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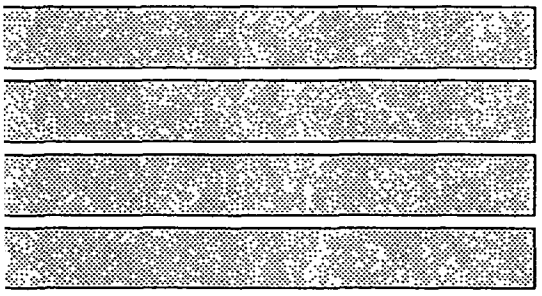
Lake Sedimentation of Argyle Lake, McDonough County, Illinois

by Richard L. Allgire and William P. Fitzpatrick
Office of Sediment & Wetland Studies

Prepared for the
Illinois Department of Conservation

July 1992



Illinois State Water Survey
Hydrology Division
Champaign, Illinois

A Division of the Illinois Department of Energy and Natural Resources

LAKE SEDIMENTATION SURVEY OF ARGYLE LAKE, MCDONOUGH COUNTY, ILLINOIS

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INTRODUCTION

The Illinois State Water Survey (ISWS) in cooperation with the Illinois Department of Conservation, conducted a lake sedimentation survey of Argyle Lake in Argyle State Park in 1991. This report presents the results of that survey and compares them to a previous lake sedimentation survey conducted by the ISWS in 1962.

Reservoir Description

Argyle State Park is located in McDonough County approximately 1.5 miles north of Colchester, Illinois (figure 1). Argyle Lake Dam is located in the northwest quarter of Section 6, Township 5 N, Range 3 W.

A tributary to the East Fork of the La Moine River was dammed to form the lake in 1950. The lake has a surface area of 93 acres and a watershed area of 4,200 acres or 6.56 square miles. The average annual precipitation (1951-1980) was 35.02 inches (at Macomb). The average annual runoff(1945-1991) was 9.07 inches at the La Moine River at Colmar (Richards, Hayes, and Sullivan, 1992) and the average annual lake evaporation rate was 35 inches (Roberts and Stall, 1967).

LAKE SEDIMENTATION SURVEY

Surveying Techniques

Argyle Lake was surveyed in 1949 immediately prior to the closing of the dam gate and impounding of water in January 1950. The lake was resurveyed in 1962 to determine the lake volume, and the volume and characteristics of the accumulated sediment. The lake was surveyed a third time in 1991 to determine: 1) the present lake volume, 2) the volume and mass of sediment deposited since the 1962 survey, 3) the stage-volume-area relationships within the lake, and 4) to compare the pre- and post-1962 survey results.

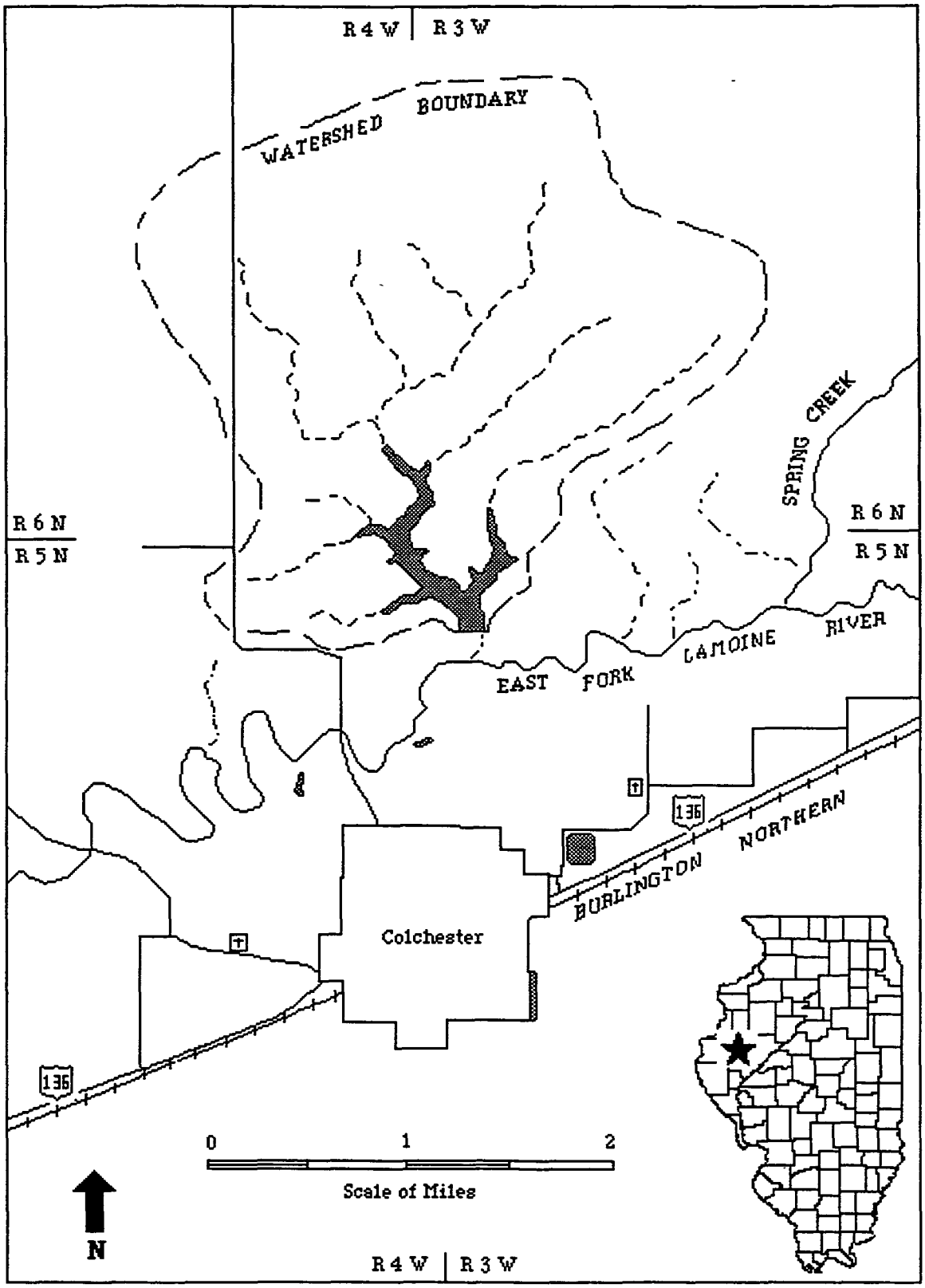

Figure 1. Location of Argyle Lake and its watershed

The lake was divided into 16 lake segments for the 1962 survey by establishing 15 cross-section or range lines. Concrete survey monuments were set at each end of the cross sections to permanently mark the locations. These monuments (figure 2) were located during the 1991 survey and the cross-section lines were resurveyed.

The 1991 survey was made by stretching a marked polypropylene cable between the two survey monuments to measure linear distance along the survey line. A boat containing a sonar sounding unit was maneuvered along the cable while continuously plotting a profile of the lakebed relative to the spillway elevation. The survey boat then took manual sounding measurements near shore on each end of the survey line and at selected linear distances along the line. These manual soundings were used as a check to correlate the 1991 water and sediment depths with those from the 1962 survey.

The manual soundings were made using a 2-inch-diameter aluminum sounding pole marked at 0.1 foot intervals. To increase its sensitivity to the lakebed and to obtain a more precise depth measurement, the sounding pole has an 8-inch-diameter, free-sliding sediment shoe that floats on top of the lakebed surface. The pole was lowered through the water column to the lakebed to measure the present water depth. It was then pushed downward through the softer accumulated sediment until the firmer original lakebed was reached. The thickness of the accumulated sediment is the difference between the water depth and the original lakebed depth.

Sediment Sample Collection

The 1991 survey collected lakebed sediment samples at eight locations throughout the lake (figure 2). The samples were analyzed for particle size distribution and unit weight. The sampling locations were selected to gather representative samples of lakebed sediments from different regions of the lake.

Two types of samplers were used: a 3-foot-long, 2-inch-diameter piston-type core sampler and an Eckman Dredge surface sampler. The core samples were placed on a sample board to record their length and physical descriptions. Based on field observations, 1 to 6 subsamples were then cut from the core and sent to the laboratory for particle size and unit weight analysis. The Eckman Dredge was used to sample the top 2 to 4 inches of the lakebed surface for particle size.

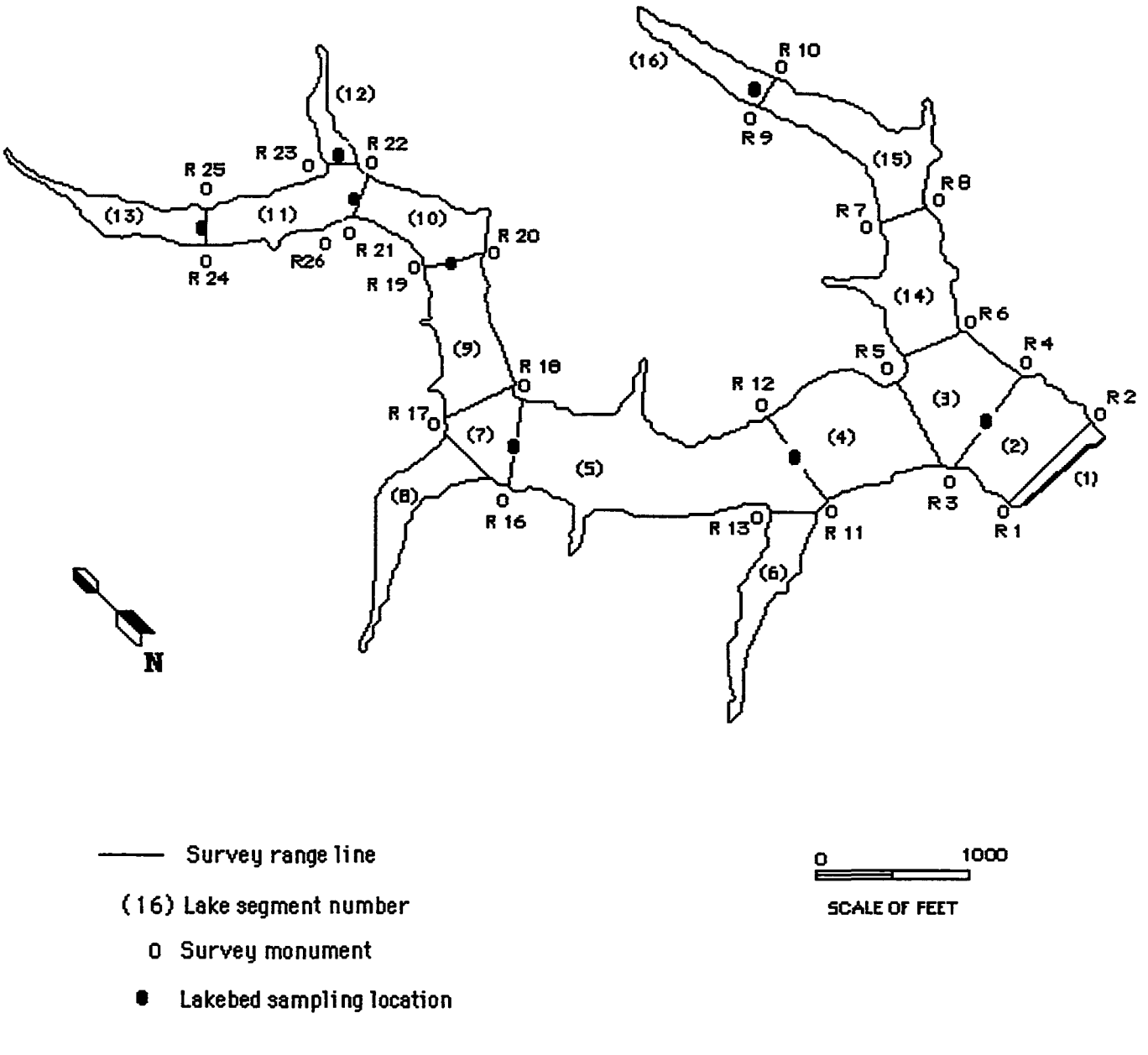

Figure 2. Argyle Lake survey range lines, lake segment numbers, survey monuments, and lakebed sample locations

LAKE SEDIMENTATION ANALYSIS

Depth Analysis

The sonar and sounding pole measurements were used to create cross-section plots for each of the resurveyed range lines. The data from the 1962 survey were also included to illustrate and compare the changes in the lakebed profile since the lake was built in 1950.

Originally, Argyle Lake had a maximum depth of 41.2 feet and an average depth of 19.8 feet. The 1962 survey found a maximum depth of 37.4 feet and an average depth of 19.0 feet. The 1991 survey determined a maximum depth of 34.4 feet and an average depth of 17.2 feet. Therefore, since its construction the lake has lost a total of 6.8 feet of maximum depth and 2.6 feet of average depth. Table 1 lists the loss of maximum and average depths in feet for different lake survey periods.

Table 1. Loss of Maximum and Average Depths

Year	*Loss of maximum depth (feet)*	*Annual loss (feet)*	*Loss of average depth (feet)*	*Annual loss (feet)*
1950- 1962	3.8	0.3	0.8	0.06
1962- 1991	3.0	0.1	1.8	0.06
1950- 1991	6.8	0.16	2.6	0.06

As shown in table 1, the annual loss of average depth has remained unchanged since the lake was built in 1950 even though the loss of the maximum and average depths change for each time period. There are, however, significant differences in sedimentation rates between the upper and lower segments of the lake. Figure 3 plots cross section R21-R22 located in the upper end of the lake. Compare this plot to figure 4 of cross section Rl - R2 located near the dam in the lower end of the lake noting the differences in the thickness of the sediment deposits and the total depth and volume of cross-sectional area. Plots of all of the range lines comparing the 1950, 1962, and the 1991 bed profiles are shown in appendix I.

Volume Analysis

Lake sedimentation rates can be expressed as the sediment volume or as the mass of sediment deposited. Lake volume loss is useful in discussing the amount of storage capacity of the lake. The mass or weight of sediment, usually measured in tons, allows for

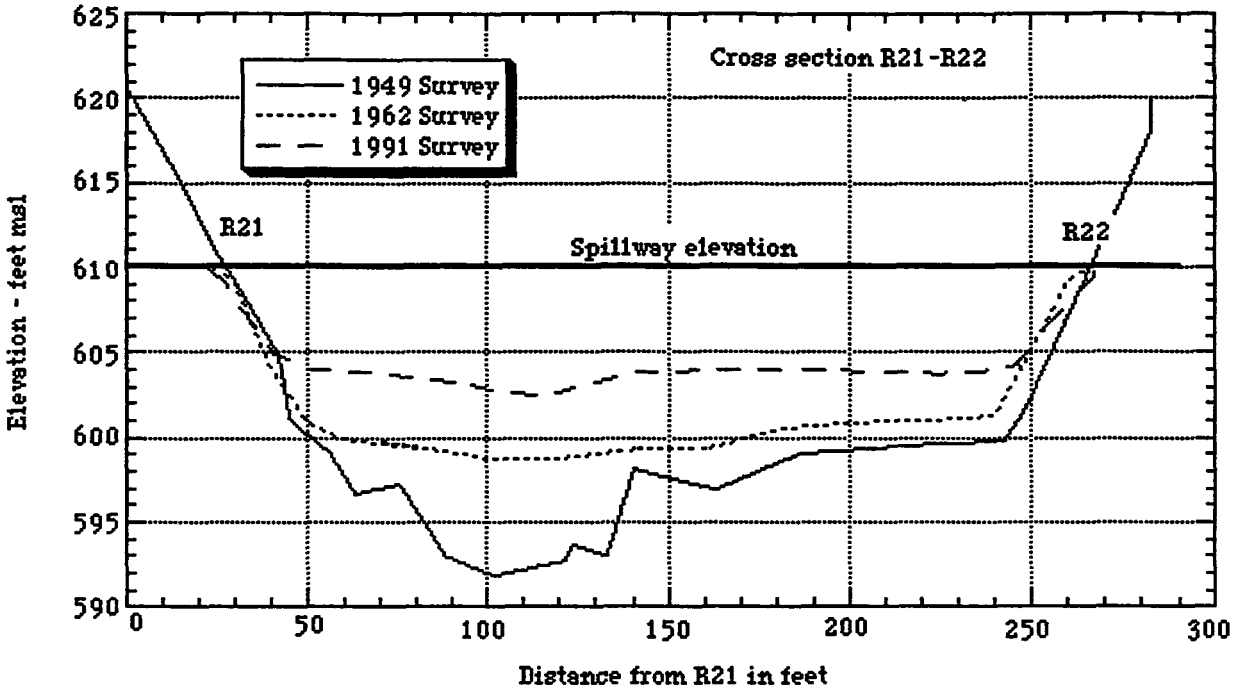

Figure 3. Typical cross section of upstream Argyle Lake

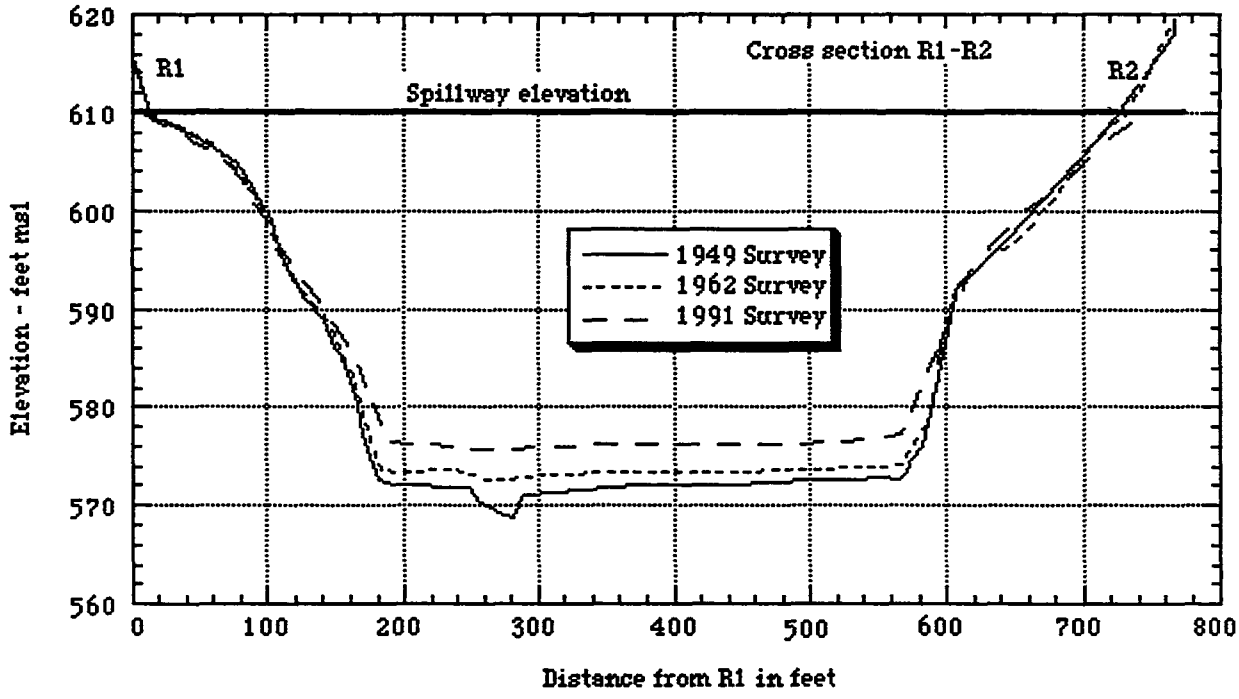

Figure 4. Typical cross section of Argyle Lake near the dam

comparison of sedimentation rates between lakes and sediment yields from different watersheds.

A lake with a high volume loss could have a low sediment mass and vice versa. Various factors influence the volume-weight relationship of sediments, such as drying and compaction, particle sizes, amount of sediment accumulated, and location of the deposition within the lake. Lake sediments that have been exposed to drying, due to lake-level drawdowns, shrink and compact in volume, thus becoming denser with an increase in unit weight. This reduction in sediment volume and subsequent increase in unit weight does not affect the total mass or weight of sediment measured in a lake.

The range line data were used to calculate the cross-sectional areas for each survey line. This area was then compared to the cross-sectional area from the 1962 survey. The manual soundings with the sounding pole were computed and compared with the sediment depths as a cross check to ensure quality control in the data analysis process. The cross-sectional areas were then combined with the surface areas of the lake segments to determine the water and sediment volumes in the lake. This procedure was developed by the U.S. Soil Conservation Service and described in their *National Engineering Handbook* (U.S. Department of Agriculture, Soil Conservation Service, 1968).

Table 2 lists by lake segment the original, the 1962, and the 1991 volumes, and the percent of original volume lost to sedimentation. As seen in table 2, the original lake volume in 1950 was 1,980 acre-feet. The volume was 1,831 and 1,549 acre-feet in 1962 and 1991, respectively. Therefore, sediment deposition for specific time periods (1950-1962,1962-1991, and 1950-1991) was 149,282, and 431 acre-feet, respectively.

The lake has lost a total of 21.8 percent of its original volume or an average annual volume loss of 0.53 percent. Figure 5 illustrates the percent loss of original lake volume by lake segment.

Stage-Volume-Area

The sonar and sounding pole measurements along the range lines were used to create a bathymetric map of the lake (figure 6). The areas and contour elevations from this map were used to develop the stage-volume-area relationships shown in figure 7. These curves give the water surface area and the water volume remaining in the lake for given elevations based on the spillway elevation.

Lake Sediment Characteristics

A total of 18 particle size and 18 unit weight samples were collected from eight locations in Argyle Lake during the 1991 survey. All of the samples were taken from near

Table 2. Argyle Lake Volumes and Percent Volume Loss by Lake Segments

Lake segment	*1950 original volume (acre-ft)*	*1962 volume (acre-ft)*	*1991 volume (acre-ft)*	*Volume lost since 1950 (percent)*
1	32.8	30.8	24.8	24.5
2	221.8	212.4	179.6	19.0
3	234.7	226.4	191.4	18.4
4	197.6	187.3	186.3	5.7
5	556.5	520.7	458.5	17.6
6	67.3	63.7	49.1	27.1
7	45.1	41.5	36.6	18.9
8	49.6	46.6	40.3	18.8
9	125.4	110.4	89.1	28.9
10	59.7	48.4	35.3	40.9
11	47.2	31.0	17.5	63.0
12	12.4	8.4	4.6	63.1
13	14.0	6.3	1.6	88.7
14	191.5	182.8	142.9	25.4
15	103.0	94.9	76.0	26.2
16	21.4	19.4	15.4	27.9
Total	1,980.0	1,831.0	1,549.0	21.8*

* Average percent volume loss for entire lake.

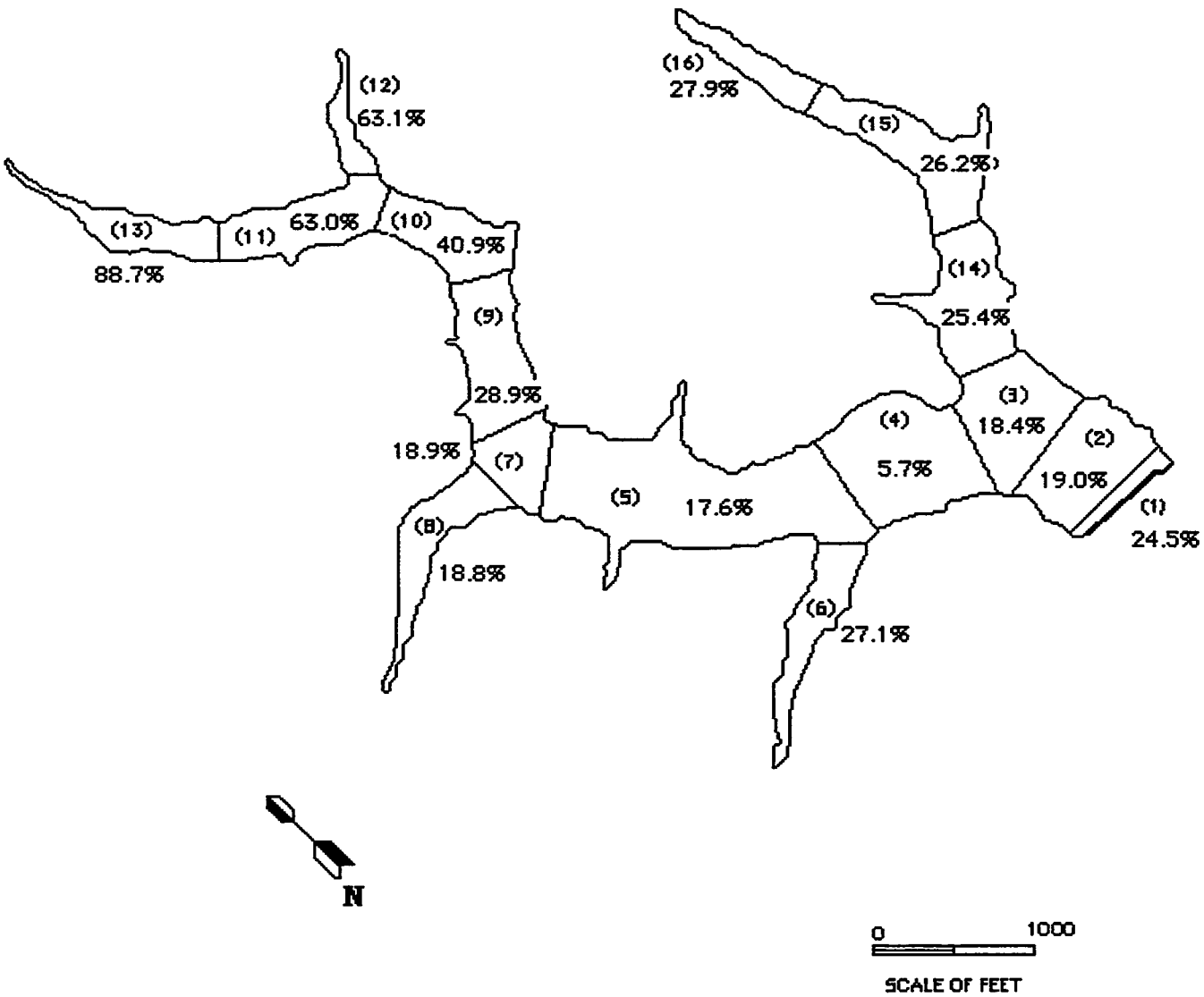

Figure 5. Percent loss of original lake volume by lake segment (number in parentheses) for Argyle Lake since 1950

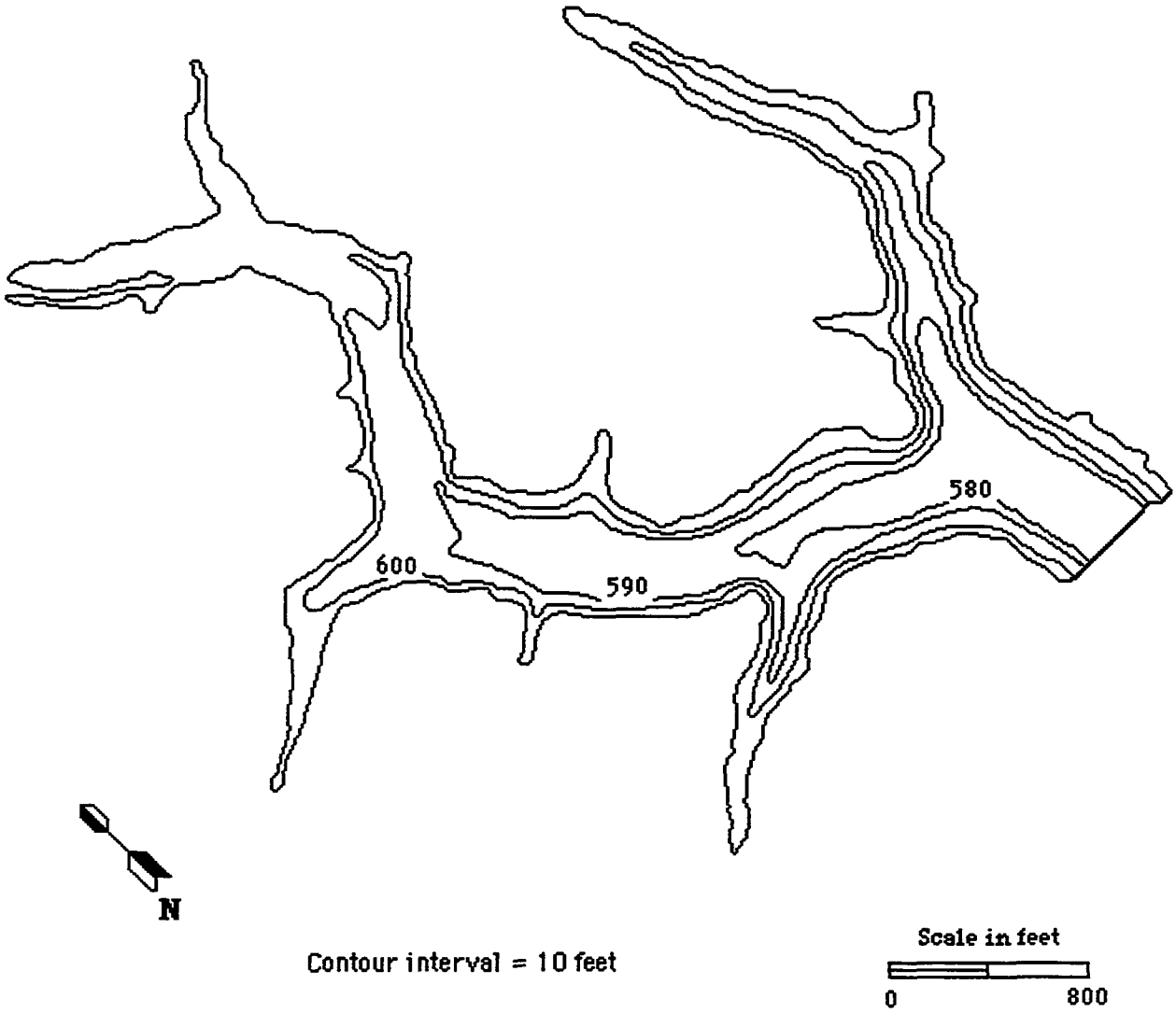

Figure 6. Bathymetric map of Argyle Lake

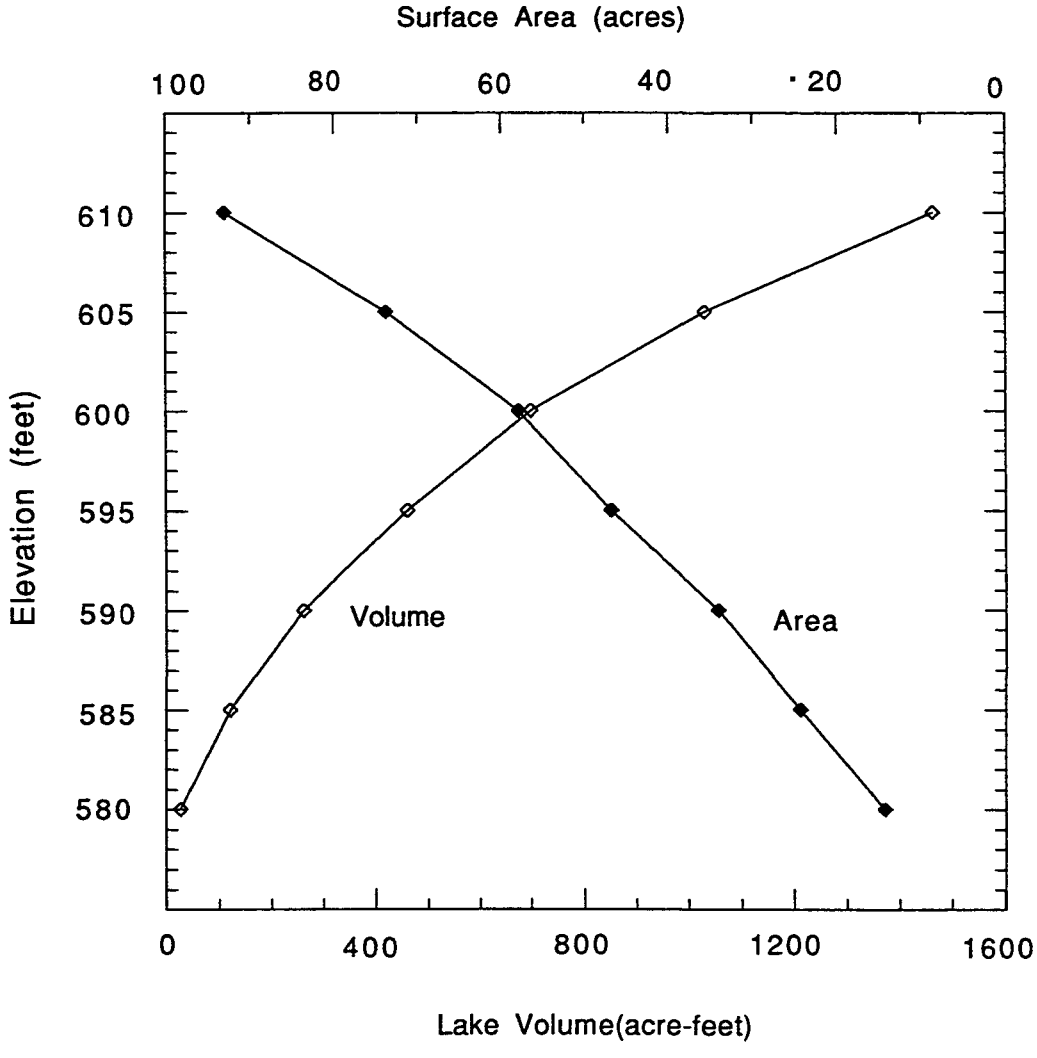

Figure 7. Stage-Volume-Area relationships for Argyle Lake, 1991

the midpoint of their respective survey lines and were analyzed at the Illinois State Geological Survey's Geotechnical Laboratory in Champaign, Illinois.

The sediments deposited in Argyle Lake, fine-grained with little or no sand and gravel, are typical of those found in Illinois lakes. The weighted average of all the particle-size samples is 1 percent sand, 41 percent silt, and 58 percent clay.

The average density for sediments in Argyle Lake was 42 pounds per cubic foot. The highest sediment densities were found in the upper reaches of the lake, with segment 13 having the highest density, 66.7 pounds per cubic foot. The lowest sediment densities, 32.7 pounds per cubic foot, were found near the dam.

Results of the particle size and unit weight analysis for each sample collected during the 1991 survey are listed in appendix II.

Sedimentation Rates

The sedimentation rate in a lake is expressed as the mass or weight of sediment deposited, usually in tons or kilotons. The weight of sediment in each lake segment is calculated by using its average sediment density and the sediment volume. The total mass of sediment for the lake is then the sum of all the segmental weights. Table 3 summarizes the sediment deposition data for Argyle Lake.

The mass of sediment deposited from 1950-1962 as calculated by the 1962 survey was 150,300 tons or an average annual deposition of 12,020 tons. From 1962-1991, 244,400 tons were deposited for an average annual deposition of 8,400 tons. Therefore, the total deposition since the lake's construction in 1950 was 394,700 tons or an average annual deposition of 9,500 tons. This amounts to an average annual sediment yield per acre of watershed of 2.3 tons. Table 4 summarizes the sedimentation data for Argyle Lake for the 1962 and 1991 surveys.

SUMMARY

Argyle Lake was completed in 1950. The lake was surveyed in 1949 just prior to impoundment to determine its volume. It was surveyed again in 1962 to determine its volume, volume loss rate, and sedimentation rate. The lake had an original volume of 1,980 acre-feet and the 1962 survey calculated a volume of 1,831 acre-feet. This represents a 7.5 percent volume loss during the lake's first 12.5 years or 0.6 percent annual volume loss due to the deposition of 150,300 tons of sediment.

The lake was resurveyed in 1991 to determine the present volume, and the volume loss rate and sedimentation rate since the previous survey. The 1991 lake volume was

Table 3. Lake Sediment Volume, Average Sediment Density, and Sediment Tonnage by Lake Segment

Lake segment	*Sediment volume (acre-feet)*	*Average density (lbs. per cubic foot)*	*Sediment kilotons)*
1	8.0	32.7	5.7
2	42.2	32.7	30.0
3	43.3	32.7	30.8
4	11.3	32.8	8.1
5	98.0	38.0	81.1
6	18.2	32.8	13.0
7	8.5	43.1	8.0
8	9.3	43.1	8.7
9	36.3	51.3	40.6
10	24.4	54.3	28.9
11	29.7	57.8	37.4
12	7.8	49.0	8.3
13	12.4	66.7	18.0
14	48.6	42.1	44.6
15	27.0	42.1	24.8
16	6.0	51.4	6.7
Total	431.0	42.0*	394.7

* Average sediment density for entire lake.

Table 4. Sedimentation Survey Data Summary: Argyle Lake

Age		41.5 years (built in 1950)
Sedimentation surveys		1962 (12.5-year interval) 1991 (29-year interval)
Watershed area		4,200 acres (6.56 square miles)

Reservoir data

Surface area	1962	96 acres
	1991	93 acres
Storage capacity	1950	1,980 acre-feet (645 million gallons)
	1962	1,831 acre-feet (597 million gallons)
	1991	1,549 acre-feet (505 million gallons)

Volume loss (percent)		*Average annual loss (percent)*
1950 - 1962	7.5	0.60
1962 - 1991	15.4	0.53
1950 - 1991	21.8	0.53

Sediment deposition (tons)		*Average annual deposition(tons)*
1950 - 1962	150,300	12,020
1962 - 1991	244,400	8,400
1950 - 1991	394,700	9,600

Sediment deposition per watershed acre (tons)

	Average	*Average annual*
1950 - 1962	36	2.9
1962 - 1991	58	2.0
1950 -1991	94	2.3

measured as 1,549 acre-feet. Therefore, 282 acre-feet of sediment have accumulated in the lake since 1962 for a total sediment volume of 431 acre-feet. This represents a 21.8 percent volume loss to sedimentation or 0.53 percent per year.

The 1991 average sediment density measured 42 pounds per cubic foot. Therefore, the mass of sediment deposited since 1962 was 244,400 tons for a total sediment mass in the lake since construction of 394,700 tons. This is an average of 9,500 tons per year or an average annual yield per watershed acre of 2.3 tons.

ACKNOWLEDGMENTS

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Eva Kingston edited the report, and Becky Howard prepared the camera-ready text.

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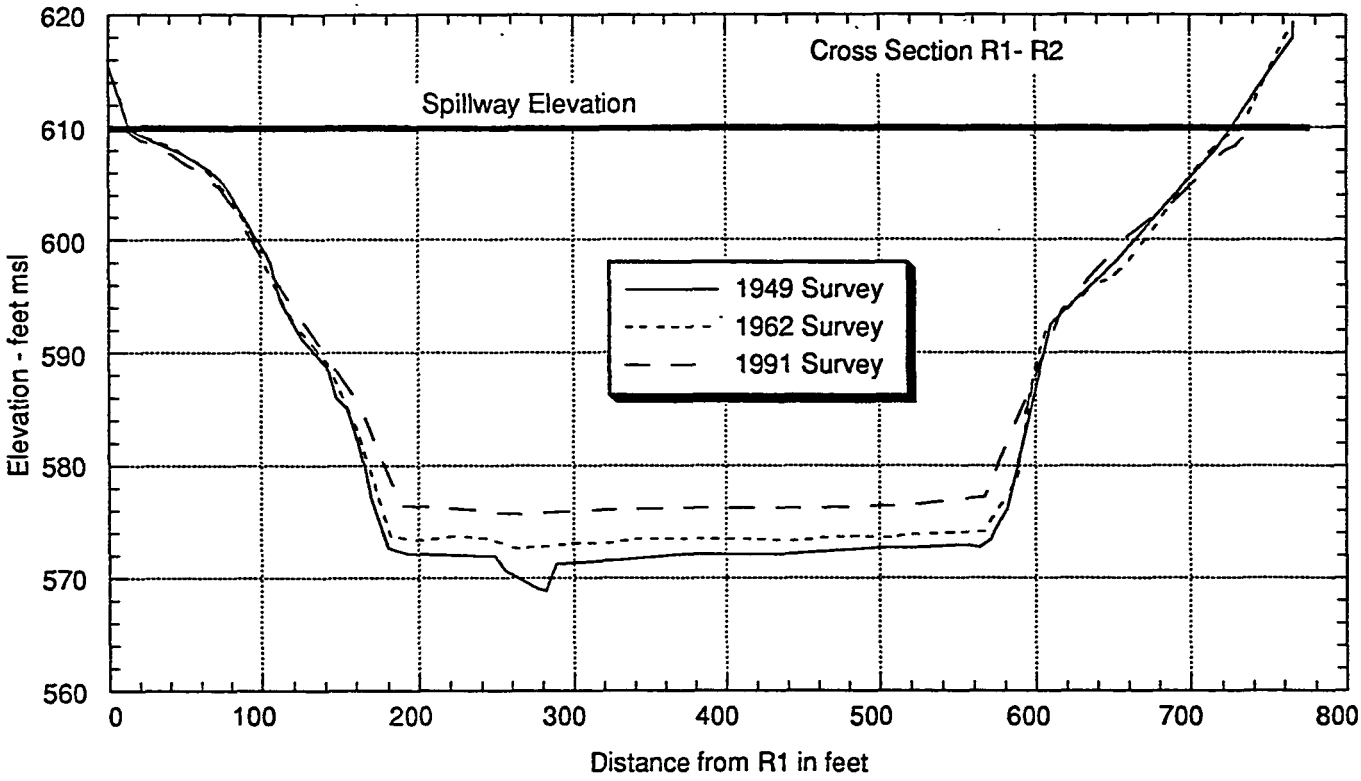
U.S. Department of Agriculture, Soil Conservation Service. 1968. *National Engineering Handbook,* Section 3, "Sedimentation", chapters 1, 2, and 7.

Appendix I:
Cross-sectional Plots of Survey Range Lines for Argyle Lake


Cross Section R1- R2
Spillway Elevation
1949 Survey
1962 Survey
1991 Survey
Elevation - feet msl
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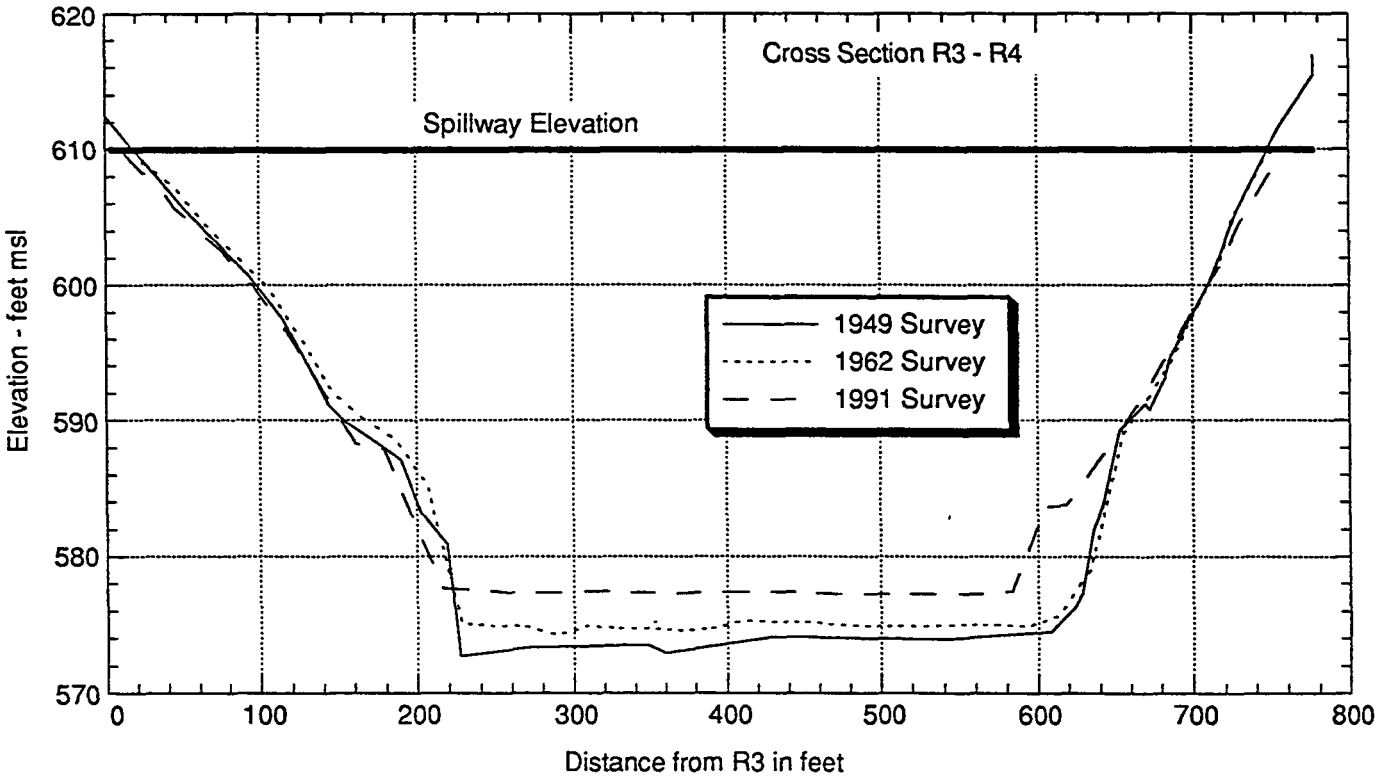
610
600
590
580
570
560
0
100
200
300
400
500
600
700
800
Distance from R1 in feet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Spillway Elevation
1949 Survey
1962 Survey
1991 Survey
Elevation - feet msl
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580
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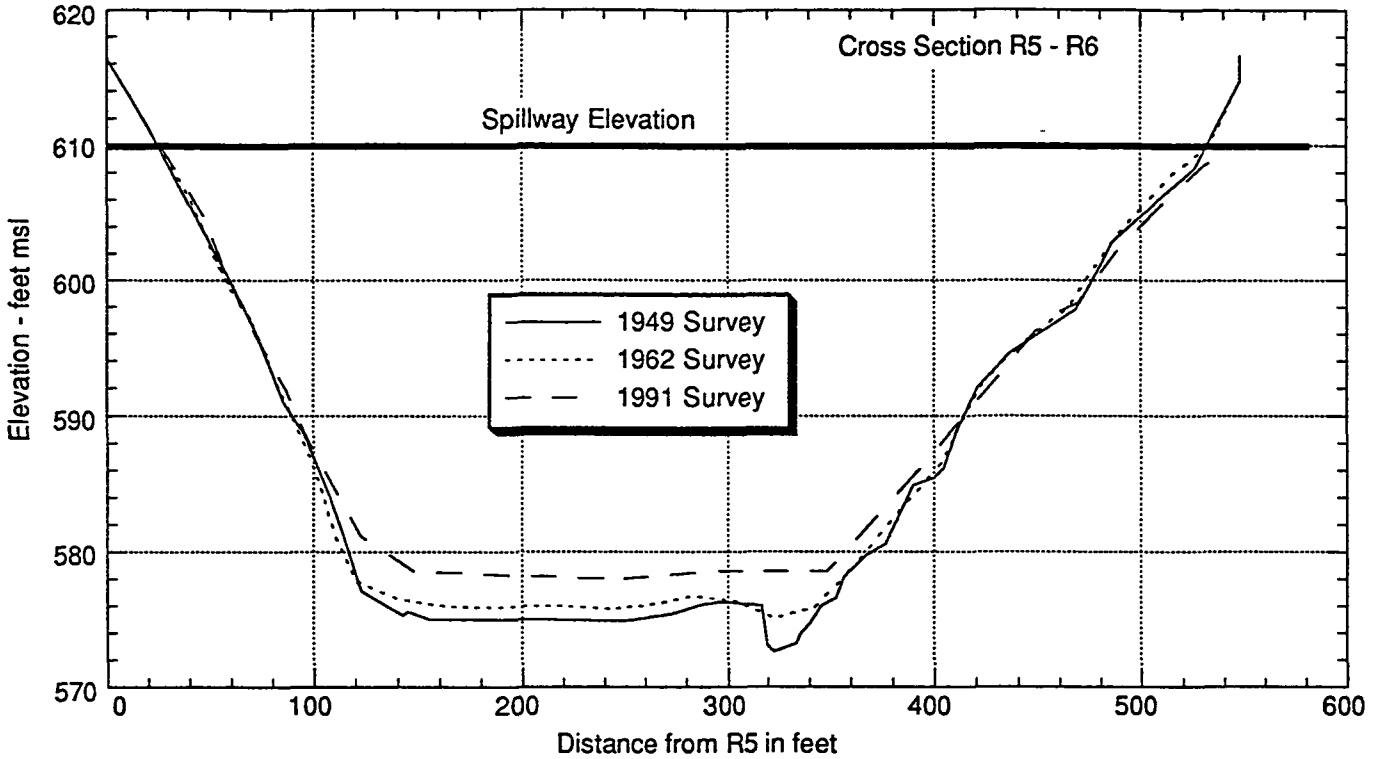
200
300
400
500
600
700
800
Distance from R3 in feet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Spillway Elevation
1949 Survey
1962 Survey
1991 Survey
Elevation - feet msl
Distance from R5 in feet
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200
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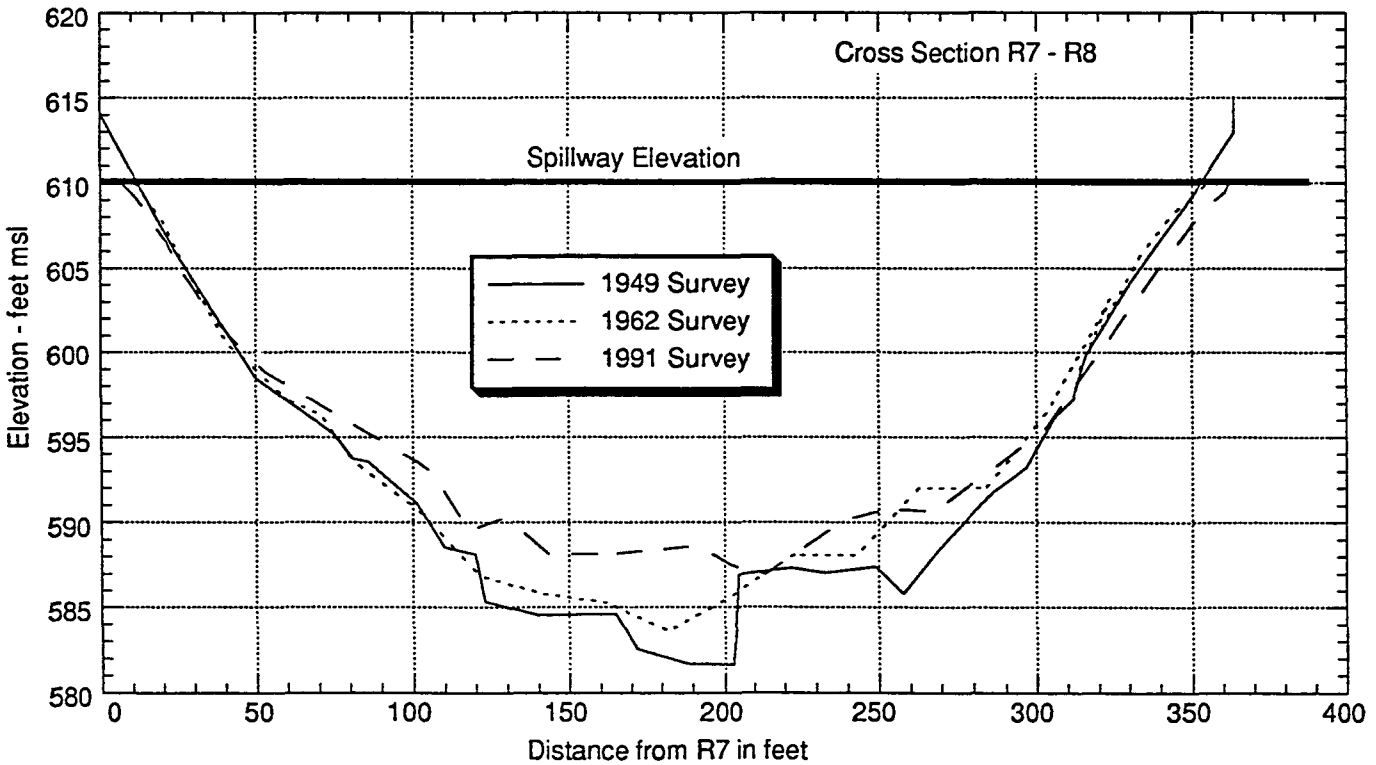
400
500
600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Spillway Elevation
1949 Survey
1962 Survey
1991 Survey
Elevation - feet msl
Distance from R7 in feet
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350
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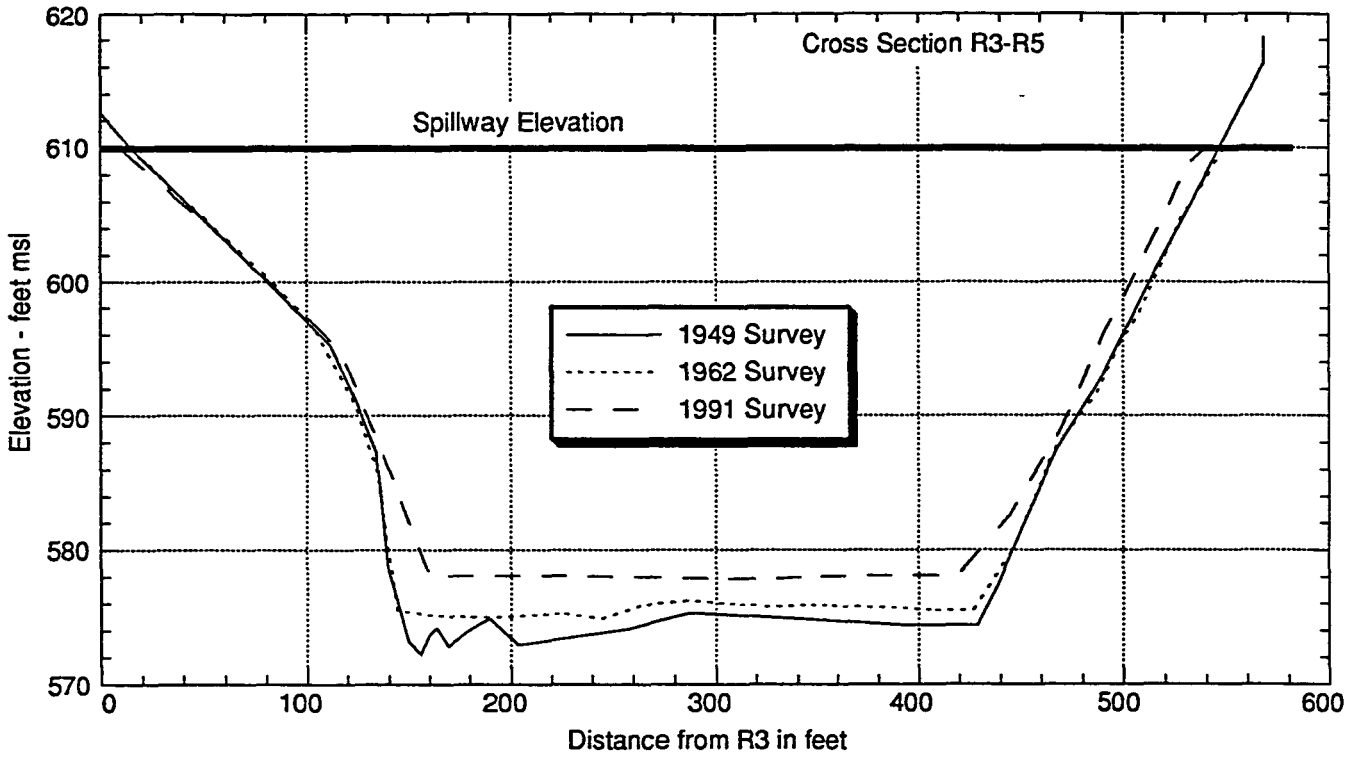
Cross Section R3-R5
Spillway Elevation
1949 Survey
1962 Survey
1991 Survey
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300
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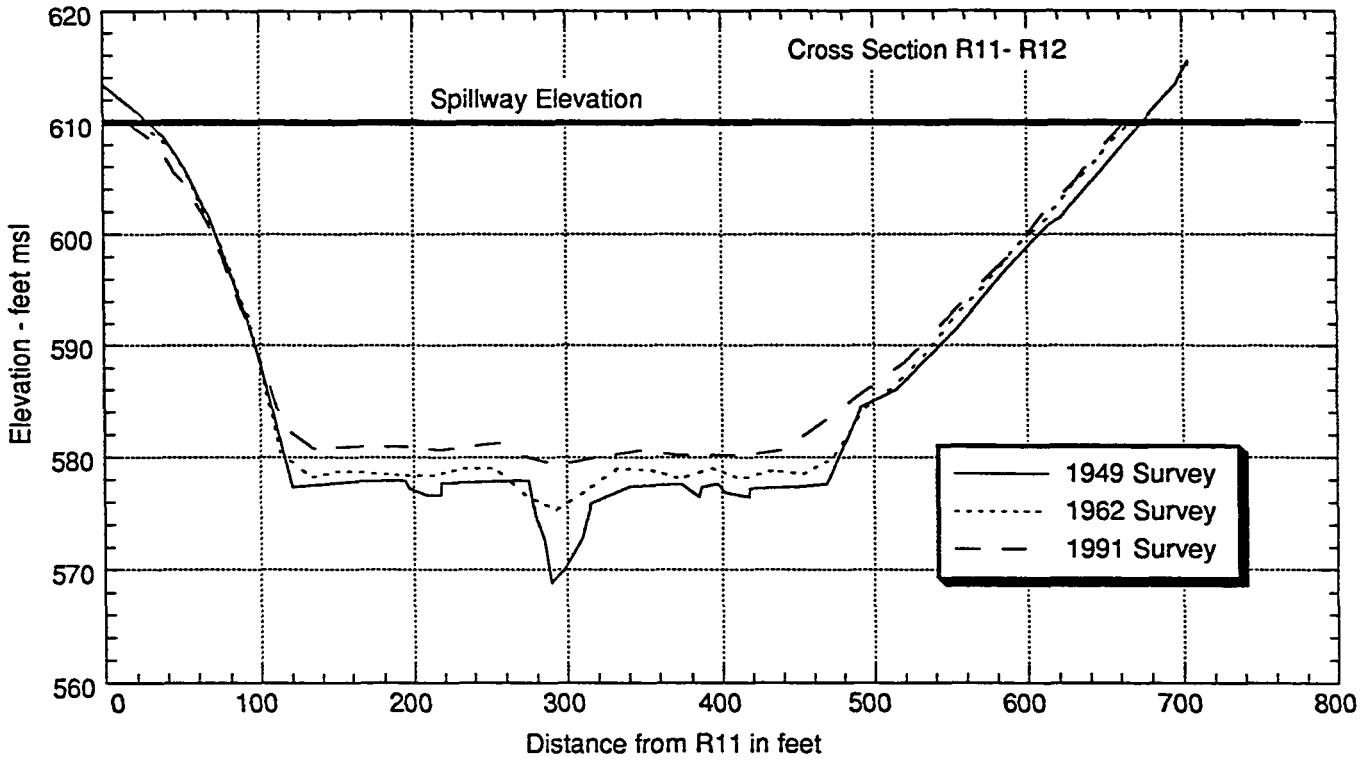
500
600
Distance from R3 in feet


Cross Section R11- R12
Spillway Elevation
1949 Survey
1962 Survey
1991 Survey
Elevation - feet msl
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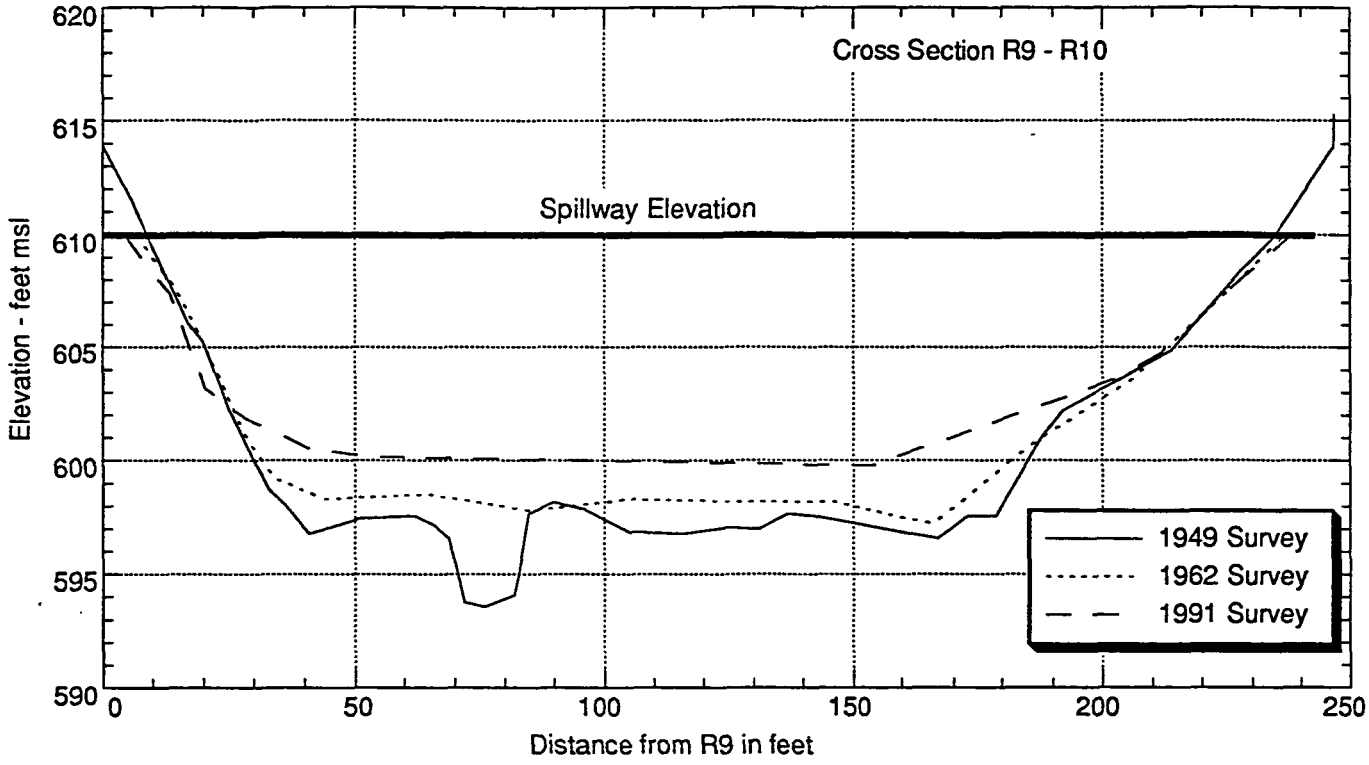
100
200
300
400
500
600
700
800
Distance from R11 in feet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Spillway Elevation
Elevation - feet msl
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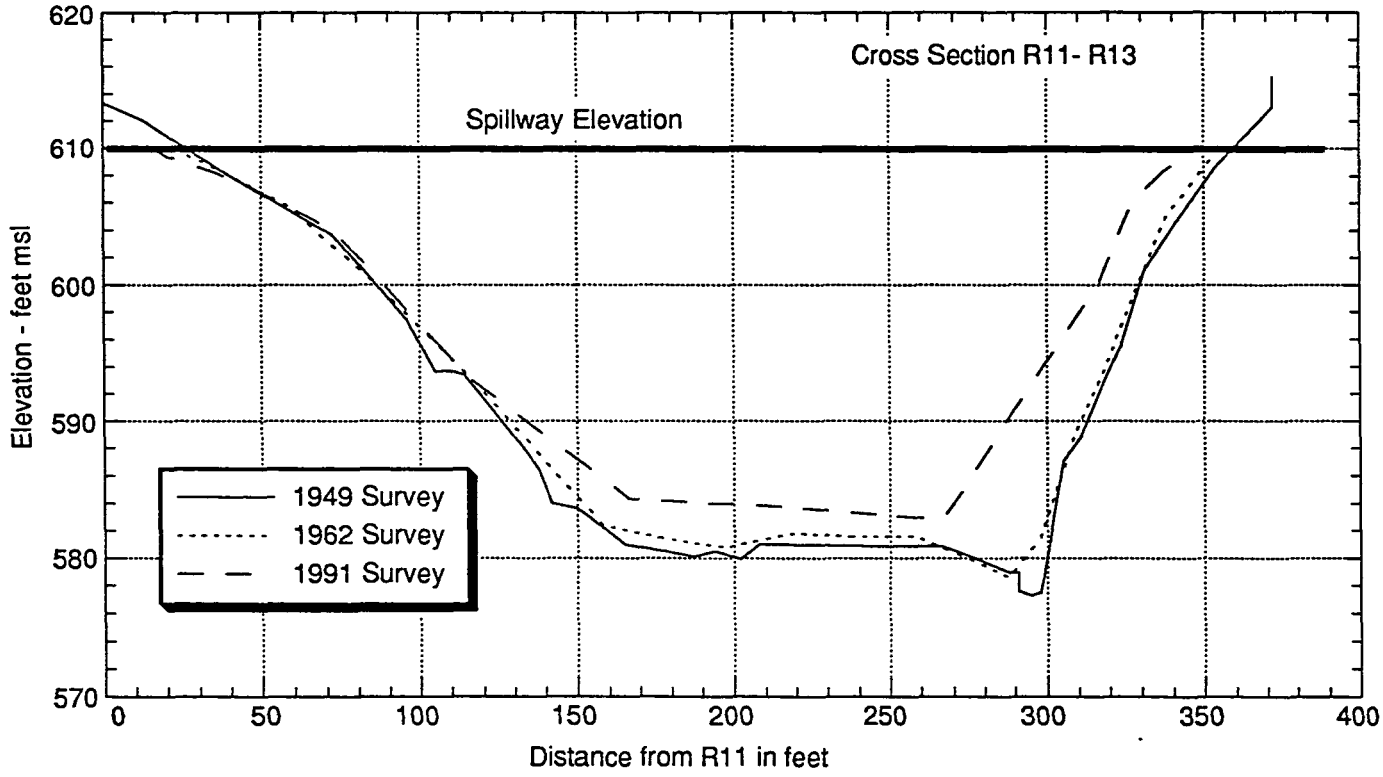
Distance from R9 in feet
1949 Survey
1962 Survey
1991 Survey


Cross Section R11- R13
Spillway Elevation
Elevation - feet msl
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100
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200
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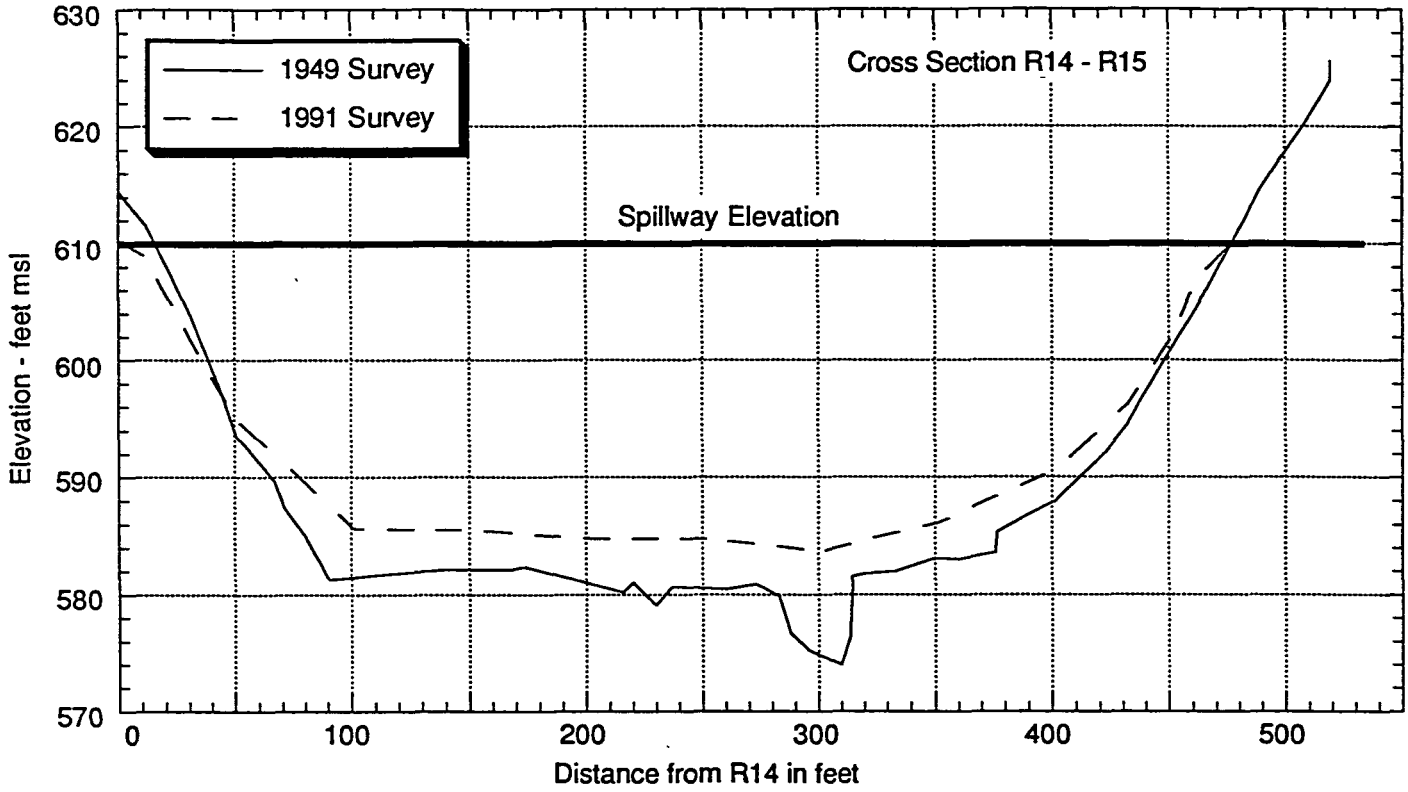
350
400
Distance from R11 in feet
1949 Survey
1962 Survey
1991 Survey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1991 Survey
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580
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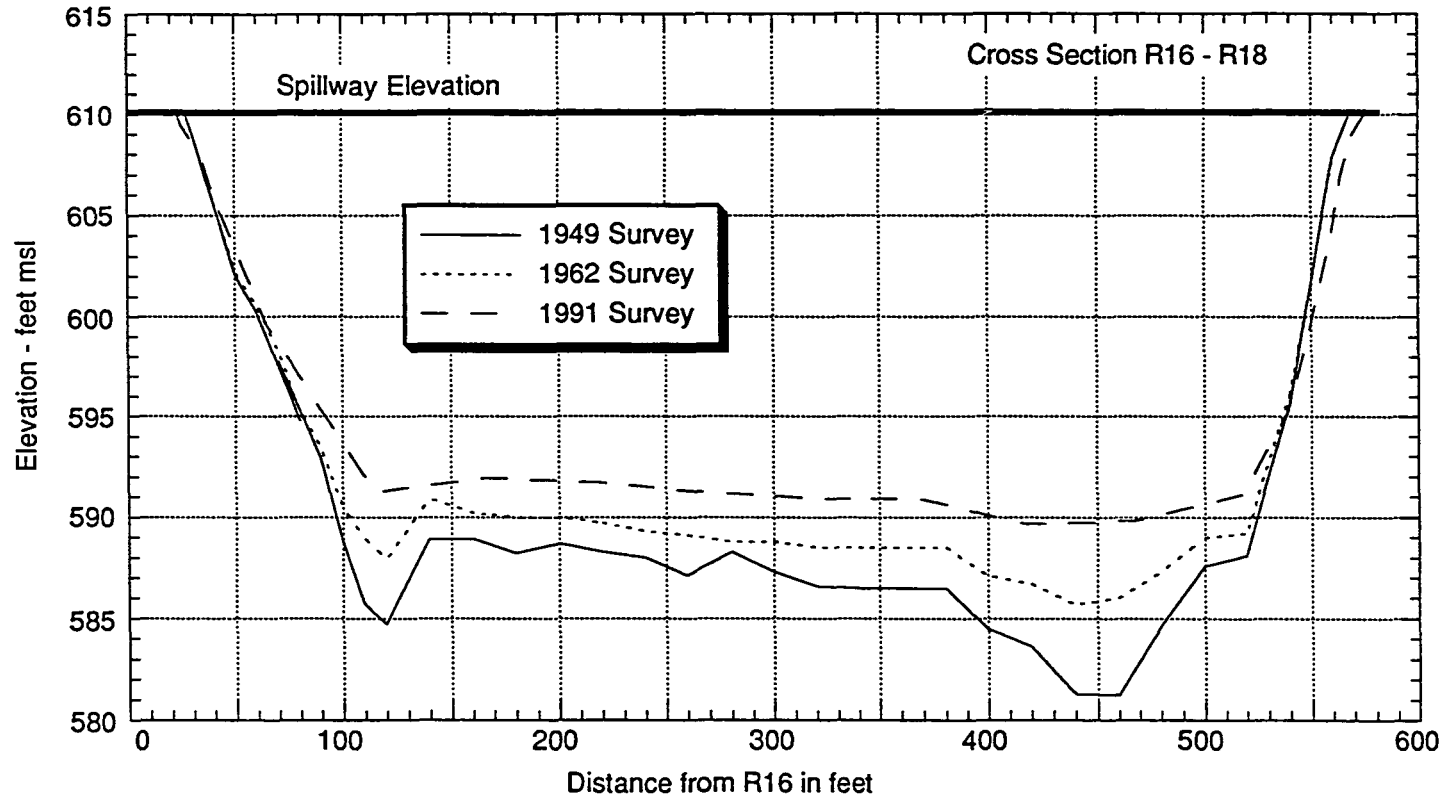
400
500
Distance from R14 in feet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1949 Survey
1962 Survey
1991 Survey
Elevation - feet msl
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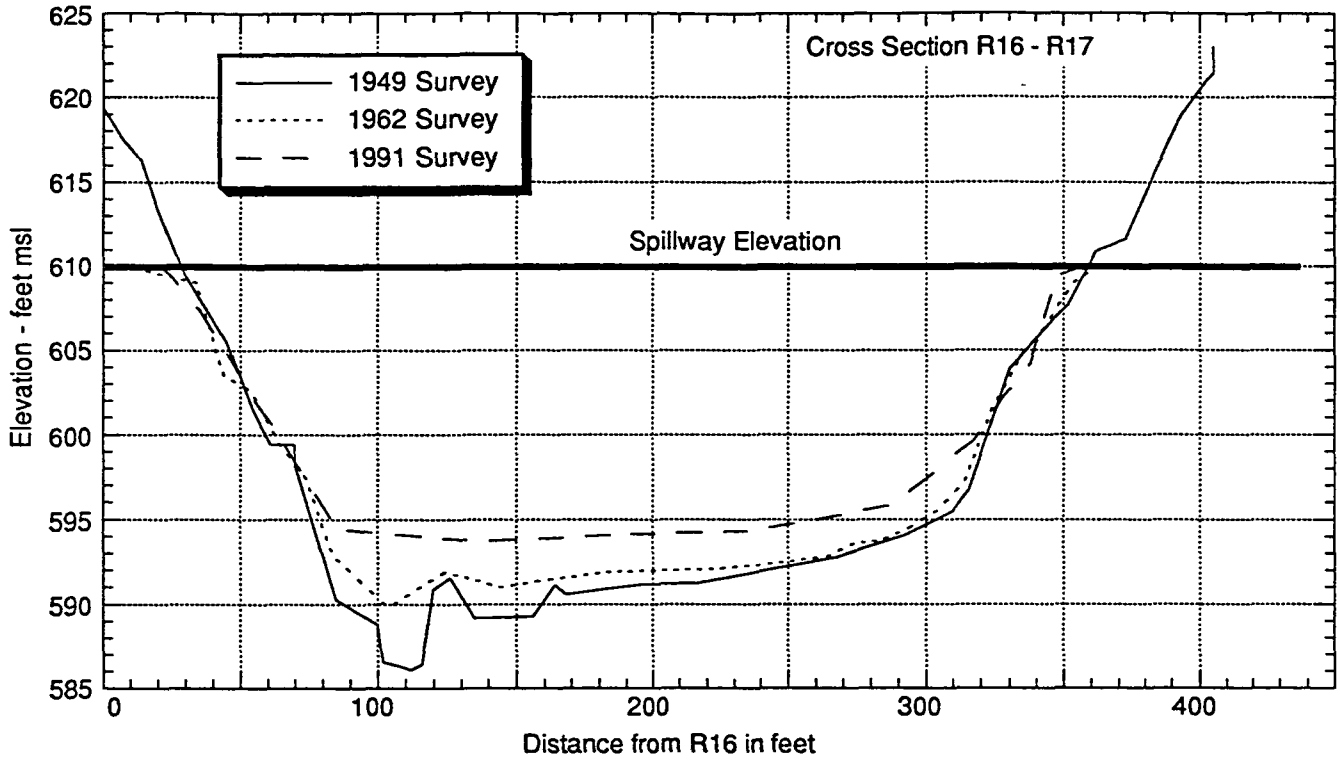
500
600
Distance from R16 in feet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1962 Survey
1991 Survey
Spillway Elevation
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610
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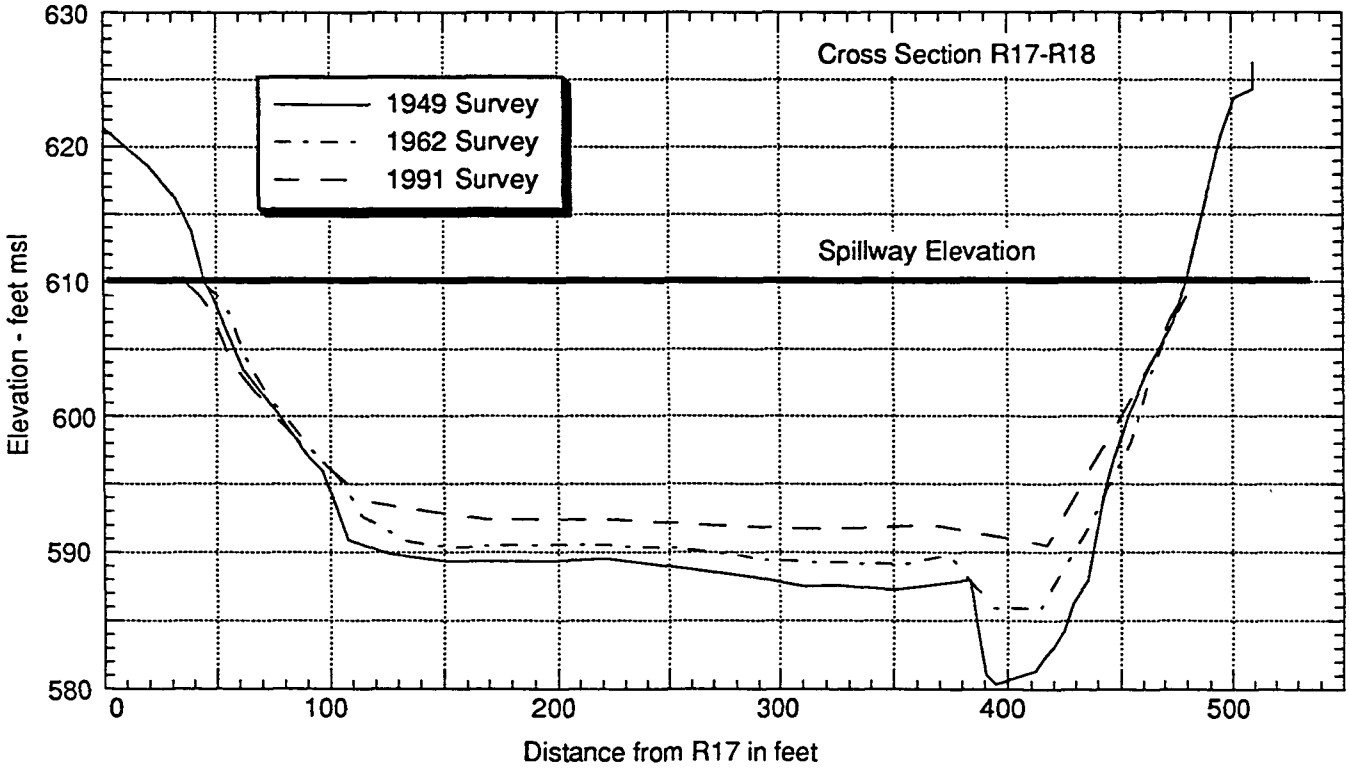
Distance from R16 in feet


Cross Section R17-R18
1949 Survey
1962 Survey
1991 Survey
Spillway Elevation
Elevation - feet msl
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590
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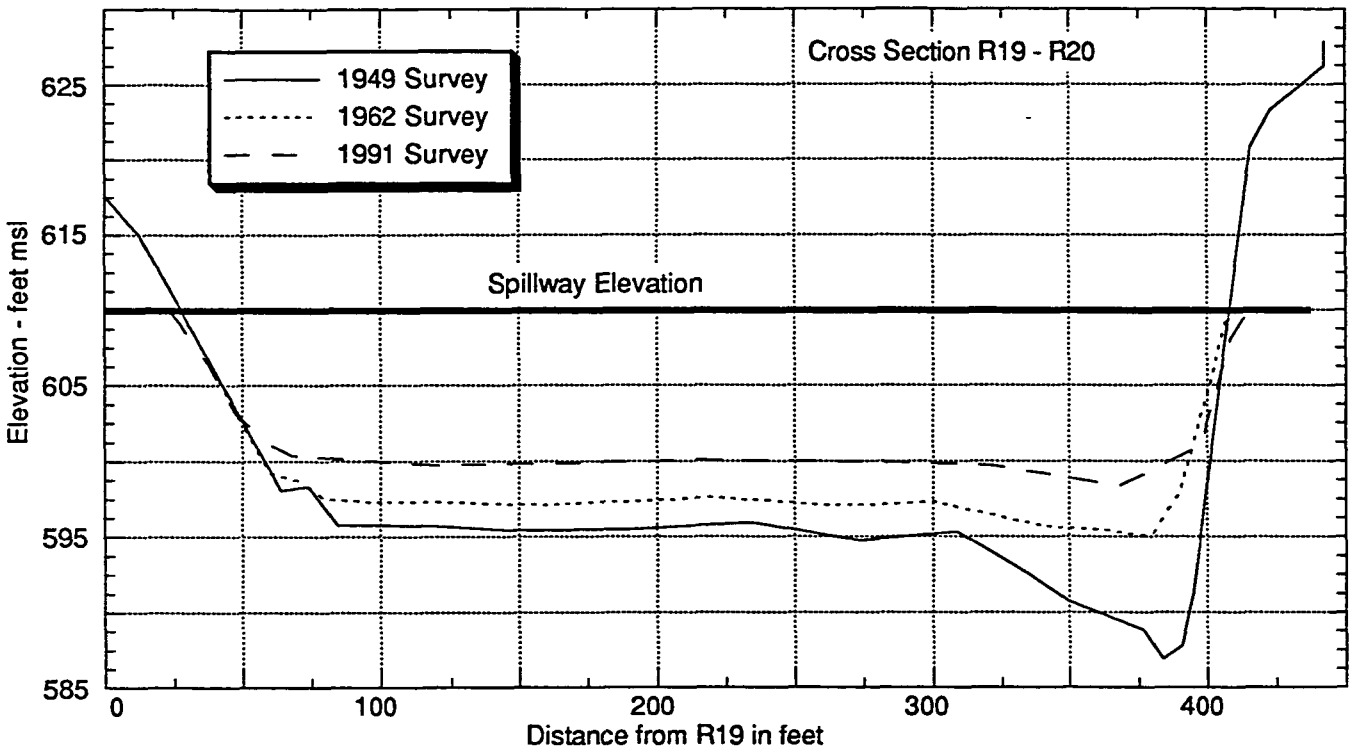
0
100
200
300
400
500
Distance from R17 in feet


Cross Section R19 - R20
1949 Survey
1962 Survey
1991 Survey
Spillway Elevation
Elevation - feet msl
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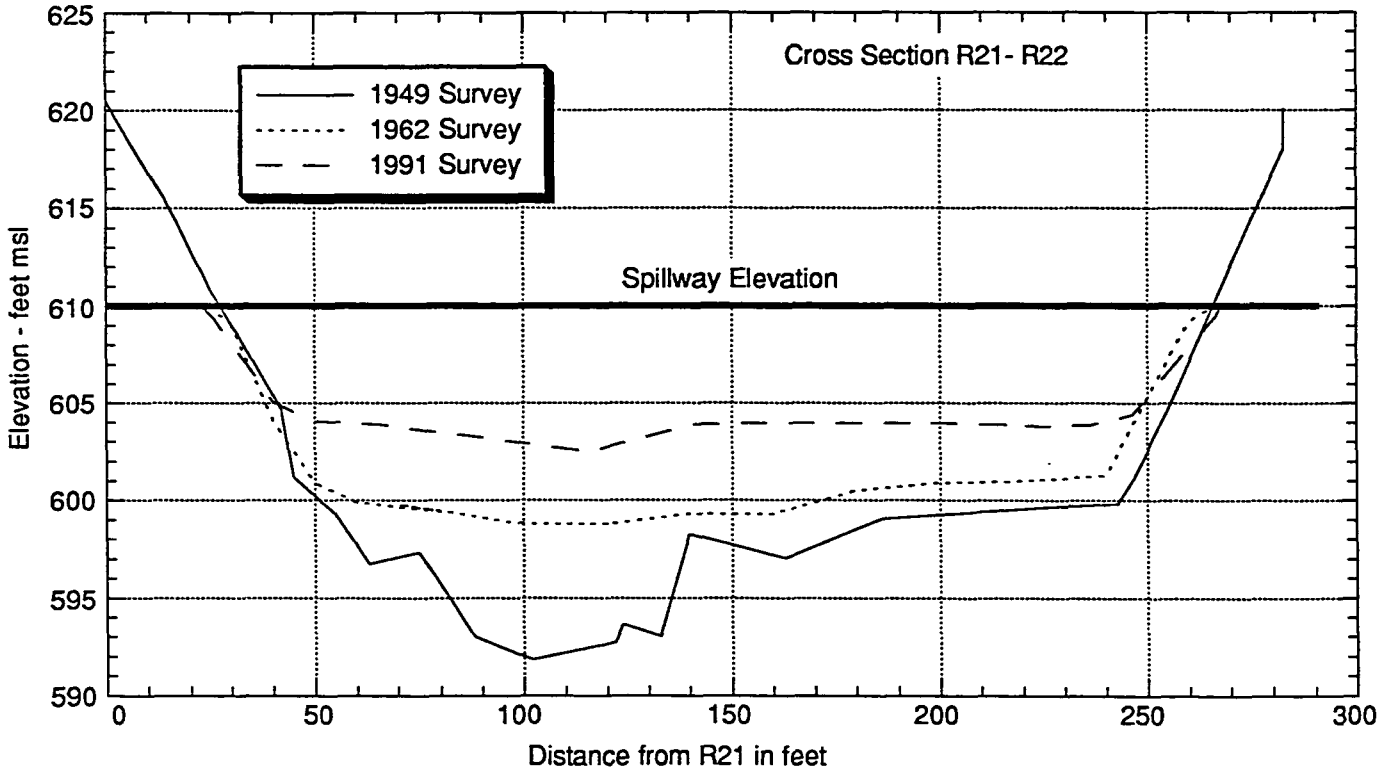
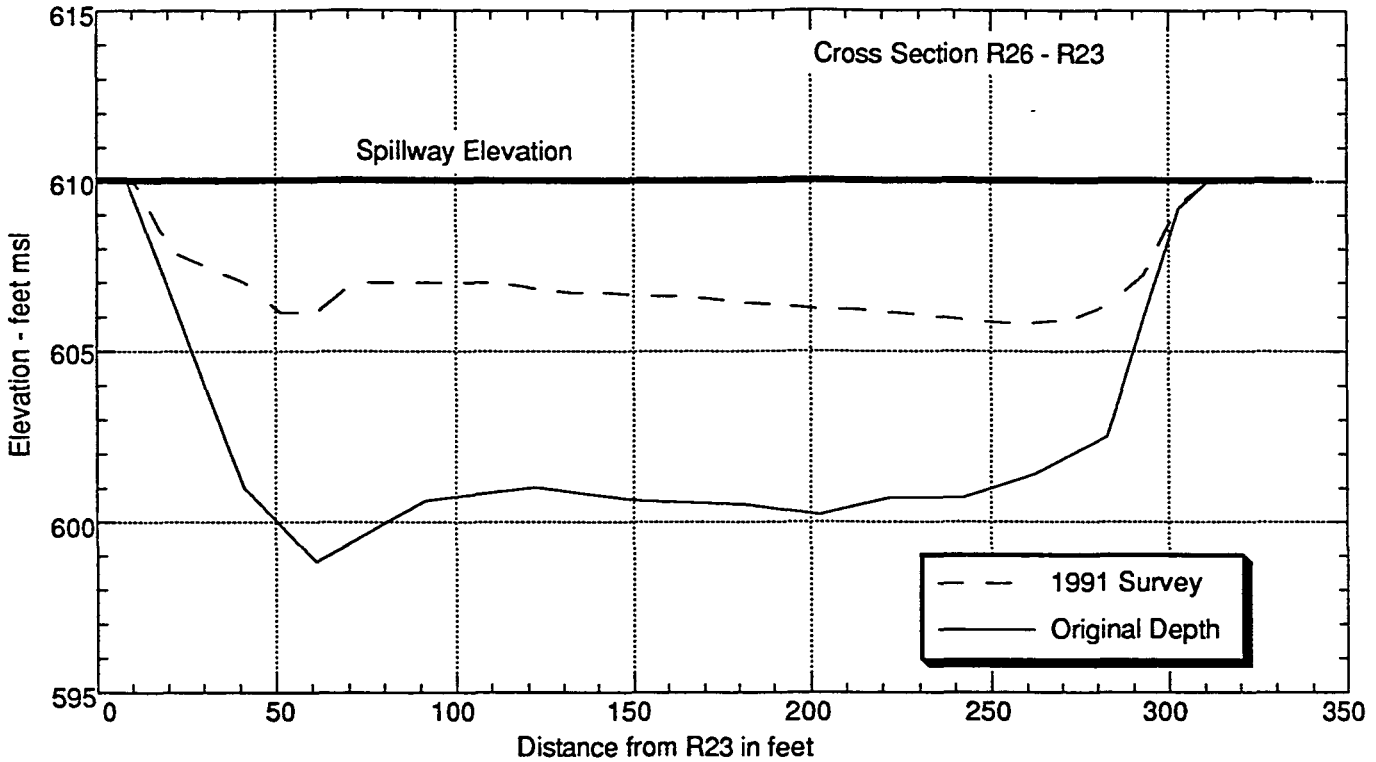
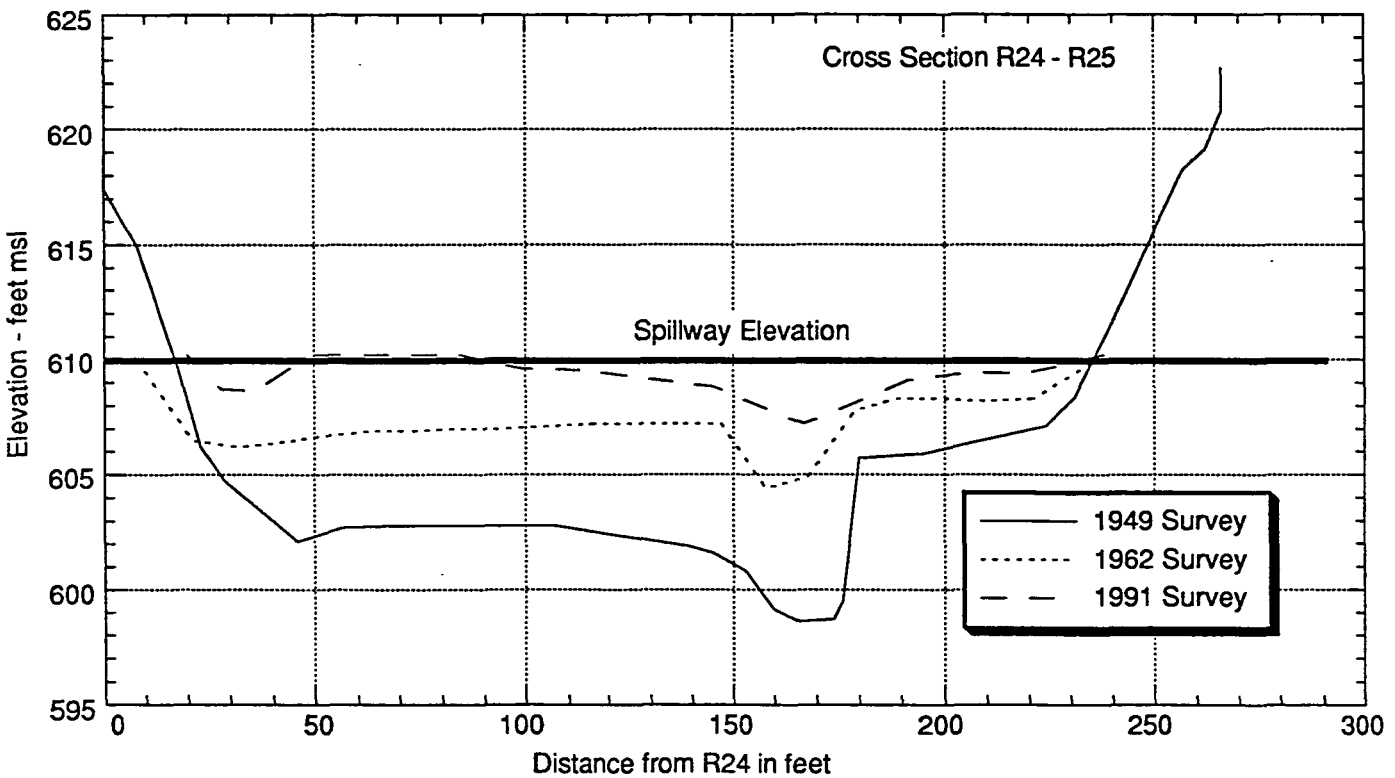
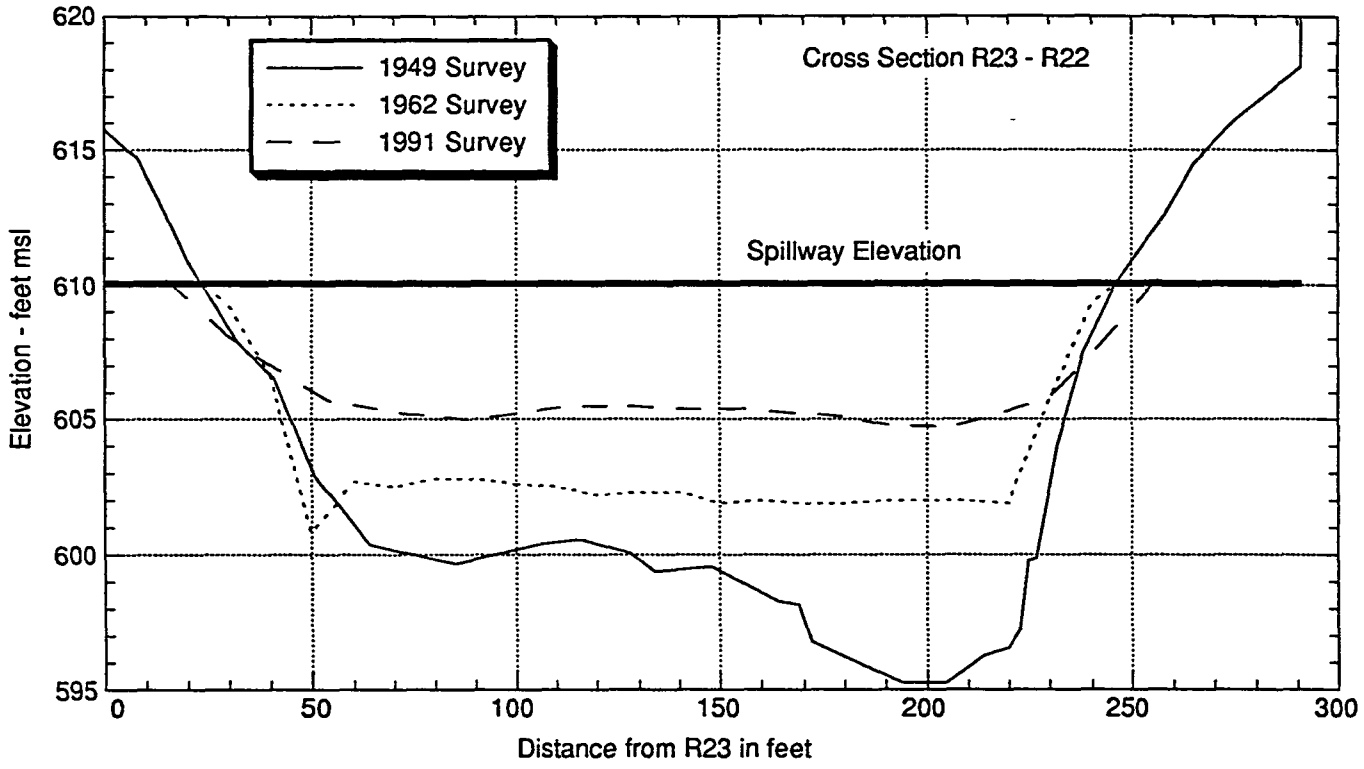
615
605
595
585
0
100
200
300
400
Distance from R19 in feet


Cross Section R21- R22
1949 Survey
1962 Survey
1991 Survey
Spillway Elevation
Elevation - feet msl
625
620
615
610
605
600
595
590
0
50
100
150
200
250
300
Distance from R21 in feet


Cross Section R26 - R23
Spillway Elevation
Elevation - feet msl
615
610
605
600
595
0
50
100
150
200
250
300
350
Distance from R23 in feet
1991 Survey
Original Depth


Cross Section R24 - R25
Spillway Elevation
Elevation - feet msl
625
620
615
610
605
600
595
0
50
100
150
200
250
300
Distance from R24 in feet
1949 Survey
1962 Survey
1991 Survey


Cross Section R23 - R22
1949 Survey
1962 Survey
1991 Survey
Spillway Elevation
Elevation - feet msl
Distance from R23 in feet
620
615
610
605
600
595
0
50
100
150
200
250
300

Appendix II. Particle Size and Unit Weight Analysis: Results of 1991 Survey of Argyle Lake

Range line	*Sample mdpt below lakebed (ft)*	*Sand (percent)*	*Silt (percent)*	*Clay (percent)*	*Density (Ibs/cuft)*
R3-R4	0.05	0.1	15.5	84.4	
	0.85				25.99
	1.05	0.0	25.6	74.3	
	1.95				39.44
R9-R10	0.45	0.5	64.7	34.7	
	0.65				50.91
	1.15				51.34
	1.35	0.3	56.0	43.7	
	1.95	0.2	65.2	34.6	
	2.15				51.98
R11-R12	0.05	0.1	27.6	72.3	
	0.95	0.1	33.9	66.0	
	1.15				25.29
	1.85				43.13
	2.05	0.1	28.2	71.6	
	2.25				30.06
R16-R18	0.05	0.1	44.1	55.8	
	0.85	3.6	60.1	36.3	
	1.05				40.79
	1.55				45.39
	1.75	0.1	35.5	64.4	
R19-R20	0.15	0.2	61.0	38.8	
	0.45				55.09
	0.95				68.94
	1.75				54.59
	1.85	1.2	57.2	41.6	
R21-R22	0.05		4.0	67.6	28.4
	0.45				58.54
	0.75				39.49
R22-R23	0.05	2.5	65.9	31.7	
R24-R25	0.05	1.6	73.3	25.1	
	0.65				58.05
	0.85	0.9	80.7	18.4	
	1.05				71.94
	1.65	2.4	73.9	23.6	
	1.85				70.01