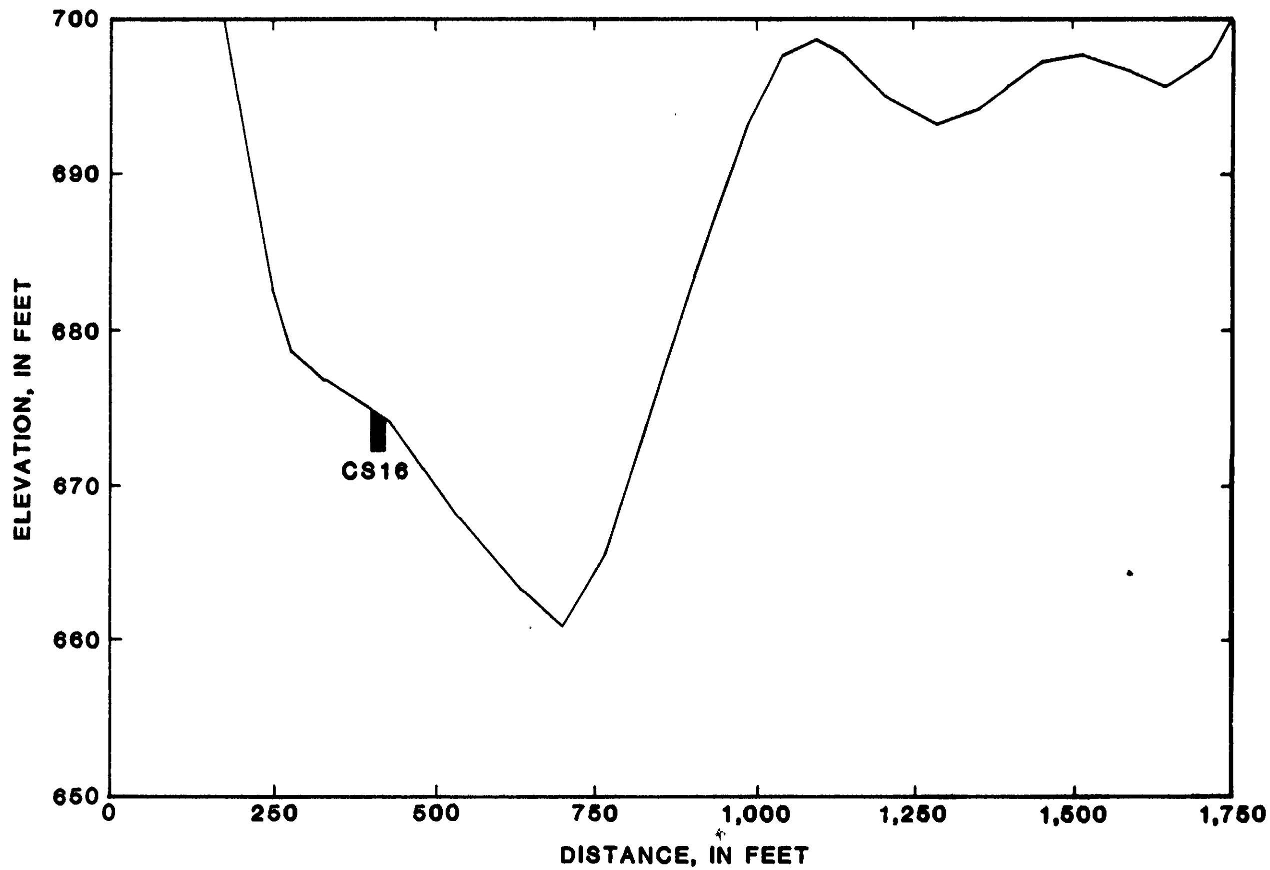


Figure 27.--Location of site CS16 in range 37 cross section.

Table 18.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS16

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction: Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.86	11	56	33
5 to 10	1.4	10	56	34
10 to 15	2.5	11	49	40
15 to 20	1.6	7	48	45
20 to 25	.81	8	48	44
25 to 30	.49	6	51	43
30 to 35	.32	4	54	42
35 to 40	.30	4	50	46
40 to 45	.22	2	49	49
45 to 50	.08	5	45	50
50 to 55	.05	1	53	46
55 to 60	.03	2	52	46
60 to 65	.03	2	54	44
65 to 70	<.03	3	55	42
70 to 75	<.03	3	56	41
75 to 80	.05	3	58	39

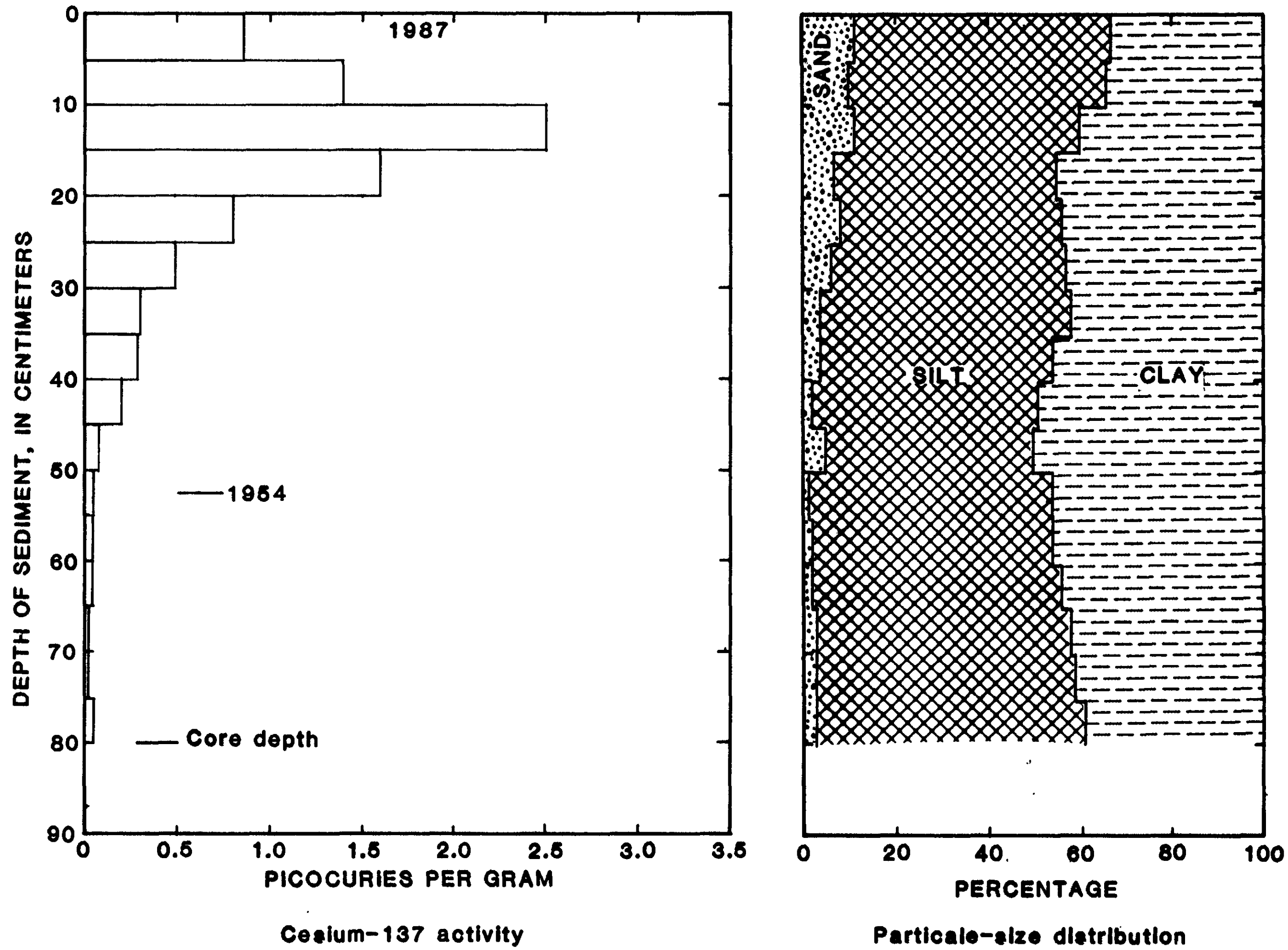


Figure 28.--Cesium-137 activity and particle-size distribution at site CS16.

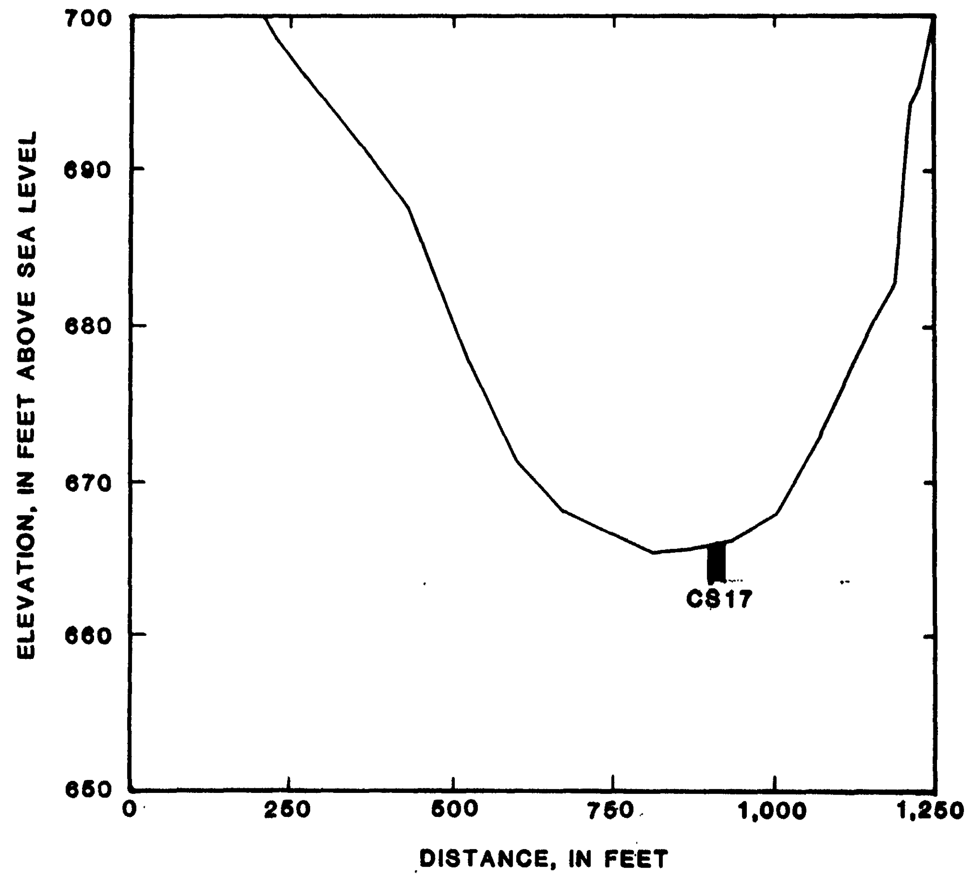


Figure 29.--Location of site CS17 in range 38 cross section.

Table 19.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS17

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	1.3	8	58	34
5 to 10	1.5	10	53	37
10 to 15	1.5	6	51	43
15 to 20	.76	8	45	47
20 to 25	.38	8	47	45
25 to 30	.24	6	44	50
30 to 35	.08	7	44	49
35 to 40	.03	8	46	46
40 to 45	<.03	8	44	48
45 to 50	<.03	7	46	47
50 to 55	<.03	8	45	47
55 to 60	.05	7	46	47
60 to 65	<.03	4	46	50
65 to 70	<.03	5	43	52
70 to 75	<.03	3	47	50
75 to 80	.03	7	45	48
80 to 85	<.03	3	49	48
85 to 90	.03	3	40	57
90 to 95	<.03	5	35	60

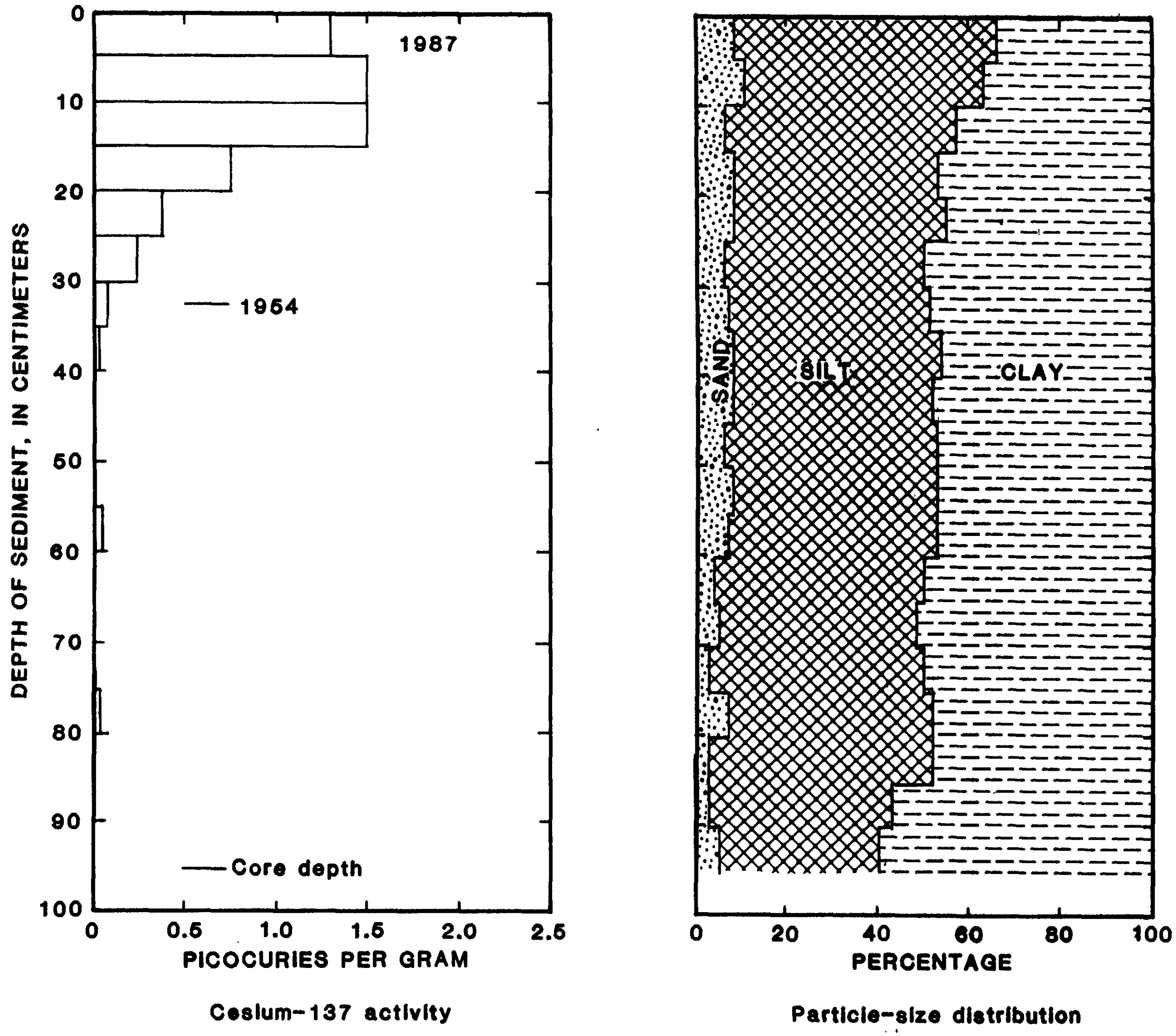


Figure 30.--Cesium-137 activity and particle-size distribution at CS17.

Table 20.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS18

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.92	6	59	35
5 to 10	1.4	6	55	39
10 to 15	1.4	7	54	39
15 to 20	.54	10	53	37
20 to 25	.51	9	56	35
25 to 30	.40	9	56	35
30 to 35	.30	11	52	37
35 to 40	.27	7	48	45
40 to 45	.05	8	40	52
45 to 50	.03	5	40	55
50 to 55	<.03	5	45	50
55 to 60	<.03	5	48	47
60 to 65	.03	6	43	51
65 to 70	<.03	4	37	59
70 to 75	.03	4	34	62

Table 21.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS19

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	2.1	4	53	43
5 to 10	3.4	3	48	49
10 to 15	2.0	1	43	56
15 to 20	.94	2	46	52
20 to 25	.70	2	52	46
25 to 30	.46	4	54	42
30 to 35	.46	4	56	40
35 to 40	.46	7	55	38
40 to 45	.51	7	55	38
45 to 50	.54	8	55	37
50 to 55	.49	8	56	36

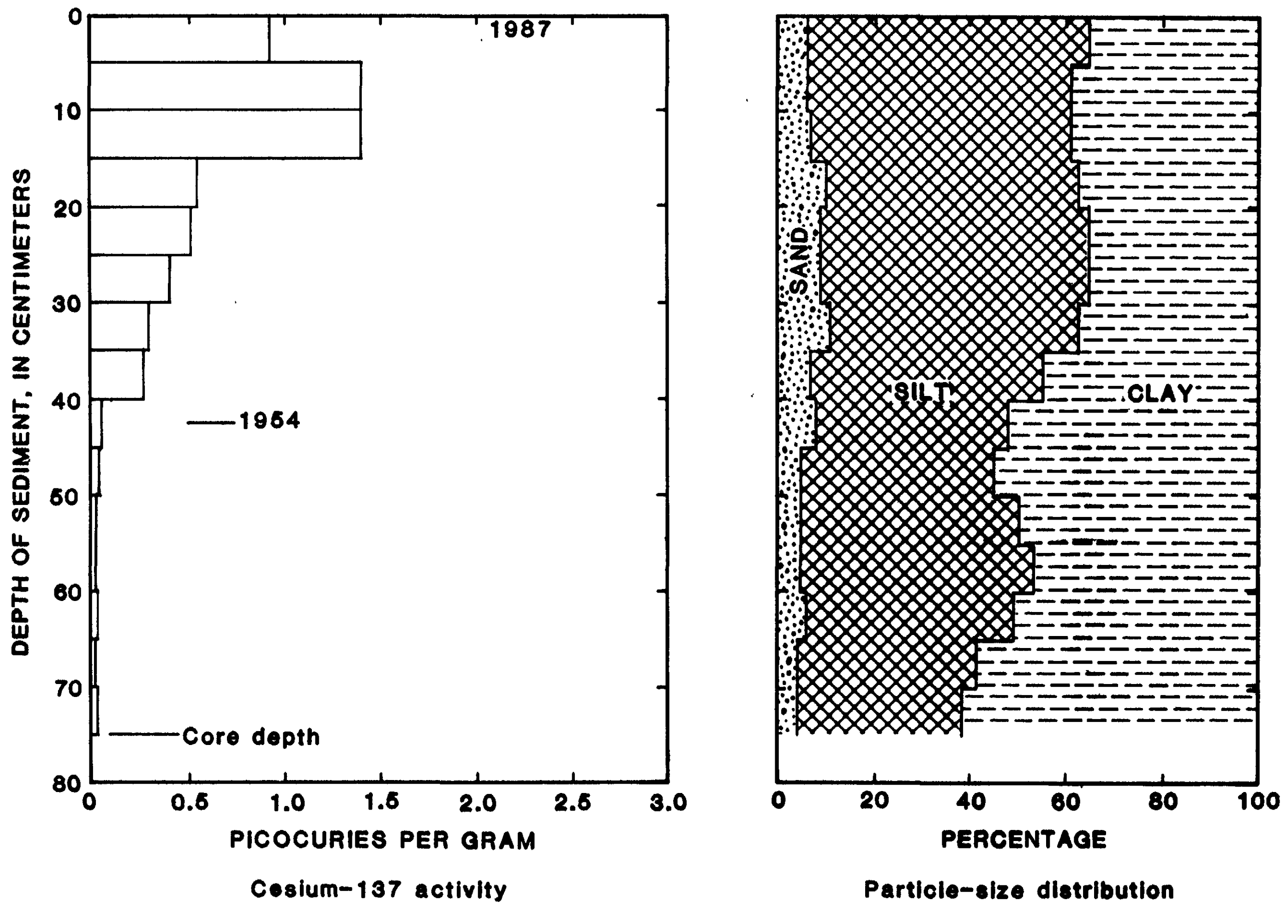


Figure 31.--Cesium-137 activity and particle-size distribution at site CS18.

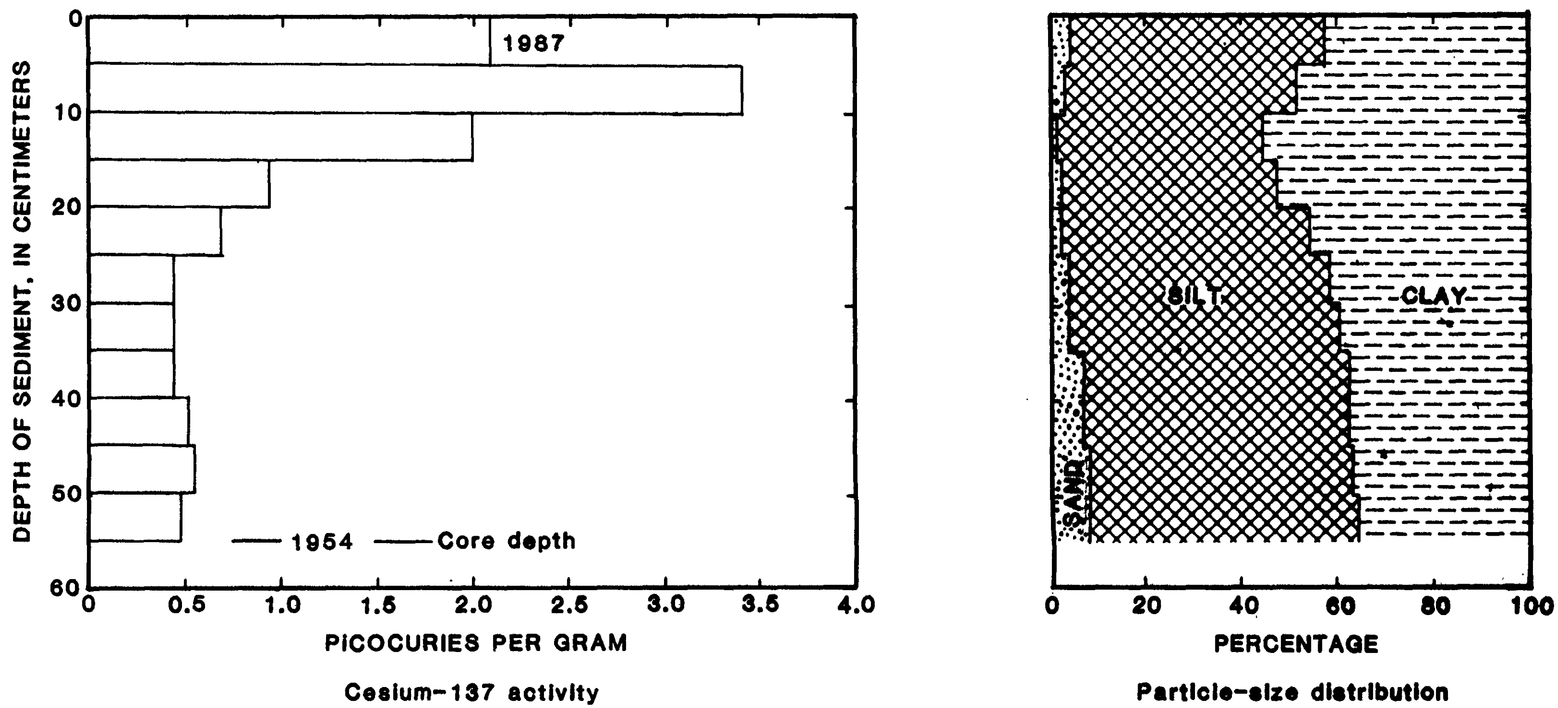


Figure 32.--Cesium-137 activity and particle-size distribution at site CS19.

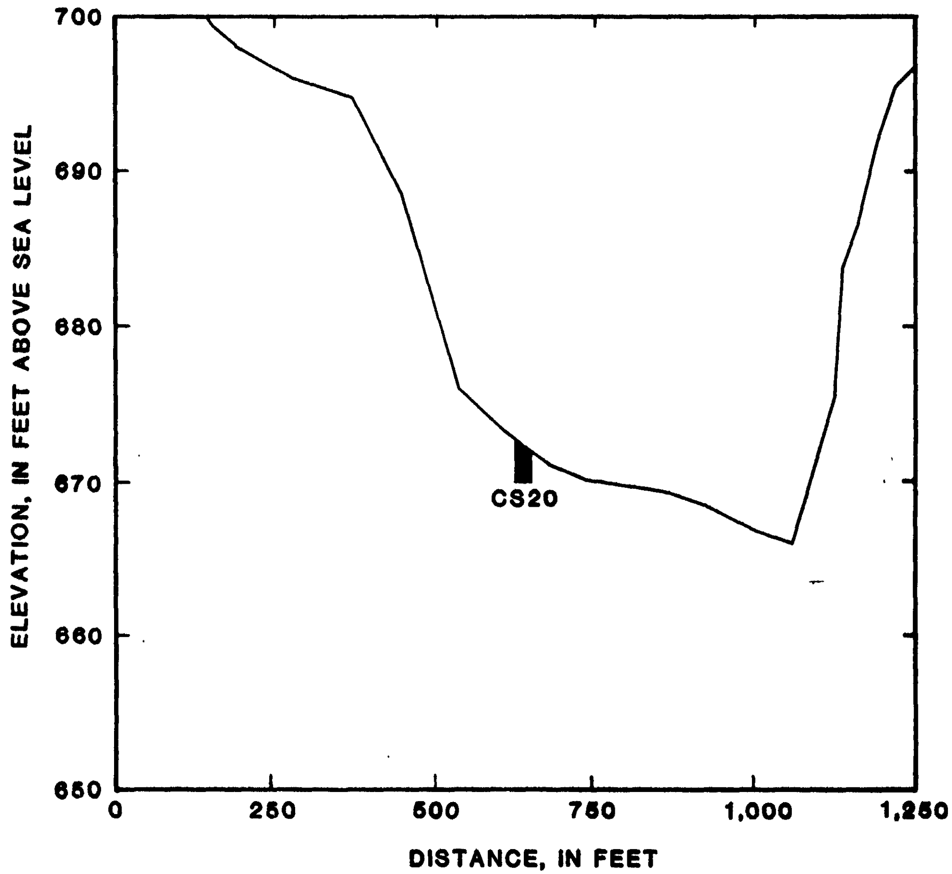


Figure 33.--Location of site CS20 in range 39 cross section.

Table 22.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS20

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	1.1	5	61	34
5 to 10	1.8	6	55	39
10 to 15	2.2	5	51	44
15 to 20	1.5	5	51	44
20 to 25	.81	7	54	39
25 to 30	1.4	6	50	44
30 to 35	.59	8	55	37
35 to 40	.43	10	54	36
40 to 45	.54	6	55	39
45 to 50	.49	6	51	43
50 to 55	.38	7	54	39
55 to 60	.38	4	53	43
60 to 65	.30	3	47	50
65 to 70	.24	2	52	46
70 to 75	.11	2	52	46
75 to 80	.08	5	49	46

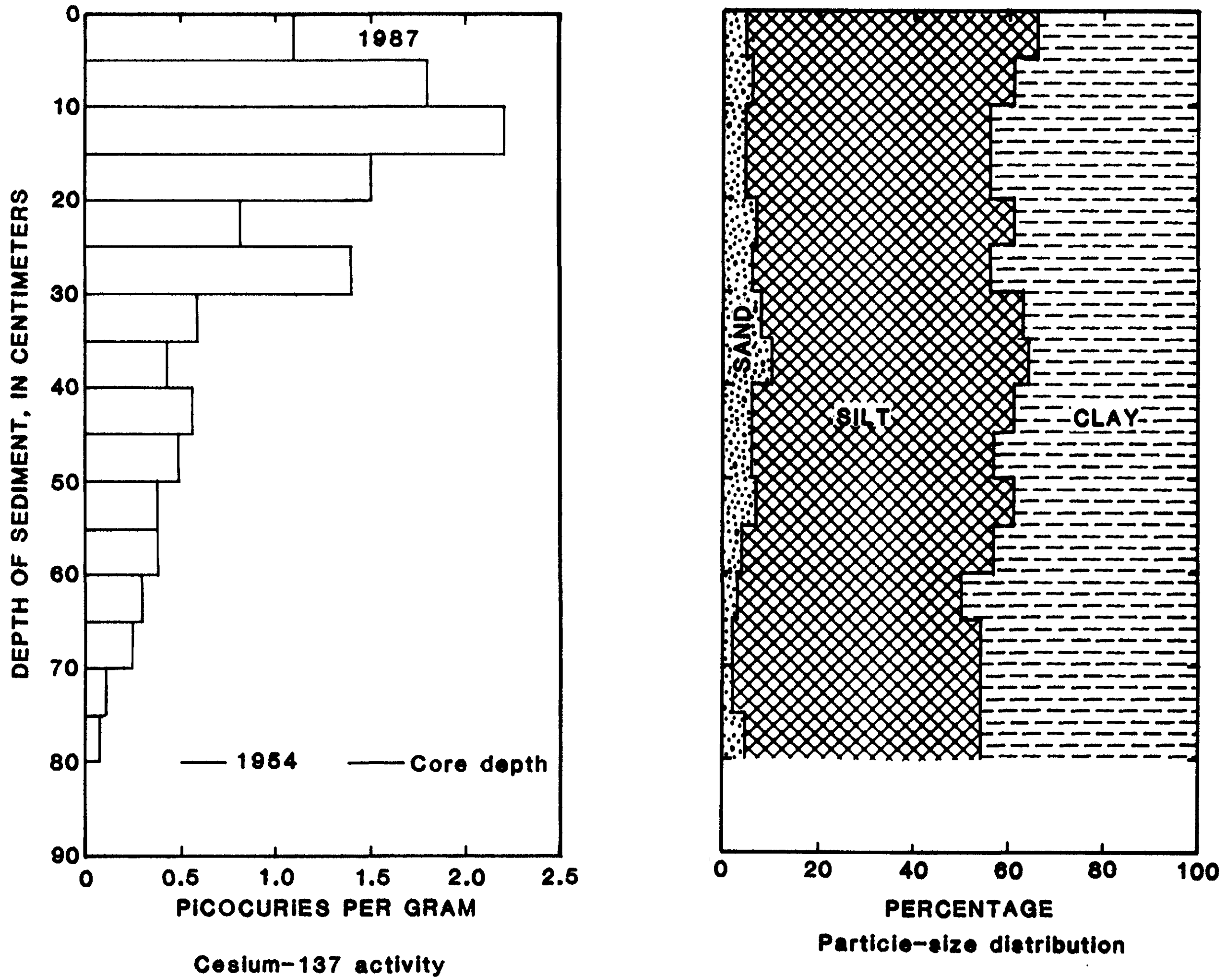


Figure 34.--Cesium-137 activity and particle size distribution at site CS20.

Table 23.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS21

[cm, centimeter; pCi/g, picocuries per gram; >, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.92	6	60	34
5 to 10	.84	6	62	32
10 to 15	1.5	6	57	37
15 to 20	1.4	7	56	37
20 to 25	1.4	5	55	40
25 to 30	.86	5	55	40
30 to 35	.51	6	54	40
35 to 40	.40	6	53	41
40 to 45	.35	1	54	45
45 to 50	.24	1	53	46
50 to 55	.19	1	55	44
55 to 60	.16	7	51	42

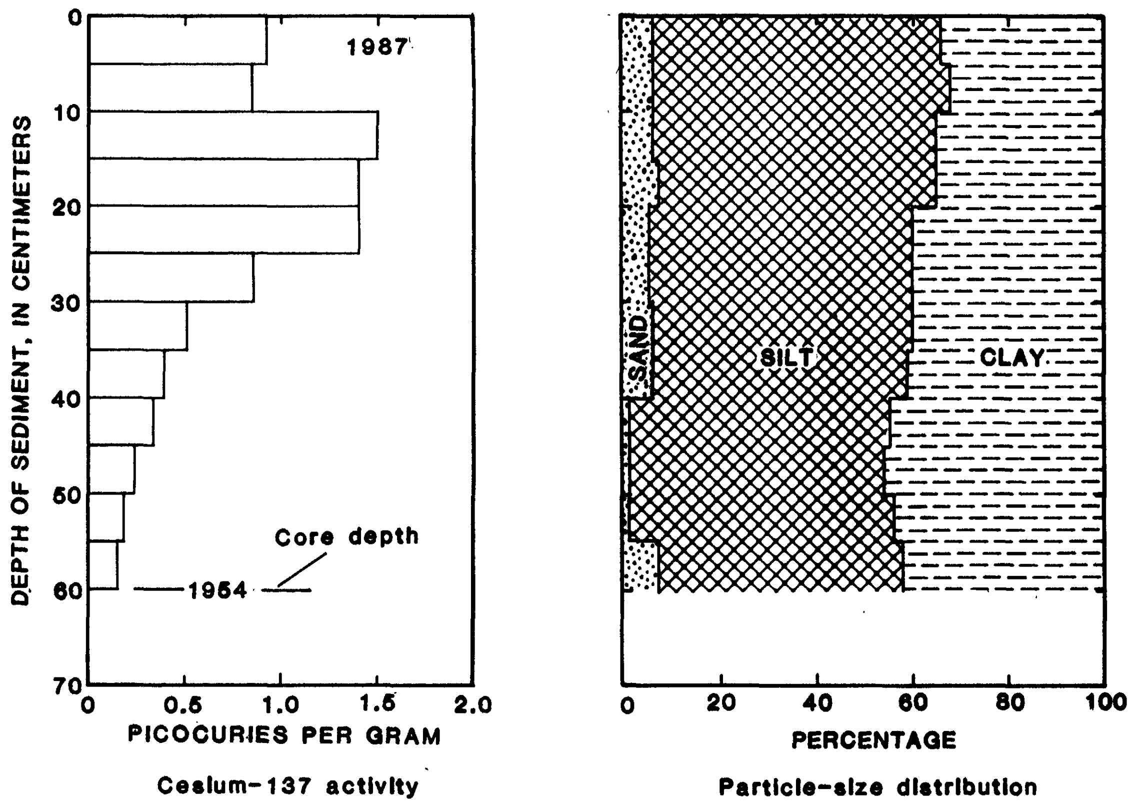


Figure 35.--Cesium-137 activity and particle-size distribution at site CS21.

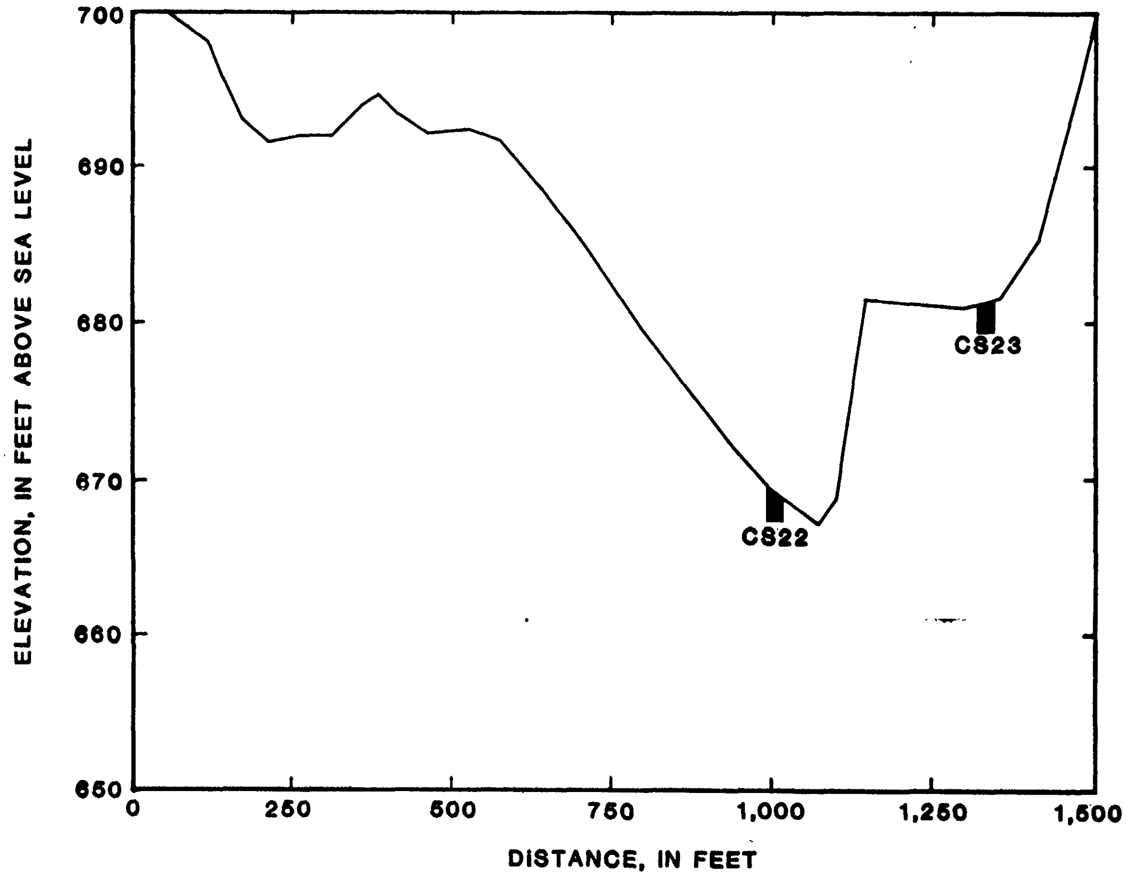


Figure 36.--Location of site CS22 and CS23 in range 40 cross section.

Table 24.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS22

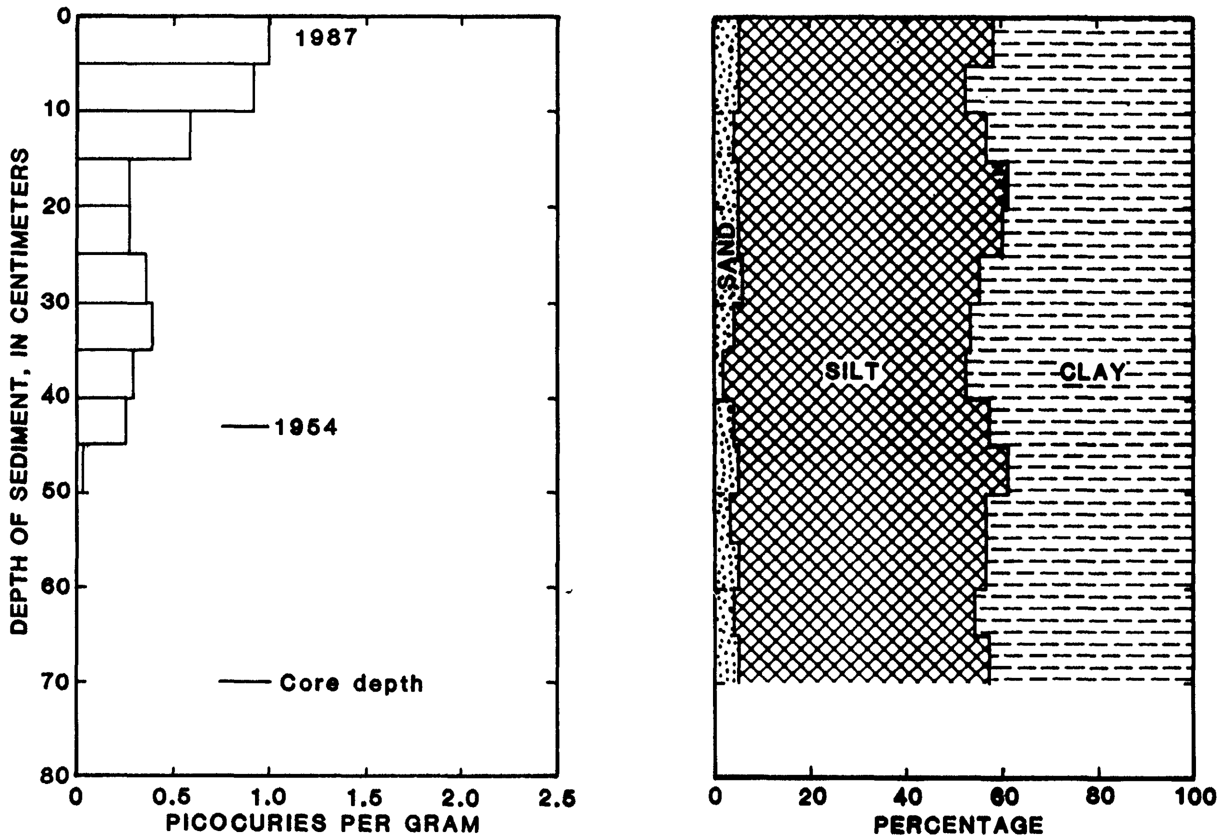
[cm, centimeter; pCi/g, picocuries per gram;
>, greater than; mm, millimeter; <, less than]

Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	1.0	5	53	42
5 to 10	.92	5	47	48
10 to 15	.59	4	53	43
15 to 20	.27	5	56	39
20 to 25	.27	5	55	40
25 to 30	.38	6	49	45
30 to 35	.40	4	53	43
35 to 40	.30	2	50	48
40 to 45	.27	4	53	43
45 to 50	.03	5	56	39
50 to 55	<.03	3	53	44
55 to 60	<.03	5	51	44
60 to 65	<.03	4	50	46
65 to 70	<.03	5	52	43

Table 25.--Cesium-137 activity and particle-size distribution of depth increments in sediment profile at site CS23

[cm, centimeter; pCi/g, picocuries per gram;
>, greater than; mm, millimeter; <, less than]

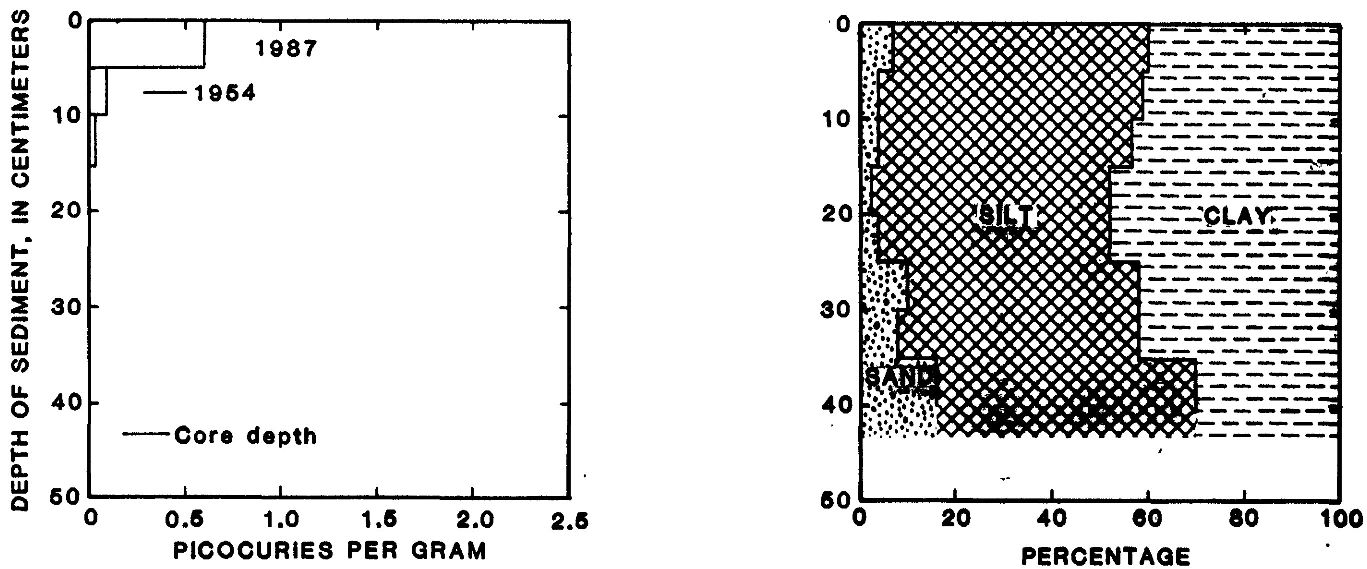
Depth increment, in cm	Cesium-137 activity, in pCi/g	Percentage of material in size fraction		
		Sand, >0.05 mm	Silt, 0.002-0.05 mm	Clay, <0.002 mm
0 to 5	0.59	7	53	40
5 to 10	.08	4	55	41
10 to 15	.03	4	53	43
15 to 20	<.03	3	49	48
20 to 25	<.03	4	48	48
25 to 30	<.03	10	48	45
30 to 35	<.03	8	50	42
35 to 43	<.03	16	54	30



Cesium-137 activity

Particle-size distribution

Figure 37.--Cesium-137 activity and particle-size distribution at site CS22.



Cesium-137 activity

Particle-size distribution

Figure 38.--Cesium-137 activity and particle-size distribution at site CS23.