CAPACITY AND SEDIMENTATION OF LOCH LOMOND RESERVOIR

SANTA CRUZ COUNTY, CALIFORNIA

By Ronald P. Fogelman and Karen L. Johnson

U.S. GEOLOGICAL SURVEY

Open-File Report 85-485

Prepared in cooperation with the

CITY OF SANTA CRUZ

4022-12

Sacramento, California
1985

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

For those readers who may prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
acres	0.4047	hm^2 (square hectometers)
acre-ft (acre-feet)	0.001233	hm^3 (cubic hectometers)
ft (feet)	0.3048	m (meters)
in (inches)	25.40	mm (millimeters)
mi (miles)	1.609	km (kilometers)
mi^2 (square miles)	2.590	km^2 (square kilometers)
lb/ft^3 (pounds per cubic foot)	16.02	kg/m^3 (kilograms per cubic meter)
ft/mi (feet per mile)	0.1894	m/km (meters per kilometer)

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ABSTRACT

A sedimentation study of Loch Lomond Reservoir in Santa Cruz County, California, was begun in 1982 to determine reservoir storage capacity and to establish permanent ranges for future studies. Results of a reservoir survey indicated a total storage capacity of 8,824 acre-feet in 1982. Comparison of thalweg profiles from this survey and a survey done prior to dam construction in 1960 shows that deposition has occurred in the lower reach of the reservoir due to landsliding and in the upper reach due to sediment inflow from Newell Creek.

INTRODUCTION

Location and General Features

Loch Lomond Reservoir is located in the Santa Cruz Mountains about 10 miles north of the city of Santa Cruz (fig. 1). The reservoir is about 2.5 miles long and ranges in width from about 400 to 1,500 feet when filled to capacity. It provides limited recreational activities and about one-third of the city's water supply. Newell Creek Dam, which forms the reservoir, was constructed in 1960 and impounds water from Newell Creek, which drains 8.2 mi^2 within the San Lorenzo River basin. The elevation of Newell Creek basin ranges from about 400 feet above sea level just downstream from the reservoir to over 2,300 feet near the northern end of the basin. The spillway elevation of Newell Creek Dam is 577.5 feet.

Santa Cruz County has a mediterranean climate that is characteristic of California's central coastal region. Annual rainfall averages 31 inches and occurs generally in the winter months between November and March (National Oceanic and Atmospheric Administration, 1983). Winter storms are often very intense and produce rapid and voluminous runoff. The landscape is generally verdant, covered primarily with redwood forest and chaparral communities (Brown, 1973).

The geology of the area has been studied and reported by many authors. Briefly, the drainage basin upstream from Loch Lomond Reservoir is characterized by interbedded layers of sandstone and shale of Tertiary age. These beds are complexly folded and faulted. The characteristic steep-sided canyons and shallow soils are susceptible to erosion, especially during intense rains. Minor disturbances in vegetal covering or land use have caused marked increases in erosion (Brown, 1973).

Purpose and Scope

The purpose of this report is to document the storage capacity of Loch Lomond Reservoir. The scope of the work included: establishing permanent range endpoints for the reservoir, surveying these endpoints to establish vertical and horizontal datum, surveying land and water cross sections, sampling the reservoir bed at selected cross sections, and determining the reservoir capacity from the cross-section data.

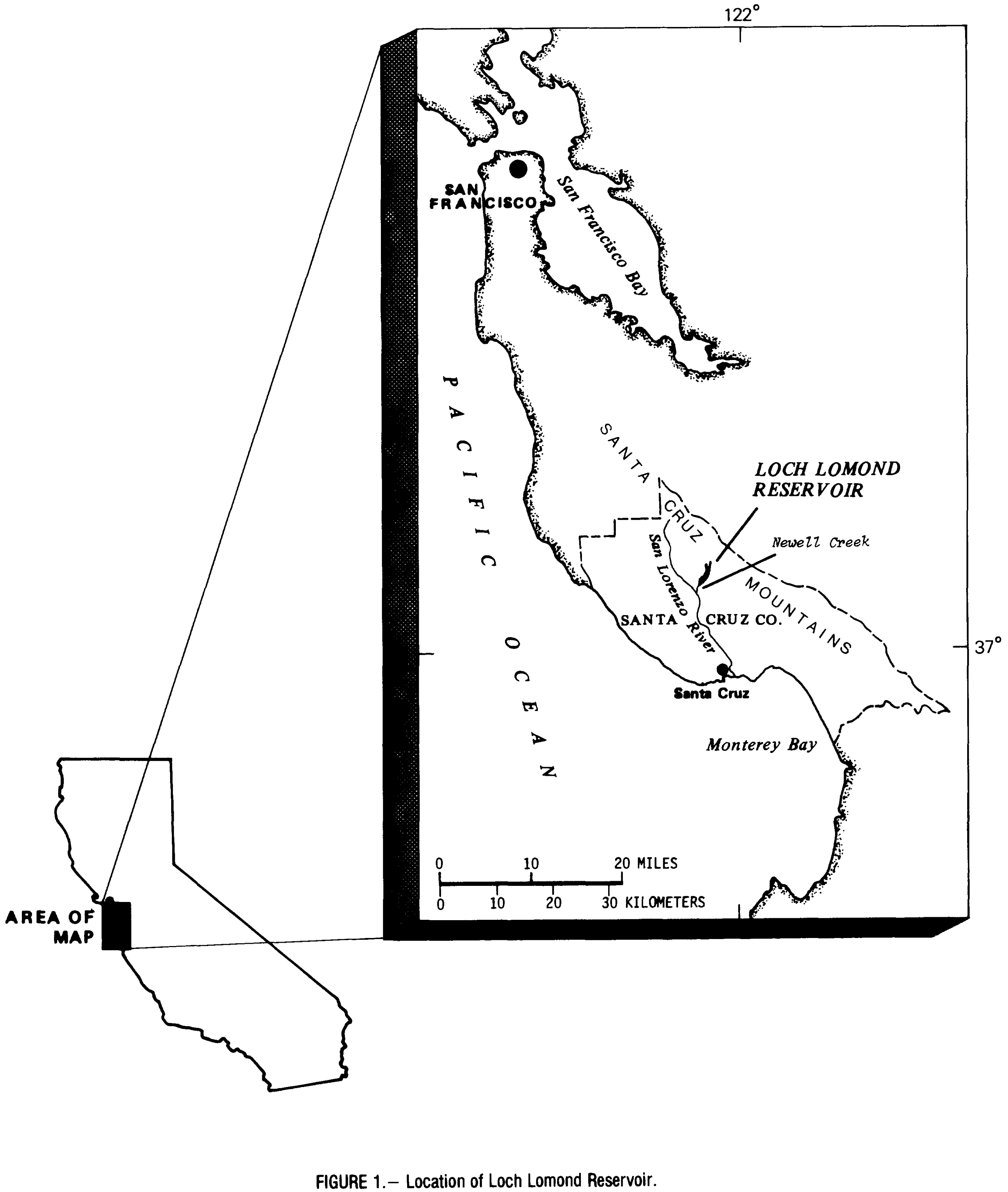

FIGURE 1.— Location of Loch Lomond Reservoir.

CAPACITY OF LOCH LOMOND RESERVOIR

Field Methods

Thirty-five permanent ranges were established at various locations along the reservoir, based on a field reconnaissance. Steel fence posts were installed at the range ends for permanent identification (pl. 1). A field survey of the range endpoints determined vertical (table 1) and horizontal (table 2) datum. Cross-section profiles were then obtained using a fathometer for the water sections and surveying the land sections at the ends of each range (fig. 5, at end of report). Bed-material samples were taken at selected ranges at the deepest point of the section (table 3). Most of the fieldwork was done in August 1982.

Computation of Reservoir Capacity

Field survey and fathometer data were compiled and ranges were plotted from horizontal survey data. The land survey and fathometer data were used to construct contour lines at 10-foot intervals, as well as a contour at the spillway (elevation, 577.5 feet above sea level). The contours were drawn by hand to approximate the shape of the original canyon. Generalized contour maps from 1960 and 1972 were used to aid in construction of the 1982 map. The contour method, as described by Eakin and Brown (1939), was then used to compute reservoir capacity. The areas within the contours were digitized and used in the following equation to compute the volume of the prismoid between each contour:

$$V = L/3\ [A + \sqrt{AB} + B]$$

where,

- V = capacity, in acre-feet;
- L = contour interval, in feet;
- A = area, in acres, of the lower contour; and
- B = area, in acres, of the upper contour.

In the lowest prismoid, L is the vertical distance between the lowest contour and the lowest point in the bottom of the section, in this case, the thalweg. The value for A is set to zero in the lowest prismoid.

The results of the contour method were verified using the range method, which was also described in detail by Eakin and Brown (1939). Total reservoir capacity computed by the range method compared within <2 percent of the contour method.

Table 1. - Vertical range data

[Not all surveying points were used as cross-section endpoints]

Range, left bank	Elevation, in feet	Range, right bank	Elevation, in feet
0L	578.35	0R	577.67
1L	583.23	1R	582.88
2L	579.38	2R(Aux pipe)	577.30
2.5L	580.23		
3L	581.10	3R	582.42
		3.5R	581.90
4L	581.55	4R	582.43
5L	579.95	5R	578.81
6L	579.36	6R	578.58
7L	579.01	7R	579.37
8L	577.83	8R	577.65
9L	576.98	9R	577.42
10L	578.15	10R	577.26
11L	578.17	11R	577.37
12L	577.86	12R	579.18
13L	577.46	13R	578.74
14L	577.81	14R	577.14
14SI(south end of island)	578.89	14NI(north end of island)	580.16
15L	577.82	15R	579.75
16L	577.85	16R	578.08
17L	578.13	17R	577.65
17.5L	577.79		
18L	577.74	18R	576.73
19L	577.75	19R	577.98
20L	579.16	20R	577.87
21L	578.17	21R	578.28
22L	577.84	22R	578.38
23L	577.72	23R	577.75
24L	577.46	24R	577.47
25L	578.69	25R	578.47
26L	577.47	26R	577.53
27L	578.49	27R	578.23
28L	577.73	28R	577.75
29L	578.52	29R	577.72
30L	579.52	30R	580.64
31L	581.19	31R	582.37
32L	581.17	32R	581.09
AL	578.08	AR	577.89
BL	578.69	BR	578.30

Table 2. - Horizontal range data

Angle	Degrees	Minutes	Distance (feet)	
			Foresight	Backsight
0R-B-1R	15	20	547	616
1R-B-2R	16	40	616	686
1L-B-0L	17	40	444	344
2L-B-1L	26	50	484	444
0R-B-0L	218	50	547	344
1L-2L-0L	20	40	203	341
0L-2L-B	45	10	341	484
B-2L-0R	44	40	484	771
0R-2L-1R	12	30	771	724
1R-2L-2R	15	50	724	648
2R-2L-3R	20	50	648	844
2.5L-3R-2L	23	30	772	844
3L-3R-2L	56	30	782	772
4L-3R-3L	24	30	710	782
5R-3R-4L	54	10	948	710
3R-4L-4R	53	20	710	780
4R-4L-5R	24	50	780	783
5R-4L-6R	39	00	783	840
5L-6R-4L	13	20	724	840
6L-6R-5L	30	30	666	724
7L-6R-6L	41	40	876	666
6R-7L-7R	30	40	876	727
7R-7L-8R	28	20	727	834
8L-8R-7L	30	50	661	834
9L-8R-8L	42	00	562	661
10L-8R-9L	32	20	852	564
8R-9L-9R	34	10	564	608
9R-9L-10R	28	40	608	748
10L-10R-9L	39	50	544	748
11L-10R-10L	30	00	748	544
10R-11L-11R	41	30	748	548
11R-11L-12R	20	00	548	696
12R-11L-13R	19	00	696	1094
13R-11L-14SI(south end of island)	48	30	1094	668
12R-11L-12L	84	00	696	350
12L-12R-11L	27	50	746	696
13L-12R-12L	12	10	782	746
14L-12R-13L	2	20	840	782
14R-12R-14L	72	20	889	840
13R-12R-14R	19	30	490	888

Table 2. - Horizontal range data--Continued

Angle	Degrees	Minutes	Distance (feet) Foresight	Distance (feet) Backsight
12L-12R-11R	73	40	746	262
12L-14R-13R	21	00	888	456
15L-14R-14NI(north end of island)	35	40	854	594
17L-14R-15L	38	20	1062	850
14L-15L-13L	3	30	644	700
14L-15L-14R	84	50	644	850
14R-15L-15R	19	10	850	720
15R-15L-16R	23	20	720	589
16R-15L-16L	66	30	589	406
16R-15L-17L	45	50	589	660
15L-17L-17R	95	40	660	608
17R-17L-18L	78	30	608	592
18L-17R-17L	49	50	762	608
19L-17R-18L	35	50	800	762
19R-17R-19L	44	10	706	800
18R-17R-19R	31	50	283	704
18L-19R-17R	52	30	940	704
19L-19R-18L	24	20	573	940
20L-19R-19L	46	20	740	573
21L-19R-20L	17	00	1064	740
19R-20L-20R	47	10	740	490
21L-20R-20L	42	30	616	490
20R-21L-21R	43	40	616	497
21R-21L-22R	44	30	497	838
22L-22R-21L	34	50	520	838
23L-22R-22L	43	30	764	520
24L-22R-23L	9	20	1022	764
22R-23L-24L	145	50	762	297
23L-24L-24R	73	20	297	420
24R-24L-AR	32	20	420	692
25R-24L-26R	38	30	422	498
24L-26R-24R	43	10	498	612
25L-26R-24L	5	20	393	498
26L-26R-25L	30	50	373	393
27L-26R-26L	40	00	595	373
26R-27L-27R	24	30	595	400
27R-27L-28R	27	40	400	469
27L-27R-26L	58	10	400	410
28L-27R-27L	45	20	323	397
29R-27R-28L	24	50	636	325

Table 2. - Horizontal range data--Continued

Angle	Degrees	Minutes	Distance (feet)	
			Foresight	Backsight
27R-28L-28R	42	40	325	245
29L-29R-27R	60	40	212	636
29R-29L-30R	18	30	212	276
30L-30R-29L	57	00	146	276
32L-32R-31L	21	30	126	154
AL-AR-24L	92	40	176	687
AR-AL-BR	83	40	176	350
AR-24L-25R	12	10	692	422
BL-BR-AL	82	10	114	350

Table 3.- Particle-size distribution and specific weight of sediment deposited in Loch Lomond Reservoir, based on samples collected in August 1982

Range	Particle-size distribution, in percent			Dry specific weight, in pounds per cubic foot
	Clay <0.004 mm	Silt 0.004-0.062 mm	Sand >0.062 mm	
2	72	26	2	31.2
4	35	64	1	40.0
6	37	62	1	36.8
8	44	56	0	39.3
9	37	61	2	42.5
10	31	63	6	38.7
11	43	50	7	35.0
13	26	63	11	40.6
15	20	62	18	47.4
17	22	59	19	64.9
19	26	69	5	45.6
21	11	60	29	53.7
22	8	56	36	67.4
23	13	57	30	66.8
25	7	43	50	63.1
26	6	35	59	77.4
27	8	40	52	78.7
28	9	46	45	68.7
29	11	63	26	69.9
30	5	31	64	82.4
32	5	32	63	83.0
A	10	53	37	55.6

Results of Computations

Reservoir capacity as determined from computations using the contour method is given in table 4. These numbers represent the capacity between selected ranges so that future comparisons can be made.

Results of the reservoir capacity and surface-area computations are shown in figure 2. The reservoir capacity is 8,824 acre-ft and the surface area is 174 acres, both at the spillway elevation.

Table 4. - Reservoir capacity between selected ranges at spillway elevation (577.5 ft)

Range	Capacity, in acre-feet
Dam--R2	441
R2--R4	1,353
R4--R5	476
R5--R7	1,184
R7--R9	773
R9--R11	766
R11--R13	788
R13--R15	837
R15--R17	383
R17--R19	706
R19--R22	667
R22--R25	309
R25--R29	136
R29--R32	5
Total --------------------	8,824

SEDIMENTATION IN LOCH LOMOND RESERVOIR

Samples of bottom sediment were collected at the lowest point in selected ranges in August 1982 (table 3). The particle-size distribution of the deposited sediments indicate that the coarser particles are deposited upstream; the finer particles travel downstream before deposition (fig. 3). The particle-size distribution ranged from 72 percent clay and 2 percent sand at range 2 to 5 percent clay and 64 percent sand at range 30. The dry specific weight ranged from 31.2 lb/ft^3 at range 2 to 83.0 lb/ft^3 at range 32 (table 3). Brown (1973) estimated the trap efficiency of the Loch Lomond Reservoir, using the methods described by Brune (1953), and concluded that 95 percent of the sediment transported into the reservoir since 1960 was deposited.

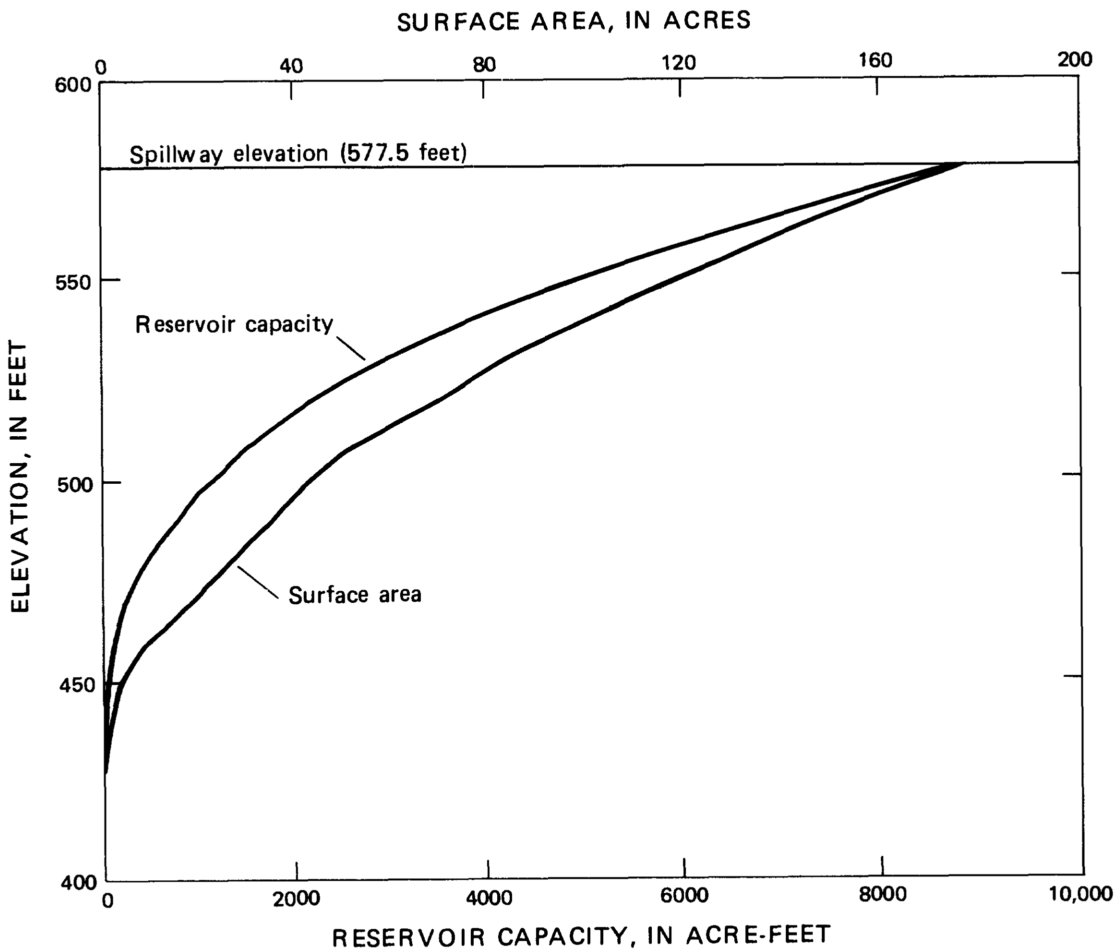

FIGURE 2. – Surface-area and capacity curves for Loch Lomond Reservoir, based on 1982 survey.

Comparison of thalweg profiles (fig. 4) from pre-dam construction in 1960 to the survey done in 1982 shows that most of the sedimentation has taken place in the upper (above range 22) and lower (below range 8) reaches of the reservoir. The sedimentation observed below range 8 is a result of landsliding below the water level and is not indicative of a loss in storage capacity (Brown, 1973). Landslides are common in this area, especially during the winter rains, and may contribute to a loss in reservoir capacity. At the upper end of the reservoir (above range 22), deposition occurs as a result of the sediment discharge from Newell Creek into the reservoir proper. About 25 feet of sediment seems to have been deposited at range 29. Between 1960 and 1982 the slope of the thalweg has steepened from about 52 to 84 ft/mi in the upper reach. Deposition in the middle reach (between ranges 8 and 22) has been minimal, as indicated by little change in slope and elevation. The inaccuracy of the base maps and initial surveys prohibits comparison with the 1982 computations; therefore, an estimate of the volume of sedimentation was not attempted. Future surveys can be compared to the results of this study to monitor sedimentation of the reservoir and the resultant loss of storage capacity.

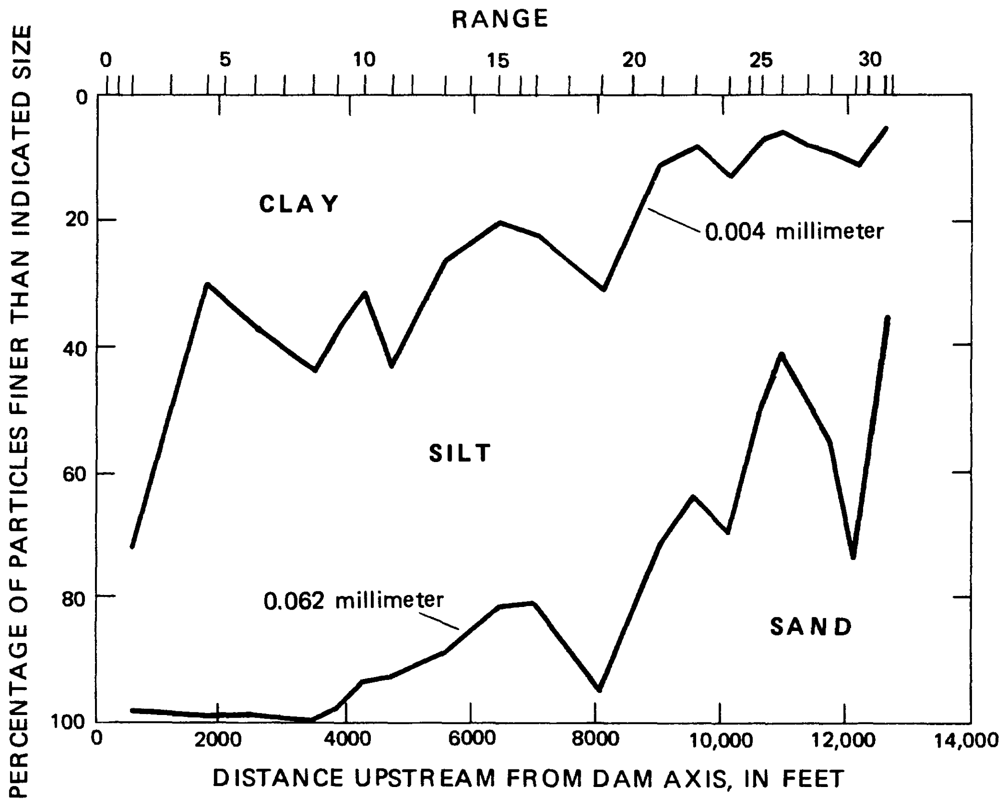

FIGURE 3. – Particle-size distribution of sediment in Loch Lomond Reservoir.

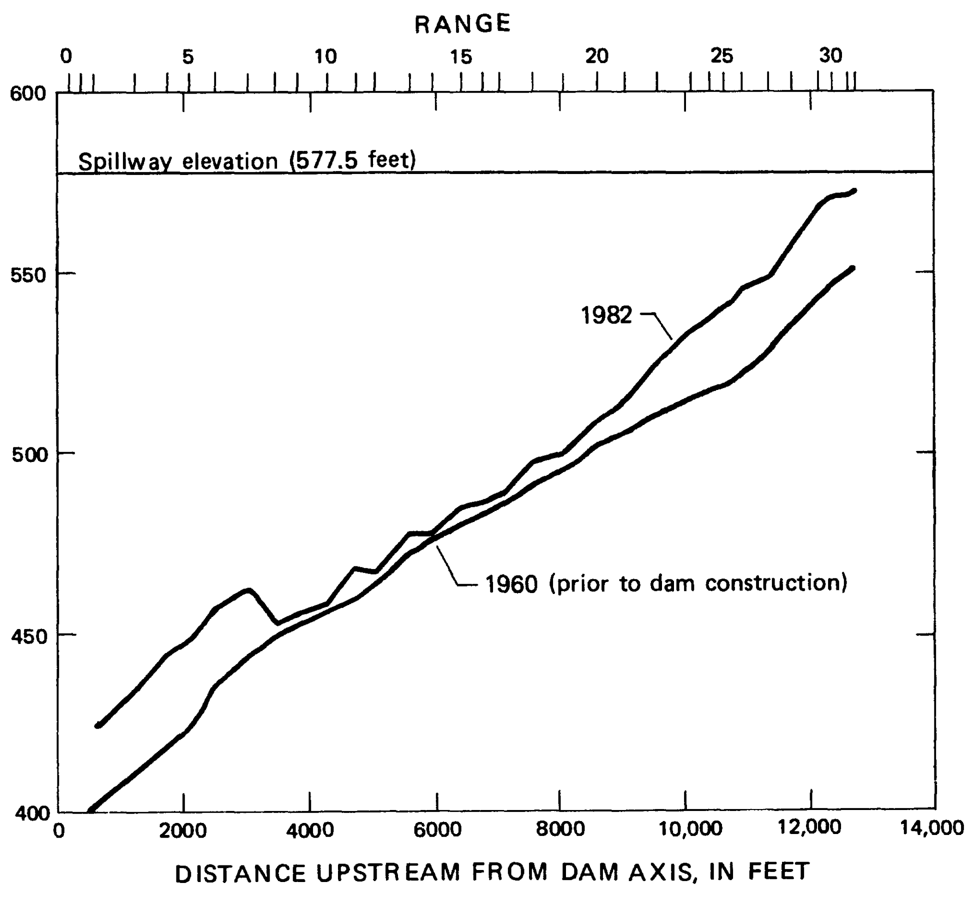

FIGURE 4. – Thalweg profiles of Loch Lomond Reservoir, 1960 and 1982.

SUMMARY

The capacity of Loch Lomond Reservoir has been determined to be 8,824 acre-ft on the basis of a survey done in 1982. The survey established permanent ranges, and the methods to calculate reservoir capacity can be utilized in order to make accurate comparisons of sediment deposition.

Sedimentation in Loch Lomond Reservoir has occurred since dam construction in 1960, resulting from landslides and from the sediment transported by Newell Creek. Accuracy of base maps and initial surveys does not allow reasonable estimates of the quantity of sediment deposited since 1960.

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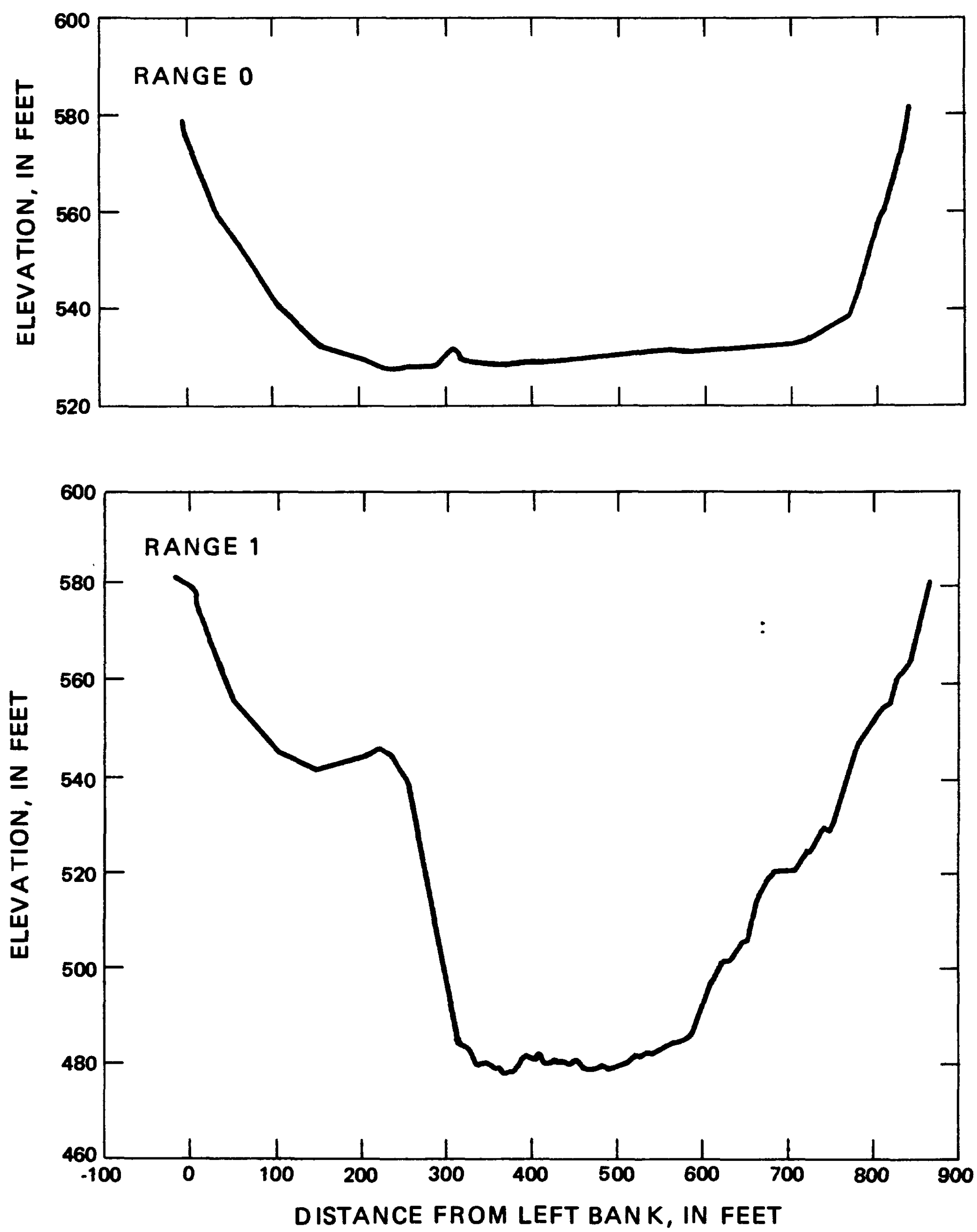
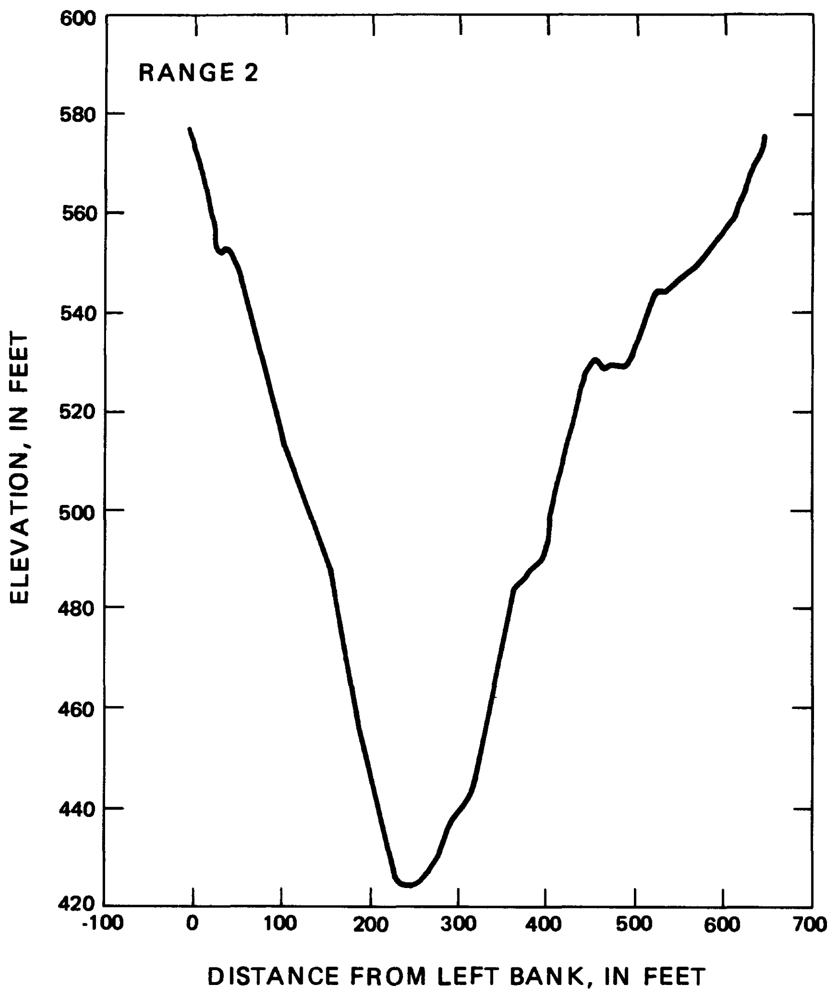


FIGURE 5. – Loch Lomond Reservoir cross sections, August 1982.



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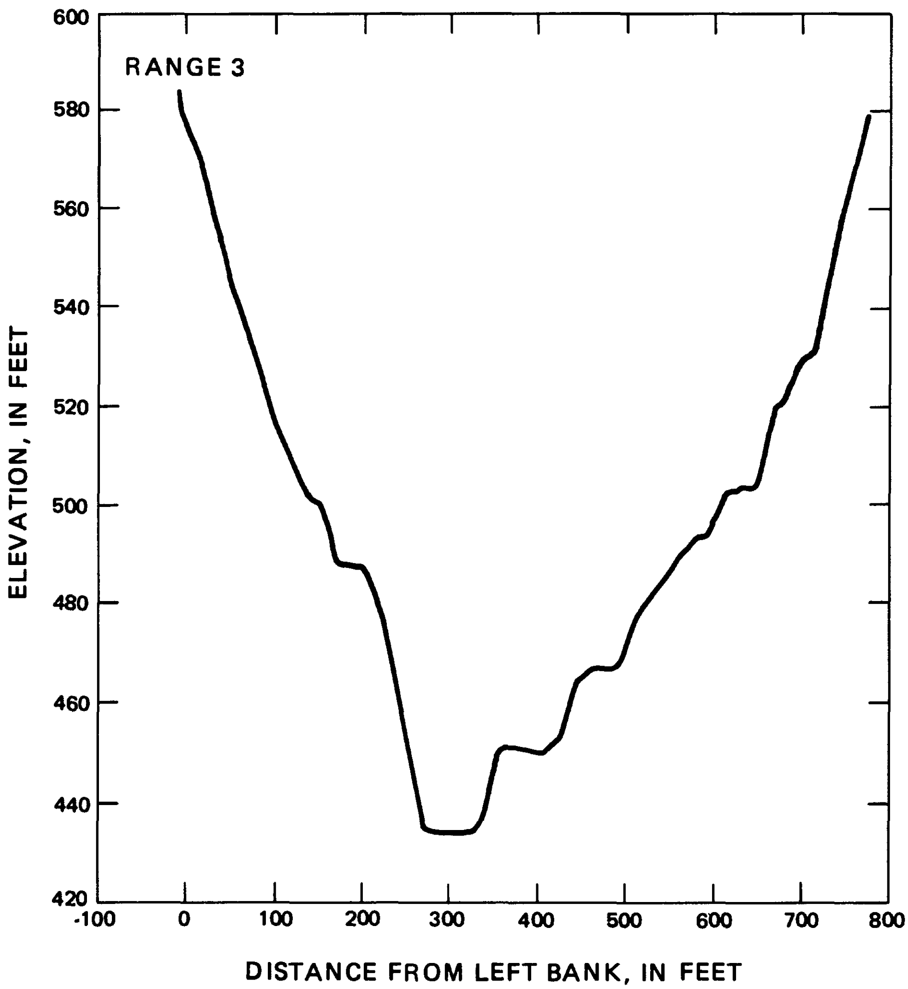

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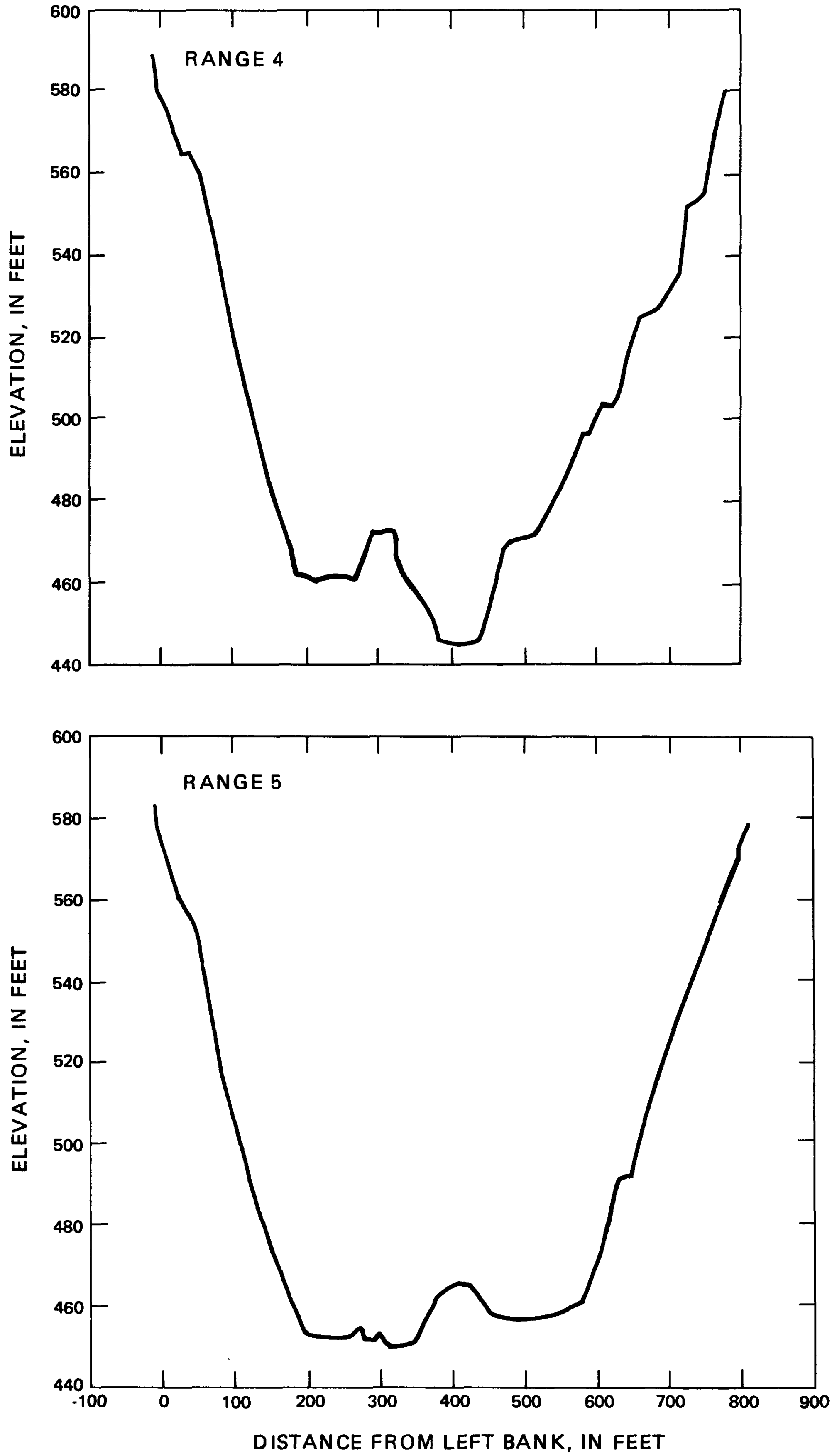

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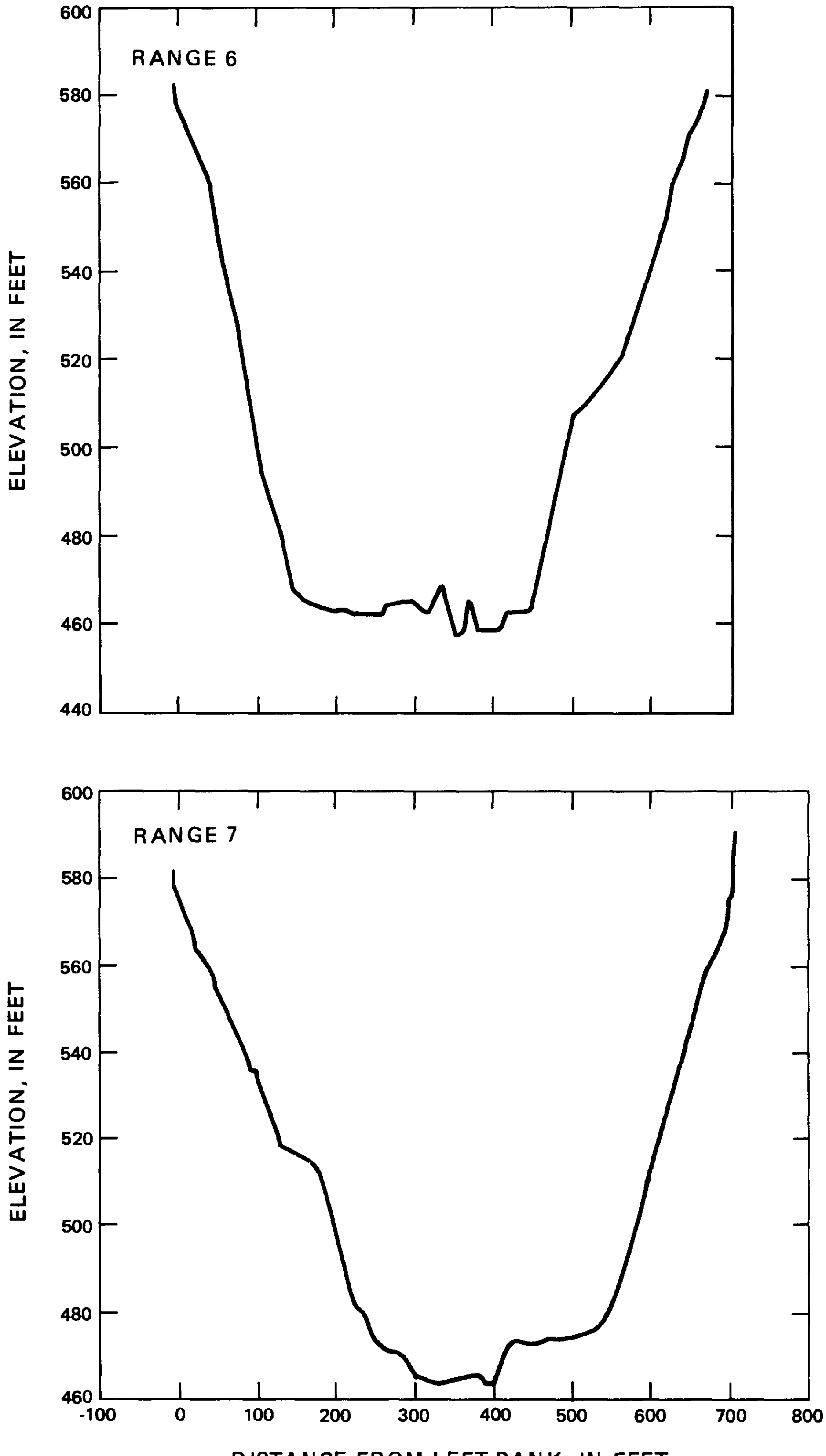

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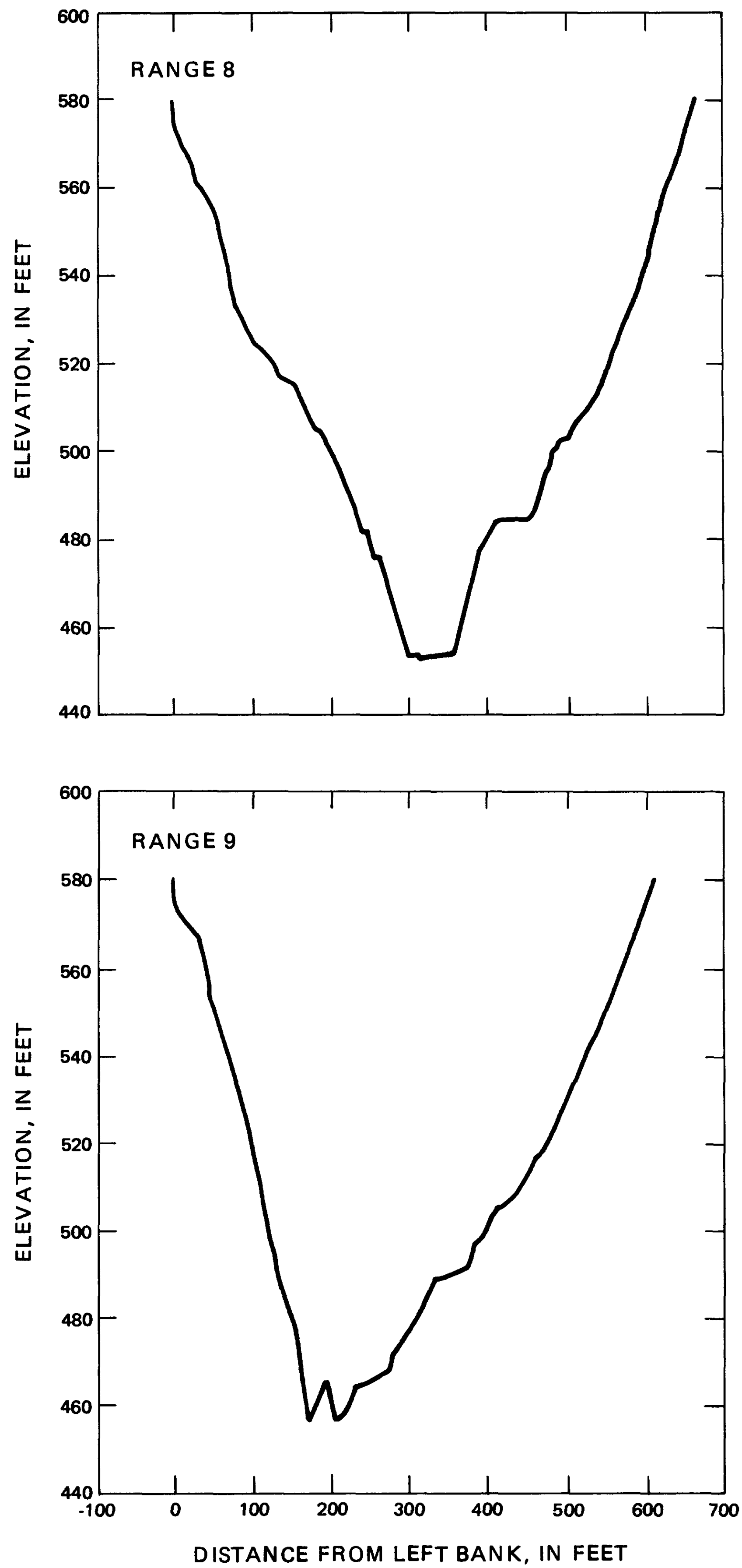

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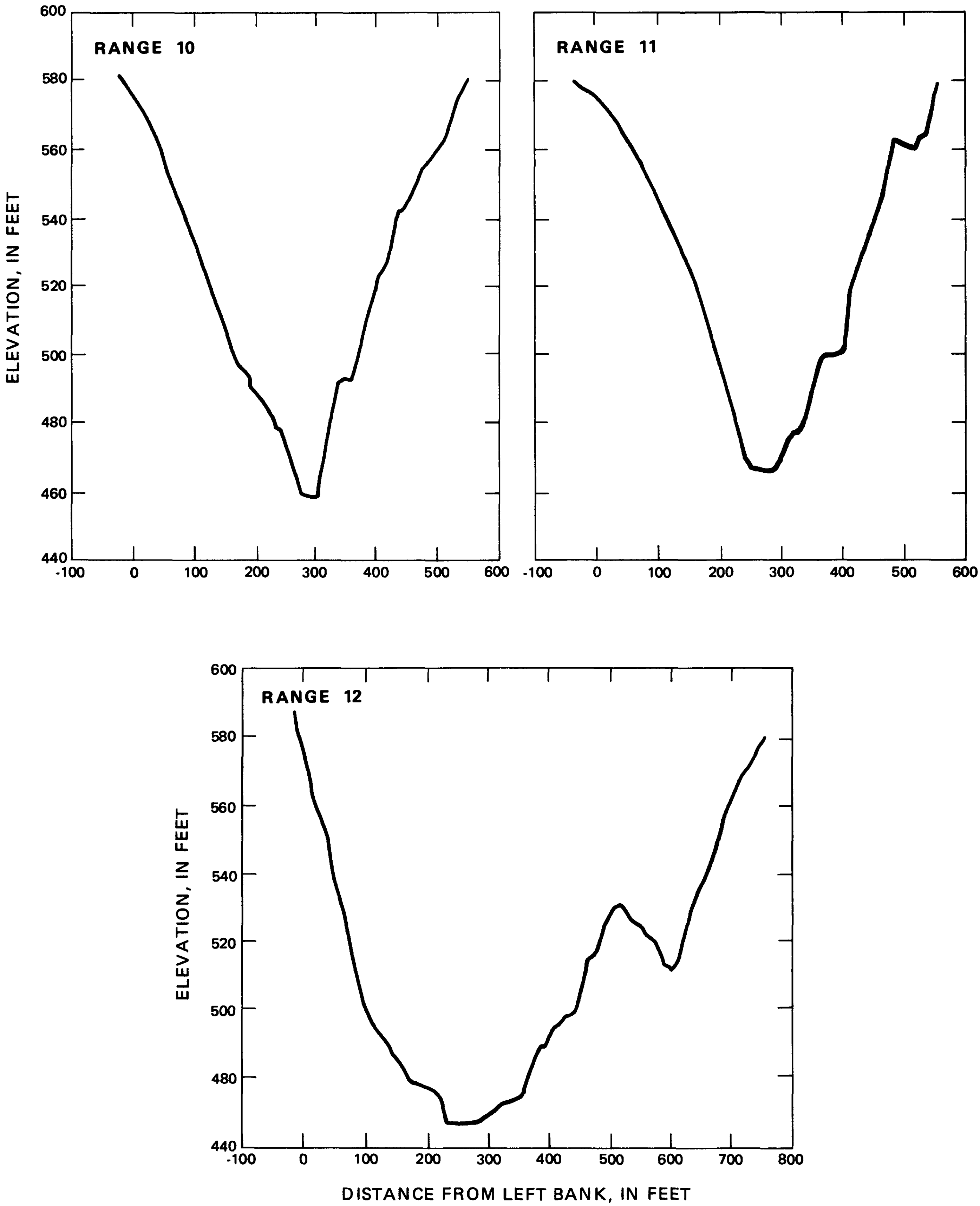

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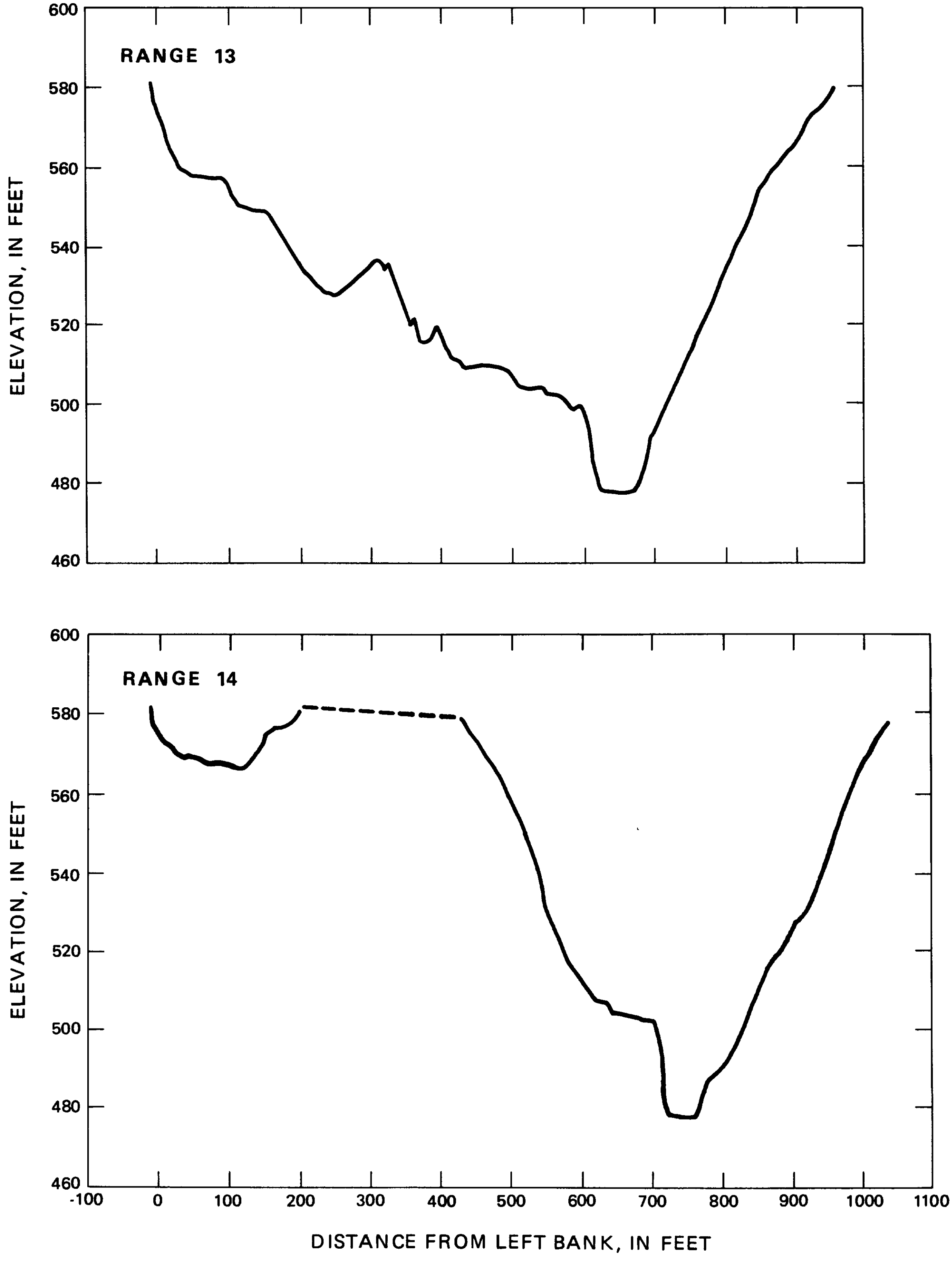

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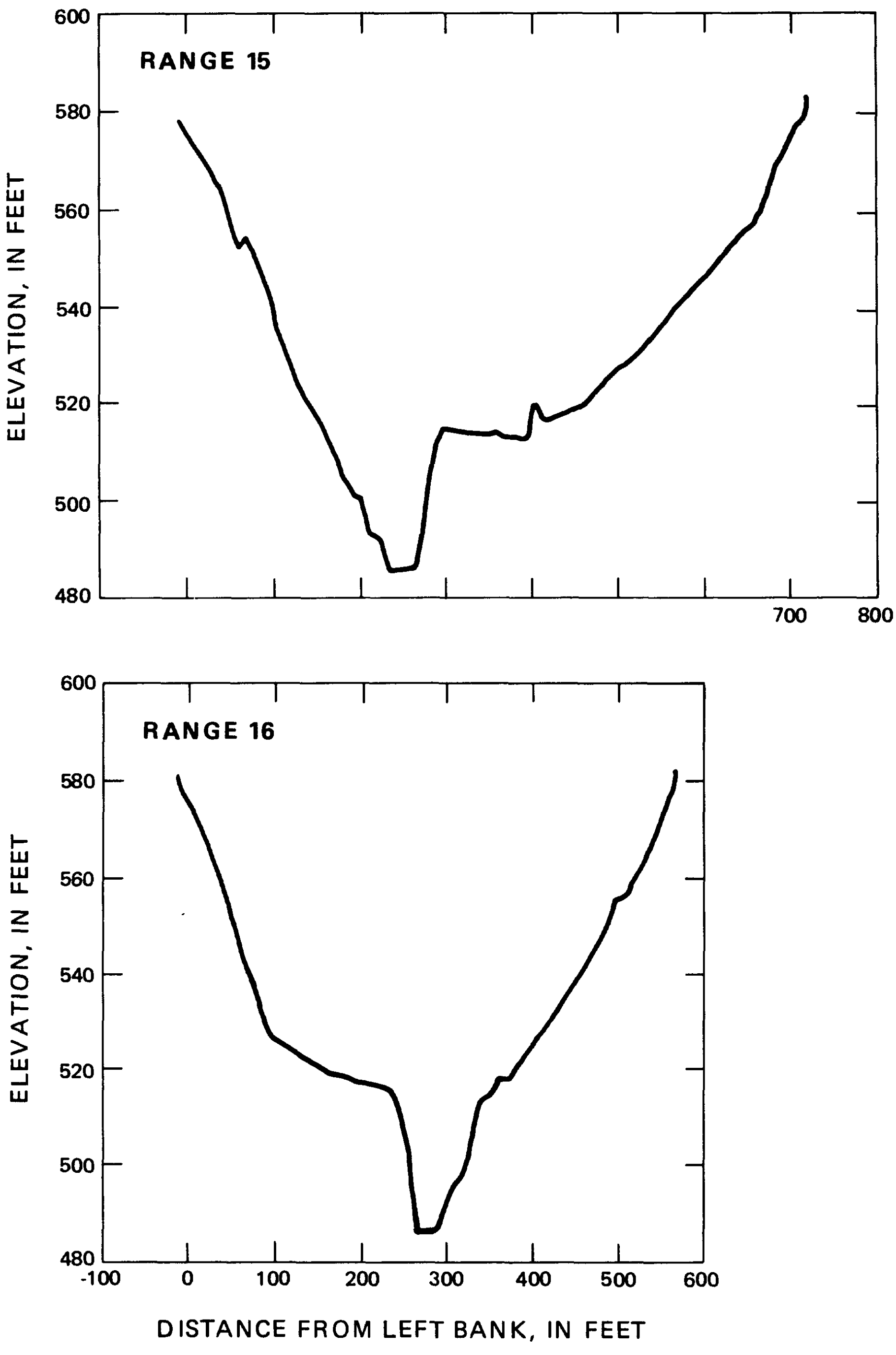

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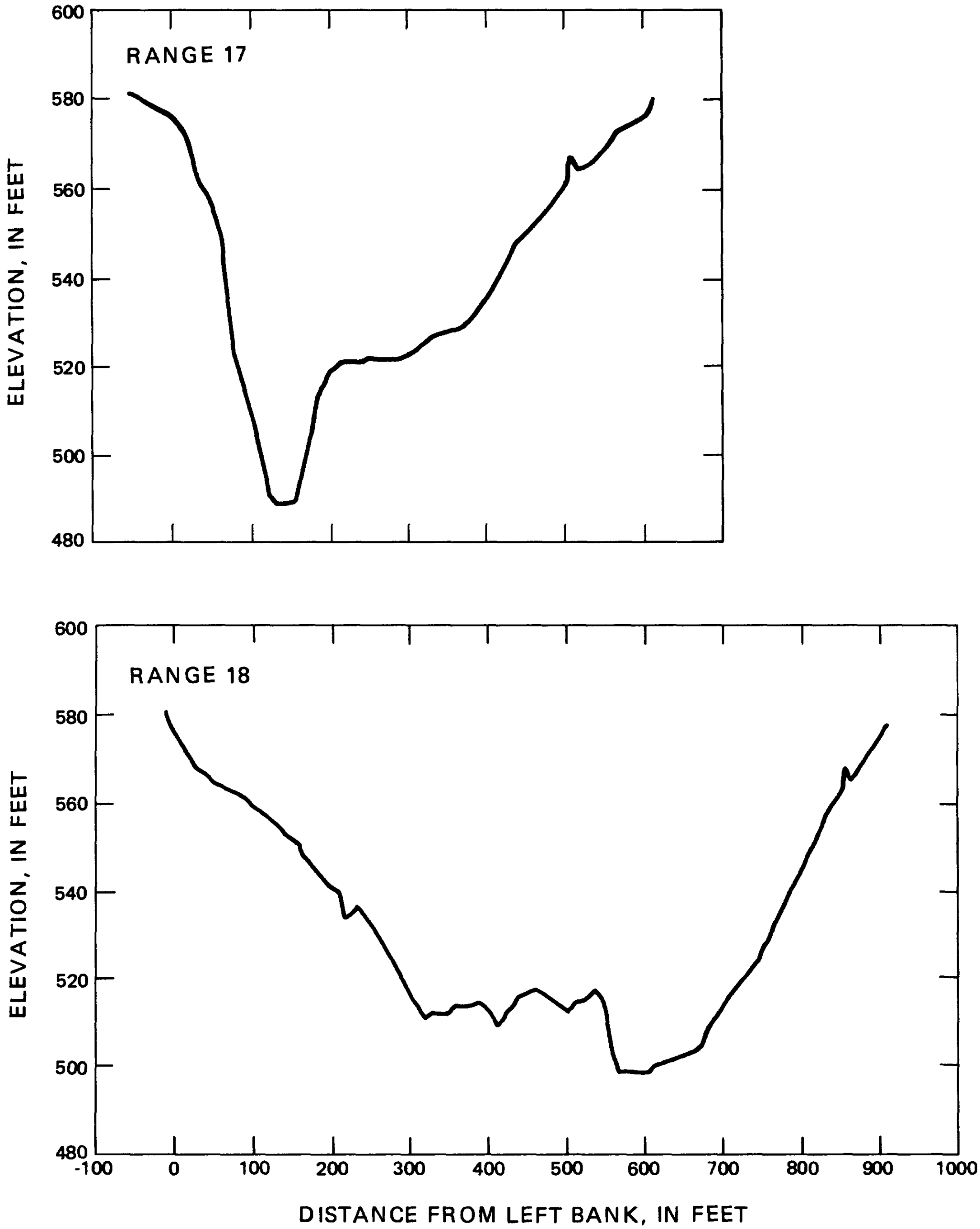

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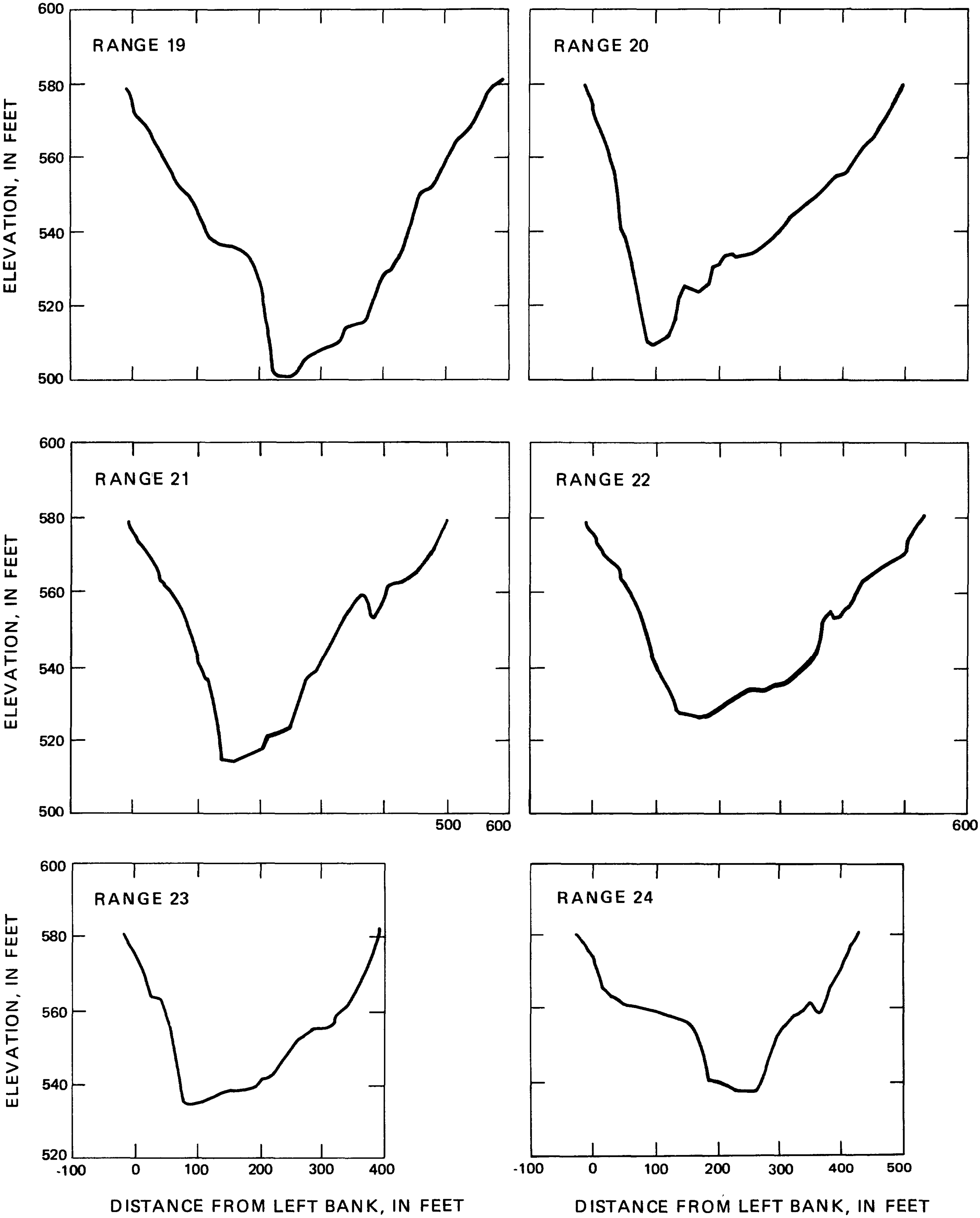

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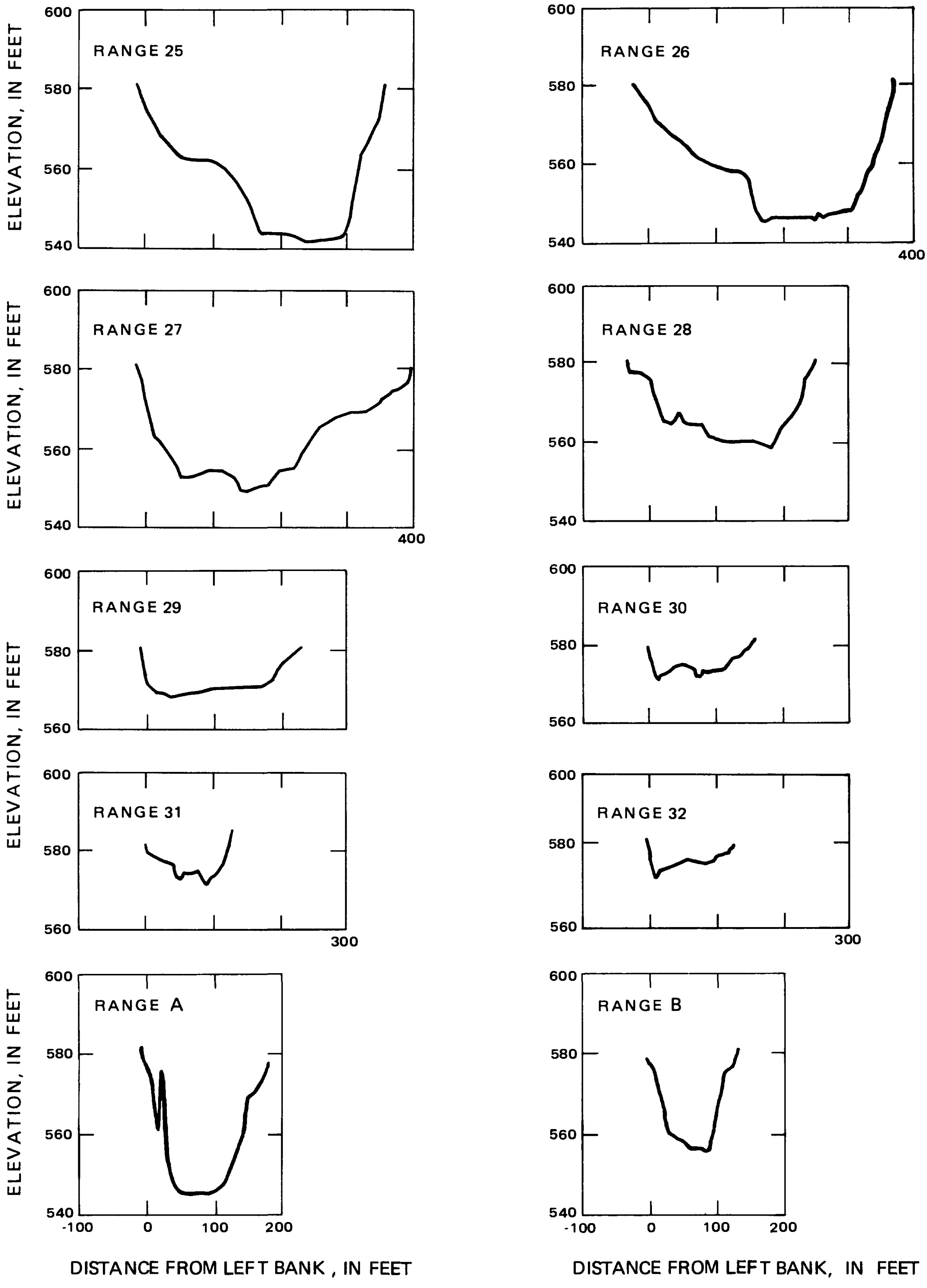

FIGURE 5. — Continued.