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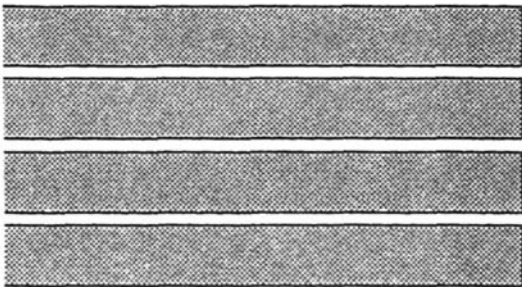
Report 563

Lake Sedimentation Survey of Lake Pittsfield, Pike County, Illinois

by Richard L. Allgie
Office of Sediment & Wetland Studies

Prepared for the
City of Pittsfield

December 1993



Illinois State Water Survey
Hydrology Division
Champaign, Illinois

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**LAKE SEDIMENTATION SURVEY OF LAKE PITTSFIELD,
PIKE COUNTY, ILLINOIS**

by

Richard L. Allgire
Office of Sediment & Wetland Studies

SWS Allgire, Richard L.
CR-563 LAKE SEDIMENTATION
SURVEY OF LAKE
PITTSFIELD, PIKE
COUNTY ILLINOIS

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LAKE SEDIMENTATION SURVEY OF LAKE PITTSFIELD, PIKE COUNTY, ILLINOIS

by
Richard L. Allgire

INTRODUCTION

The Illinois State Water Survey (ISWS) in cooperation with the city of Pittsfield conducted a lake sedimentation survey of Lake Pittsfield in October 1992. This report presents the results of that survey and compares them to previous lake sedimentation surveys conducted by Benton & Associates Consulting Engineers in 1974, by the ISWS assisted by Benton & Associates in 1979, and by the ISWS in 1985.

Reservoir Description

Lake Pittsfield is located in Pike County approximately 3 miles northeast of Pittsfield, Illinois (figure 1). Lake Pittsfield dam is located in the northeast quarter of Section 16, Township 5 N, Range 3 W.

Blue Creek, a tributary to the Illinois River, was dammed to form the lake in 1961. The lake has a total watershed area of 11.15 square miles (7,136 acres) and a net sediment contributing area of 10.74 square miles or 6,874 acres (Bogner, 1986). The average annual precipitation (1951-1980) was 36.51 inches (at Griggsville). The average annual runoff (1940-1991) was 8.98 inches at Bay Creek at Pittsfield (Maurer et al. 1992), and the average annual lake evaporation rate was 35 inches (Roberts and Stall, 1967).

The lake was built to provide a water supply for the city of Pittsfield after the original water-supply lake built in 1925 proved inadequate during droughts. The lake is also used extensively for recreational fishing, boating, picnicking, and camping.

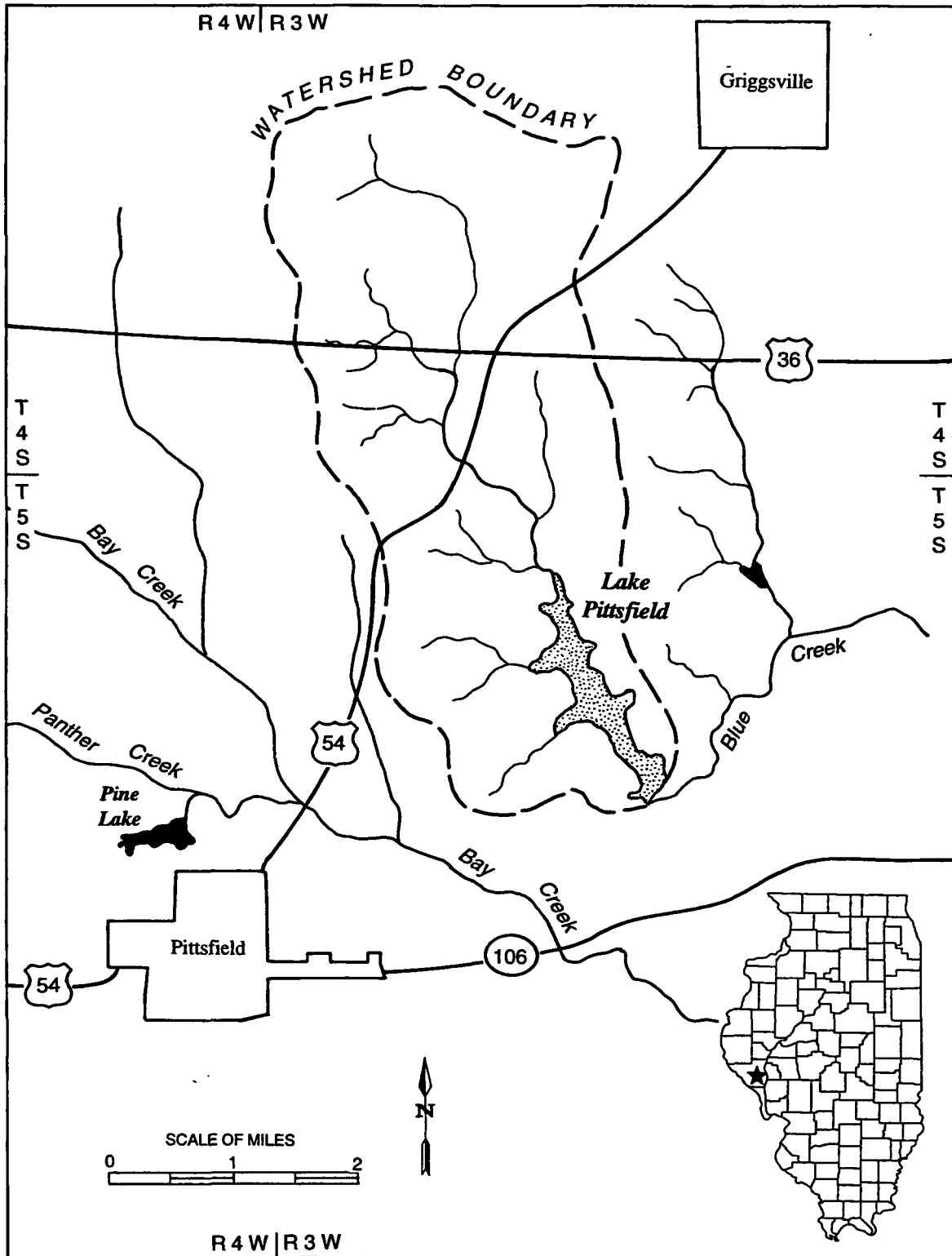


Figure 1. Location of Lake Pittsfield and its watershed

LAKE SEDIMENTATION SURVEY

Lakes act as sediment traps, collecting sediment carried by streams as they flow into the lake. As sediment deposition occurs in a lake, its depth and area gradually change. These changes can have a profound effect on the performance of the lake for its intended use. As a lake traps silt, lake size and volume diminish. These changes can affect water depth, temperature, and quality, which in turn can stress the aquatic biota leading to degradation of lake fisheries and cause undesirable growth and species composition in the aquatic vegetation.

The effects of sedimentation can be of particular importance on lakes that are vital for a community's public water supply. As lake size and volume diminish, the adequacy of a lake to fulfill the needs of a growing community are also affected. Lake sedimentation surveys are a useful tool to help lake managers identify potential threats to the future water-supply needs of their communities.

The purpose of conducting a lake sedimentation survey is to determine: 1) the present lake volume, 2) the volume and mass of sediment deposited in a lake, 3) the stage-volume relationship within a lake, and 4) if there have been prior sedimentation surveys, to document the changes in the sedimentation rate over time.

Lake Pittsfield has been surveyed four times since its construction in 1961. Table 1 summarizes the sedimentation survey history of Lake Pittsfield.

Table 1. Summary of Sedimentation Surveys for Lake Pittsfield

<i>Date surveyed</i>	<i>Lake age (years)</i>	<i>Surveyed by</i>
May 1961	0	Lake constructed - no survey
December 1974	13.5	Benton & Associates Consulting Eng.
August 1979	18.3	ISWS supervised Benton & Associates field crew, and prepared calculations
August 1985	24.3	ISWS
October 1992	31.5	ISWS

Surveying Techniques

The lake was divided into 18 lake segments for the 1974 survey by establishing 17 cross-section or range lines (figure 2). The location of each end of the cross-section lines was marked by iron rods or posts. For the three subsequent surveys, if cross-

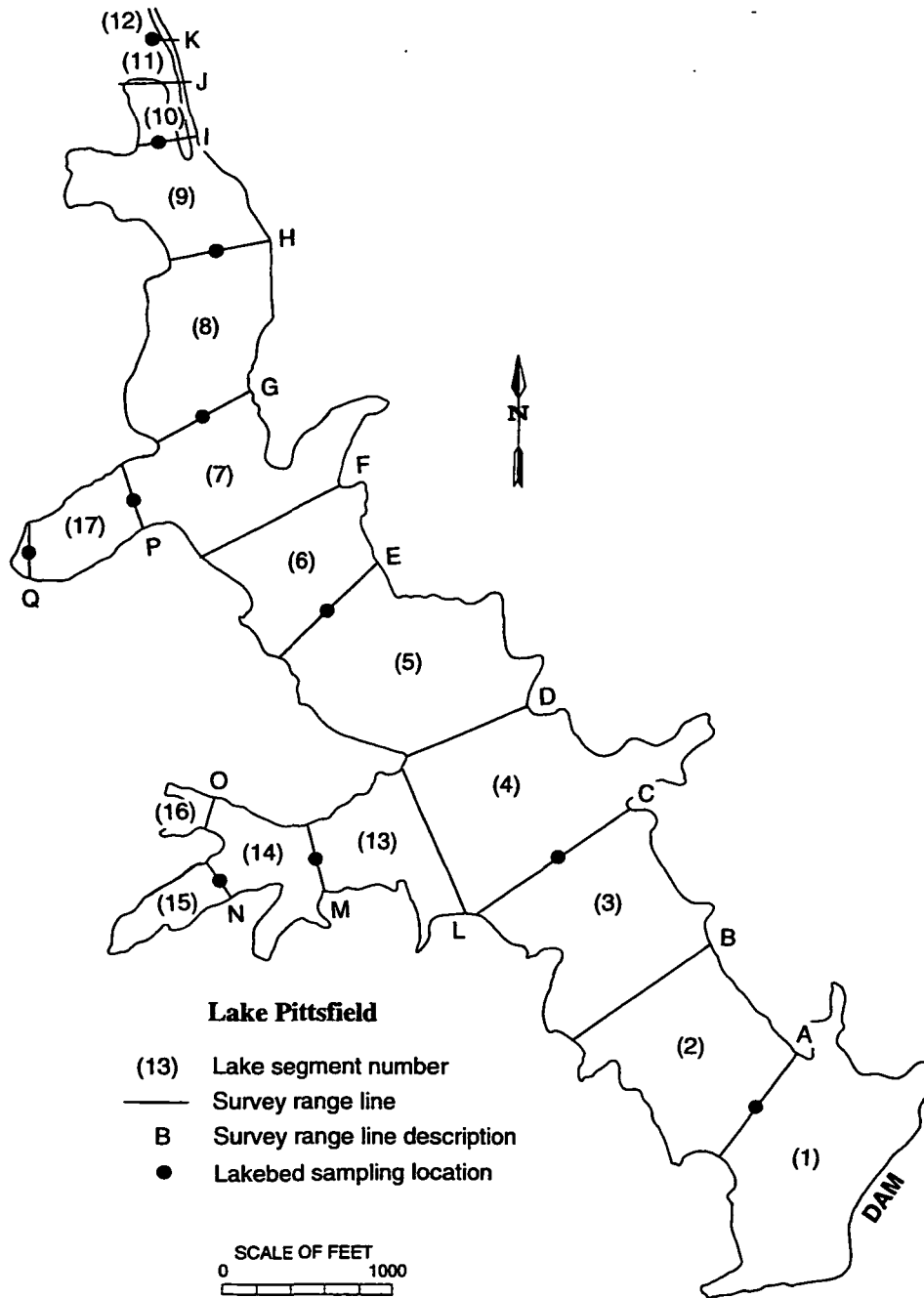


Figure 2. Lake Pittsfield lake segment numbers, survey range lines, and lakebed sampling locations

section end monuments could not be relocated, new iron rods or posts were placed as close to the original location as possible. For the 1985 survey the ends of all the cross-section lines (except for line K) were replaced with concrete survey monuments.

The survey was made by stretching a marked polypropylene cable between the two survey monuments to measure linear distance along the survey line. The water depth relative to the spillway crest elevation (596 feet mean sea level or msl) was measured at 25-foot intervals along the cross-section lines by 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 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. To ensure accuracy, the 1992 sediment thickness data were double-checked against the 1974, 1979, and 1985 survey data.

All of the lake surveys used the same general surveying techniques with the exception of transect K in the extreme upper end of the lake. Transect K had not been surveyed during any of the previous lake surveys. All of the volume calculations for transect K were estimated by using a 1961 transect profile created for the 1985 survey report. Plots for all of the survey lines comparing the 1961, 1974, 1979, 1985, and 1992 bed profiles are shown in Appendix I.

In addition to the range line soundings, 26 sonar transects were run using a sonar depth sounder. The sonar transects were run as a control check between discrete sounding pole locations and to assist in contouring the lakebed between the surveyed range lines.

Sediment Sample Collection

During the 1992 survey, lakebed sediment samples were collected at eleven locations throughout the lake (figure 2) and analyzed for unit weight. The sampling locations provided representative samples of the lakebed sediments from different regions of the lake.

The lakebed samples were collected with a 3-foot-long, 2-inch-diameter piston-type core sampler. The cores were placed on a sample board to record physical descriptions and length. Based on field observations, one to three subsamples were cut from the core and sent to the laboratory for unit weight analysis.

LAKE SEDIMENTATION ANALYSIS

Lake sedimentation rates can be expressed as the sediment volume or 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 comparison of sedimentation rates between lakes and sediment yields from different watersheds.

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, 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 of sediment in the lake.

Volume Analysis

The lake volumes for the three previous surveys and the 1961 original lake volume were recalculated when the 1992 lake volume was calculated. The earlier surveys were recalculated to maintain consistency in the analysis of the data. The recalculation resulted in approximately a 2 percent increase in the 1974 lake volume and a reduction of less than 0.5 percent in the 1961 original volume from the 1985 calculations.

The cross-section line data from each of the four surveys were used to calculate the areas for each survey line for individual survey years. The cross-sectional areas for each survey were then combined with the surface areas of the lake segments to determine the water and sediment volumes in the lake for each survey. This procedure was developed by the U.S. Soil Conservation Service and described in detail in their *National Engineering Handbook* (U.S. Department of Agriculture, Soil Conservation Service, 1968).

Typically, lake and sediment volumes are described in quantities of acre-feet. However, for water-supply analysis, volumes in million gallons (MG) are often more useful. Since Lake Pittsfield is a water-supply reservoir, this unit of measurement has been included.

Table 2 summarizes the lake volumes, sediment volumes, and the percent of the original lake volume lost to sedimentation for the four surveys.

Table 2. Summary of Lake Volumes, Sediment Volumes, and Percent of Original Lake Volume Lost to Sedimentation

<i>Year of survey</i>	<i>Lake age (years)</i>	<i>Lake volume</i>		<i>Sediment volume</i>		<i>Original volume loss (percent)</i>
		<i>(acre-feet)</i>	<i>(MG)</i>	<i>(acre-feet)</i>	<i>(MG)</i>	
1961		3563	1161			
1974	13.5	3069	1000	494	161	13.9
1979	18.3	2865	933	697	227	19.6
1985	24.3	2760	899	803	262	22.5
1992	31.5	2679	873	884	288	24.8

As seen in table 2, Lake Pittsfield had an original lake volume of 3,563 acre-feet (1,161 MG). Sedimentation has reduced the 1992 lake volume to 2,679 acre-feet (873 MG). Therefore, the sediment deposition for the period 1961 - 1992 was 884 acre-feet (288 MG), which represents 24.8 percent or nearly one-fourth of the original lake volume has been lost to sediment.

The original lake volume that is lost to sediment deposition is not necessarily consistent throughout the life of a reservoir. Changing land-use conditions in the watershed, long-term precipitation patterns, reservoir water levels, and lake age can influence the percent of volume loss during different time periods. Because Lake Pittsfield has been surveyed four times since its construction, we can quantify this changing rate of volume loss. Table 3 compares the average annual percent of volume loss for each of the four survey time periods with the average annual volume loss rate.

Table 3. Comparison of Percent Volume Loss for Different Survey Periods

<i>Survey period</i>	<i>Years</i>	<i>Lake volume loss (acre-feet)</i>	<i>Lake volume loss (percent)</i>	<i>Average annual volume loss (percent)</i>
1961-1974	13.5	494	13.9	1.03
1974-1979	4.8	204	5.7	1.19
1979-1985	6.0	105	2.9	0.49
1985-1992	7.2	81	2.3	0.32
1961-1992	31.5	884	24.8	0.79

As seen in table 3, Lake Pittsfield has a long-term average annual volume loss rate of 0.79 percent. However, the lake had a high volume loss rate of nearly 1.2 percent annually for the period 1974-1979 compared to a considerably lower volume loss rate of 0.32 percent annually for the period 1985-1992.

Table 4 lists by lake segment the volumes for each of the four surveys, the 1961 original volume, and the percent of original lake segment volume lost to sedimentation in 1992. As seen in the table, segments 11, 12, and 18 have lost more than 95 percent of their original segment volume. Figure 3 illustrates the percent loss of original lake volume by lake segment.

An apparent discrepancy occurs in segments 16-18, which have increased slightly in segment volume. Upon contacting the Pittsfield Water Plant, we learned that due to drought conditions during the late 1980s, Lake Pittsfield had at times fallen below normal pool level. The lake reached a maximum drawdown of nearly two feet below the spillway level in September 1988, exposing the sediments in the shallow areas of the lake. The storage volume in those segments increased slightly due to drying and compaction.

Segments 10-12 and 15 also would have been expected to gain some additional storage volume from this drawdown sediment exposure. However, any benefit of storage volume gained during the drought likely was offset by continued high sediment deposition in these segments.

Stage-Volume Relationship

The sounding pole measurements along the range lines and the supplemental sonar transects were used to create a bathymetric map of the lake (figure 4). The areas and contour elevations from this map were used to develop the stage-volume relationships shown in figure 5. This curve gives the water volume remaining in the lake for any lake level below the spillway crest elevation.

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 sediment volume and average sediment density. The total mass of sediment in the lake is the sum of all the segmental weights.

A total of 22 unit weight samples were collected from 11 sediment cores taken from throughout the lake. All of the cores were taken from near the midpoint of their respective survey lines. The objective was to collect representative samples from

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Table 4. Lake Pittsfield Volumes and Percent Volume Loss by Lake Segments

<i>Lake segment</i>	<i>1961 original volume (acre-ft)</i>	<i>1974 volume (acre-ft)</i>	<i>1979 volume (acre-ft)</i>	<i>1985 volume (acre-ft)</i>	<i>1992 volume (acre-ft)</i>	<i>Volume lost since 1961 (percent)</i>
1	580.9	548.9	524.3	513.2	500.2	13.9
2	472.2	440.9	423.0	415.8	408.6	13.5
3	470.7	433.2	413.7	404.6	398.8	15.3
4	478.6	436.6	407.7	402.1	389.0	18.7
5	354.6	318.2	298.8	296.7	284.5	19.8
6	205.4	180.6	169.3	162.9	159.5	22.3
7	207.9	173.9	158.1	149.7	147.6	29.0
8	154.2	120.4	101.6	89.5	81.2	47.3
9	92.9	63.6	46.1	31.9	25.7	72.3
10	23.4	10.8	7.7	3.7	3.5	85.0
11	12.8	1.5	1.2	0.6	0.5	96.1
12	83.3	4.5	3.2	2.0	1.3	98.4
13	227.7	195.4	183.8	175.5	168.7	25.9
14	101.3	80.7	74.7	67.3	65.3	35.5
15	32.7	20.7	18.4	15.9	15.4	52.9
16	4.	4.2	4.0	3.9	4.1	14.6
17	45.6	33.3	28.5	24.1	24.5	46.3
18	14.0	1.5	1.2	0.6	0.7	95.0
Total	3563	3069	2865	2760	2679	24.8*

*Denotes average percent volume loss for entire lake.

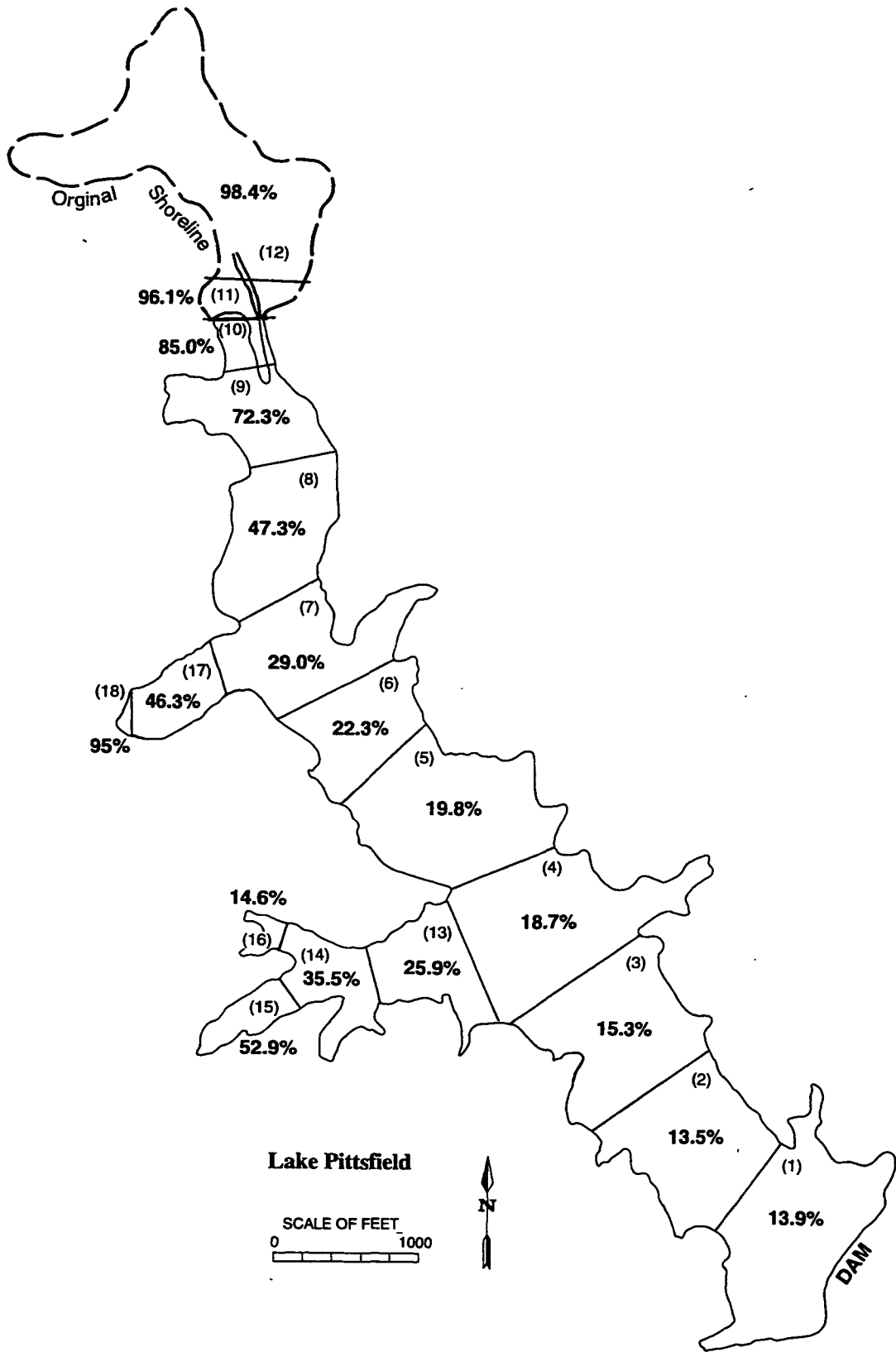


Figure 3. Percent loss of original lake volume by lake segment (number in parentheses) for Lake Pittsfield, 1961-1992

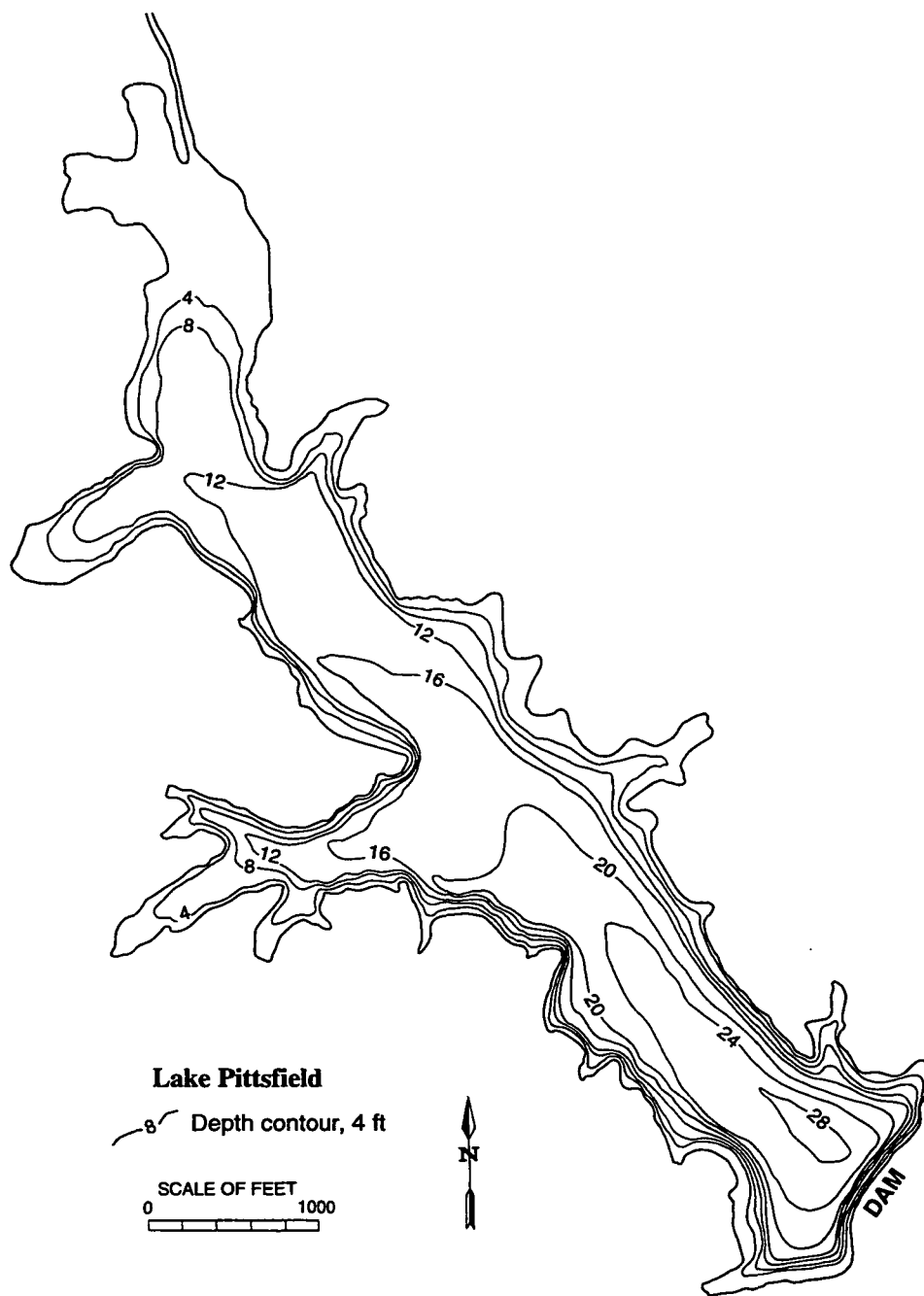


Figure 4. Bathymetric map of Lake Pittsfield

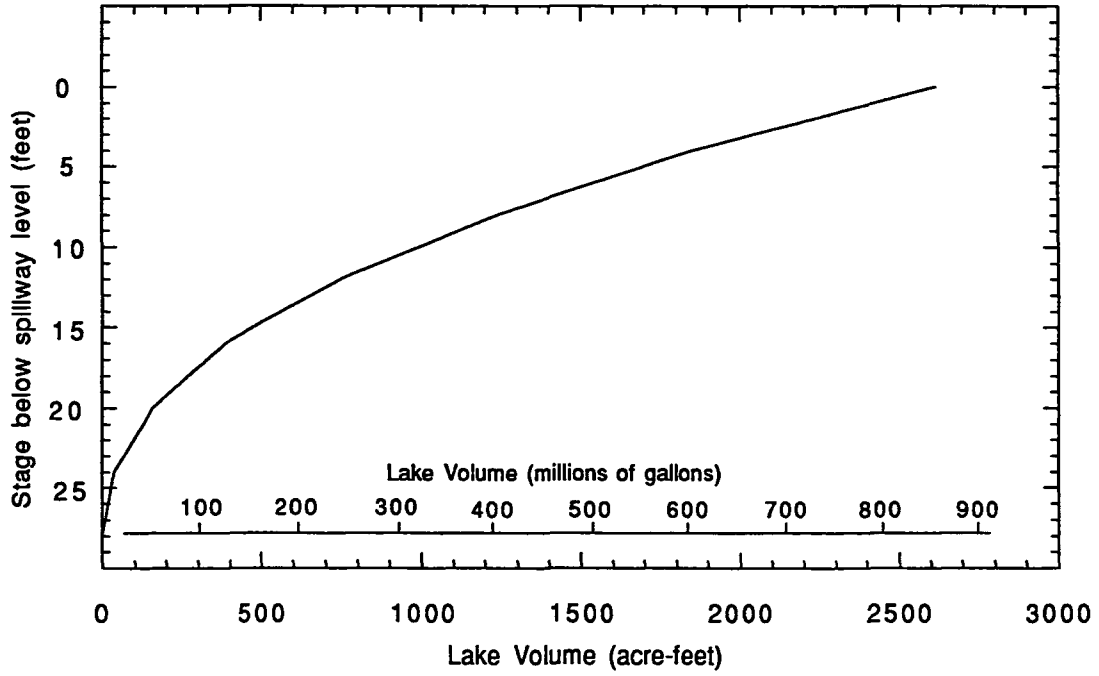


Figure 5. Stage-volume relationship for Lake Pittsfield, 1992

enough locations throughout the lake to enable calculation of the average sediment density for each lake segment. Table 5 summarizes by lake segment the average sediment densities and sediment tonnages for Lake Pittsfield for the 1992 survey.

As shown in table 6, the total mass of sediment in Lake Pittsfield from 1961-1992 was 904,800 tons or an average annual deposition of 28,700 tons. This amounts to an average sediment yield per acre of watershed of 131.6 tons and an average annual sediment yield per acre of watershed of 4.2 tons.

The same circumstances discussed earlier that caused a variable rate of volume loss for different time periods throughout the life of the reservoir also result in a varying mass of sediment deposition. Table 6 also compares the sedimentation rates for each of the four survey time periods with the long-term average.

Table 6. Comparison of Sedimentation Rates (in tons) for Different Survey Periods

<i>Survey period</i>	<i>Sediment deposition (tons)</i>		<i>Sediment deposition per acre of watershed area (tons)</i>	
	<i>Total</i>	<i>Average annual</i>	<i>Average for survey period</i>	<i>Average annual</i>
1961-1974	545,300	40,400	79.3	5.9
1974-1979	190,100	39,600	27.7	5.8
1979-1985	135,600	22,600	19.7	3.3
1985-1992	33,800	4,700	4.9	0.7
1961-1992	904,800	28,700	131.6	4.2

As shown in the table, the average annual rate of sedimentation has varied from a high of 5.9 tons per acre of watershed when the lake was newly constructed to a low of 0.7 tons per acre of watershed for the survey period 1985-1992. The long-term sedimentation rate per acre of watershed for Lake Pittsfield is 131.6 tons or an average annual sediment contribution of 4.2 tons.

There are several possible explanations for the sharp decrease in the sedimentation rate between 1985 and 1992. These include implementation of better land-use practices, a decrease in sediment runoff within the watershed due to drought conditions during the late 1980s, or both.

Table 5. Lake Sediment Volume, Average Sediment Density, and Sediment Tonnage by Lake Segment for 1992

<i>Lake segment</i>	<i>Sediment volume (acre-feet)</i>	<i>Average density (lbs per cubic foot)</i>	<i>Sediment (kilotons)</i>
1	80.7	28.4	49.9
2	63.6	29.7	41.1
3	71.9	33.6	52.6
4	89.6	36.2	70.6
5	70.1	41.4	63.2
6	45.9	43.9	43.9
7	60.3	45.8	60.2
8	73.0	51.3	81.6
9	67.2	65.6	96.0
10	19.9	72.4	31.4
11	12.3	66.4	17.8
12	82.0	66.4	118.6
13	59.0	46.8	60.1
14	36.0	56.1	44.0
15	17.3	65.3	24.6
16	0.7	65.3	1.0
17	21.1	60.3	27.7
18	13.3	70.8	20.5
Totals	884.0	47.0*	904.8

* Denotes average sediment density for entire lake.

SUMMARY

Lake Pittsfield was completed in 1961 as a water-supply source for the city of Pittsfield. The lake was surveyed in 1974, 1979, 1985, and 1992 to determine the changes in the storage volume and sedimentation rate since the previous survey.

The lake had an original volume of 3,563 acre-feet (1,161 MG). The 1992 survey determined the present lake volume to be 2,679 acre-feet (873 MG), representing a total lake volume loss of 24.8 percent or an average annual volume loss of 0.79 percent since the lake was built. The average annual volume loss rate has varied from a high of 1.19 percent (1974-1979) to a low of 0.32 percent (1985-1992).

The 884 acre-feet (288 MG) of sediment that has accumulated in Lake Pittsfield since its construction has an average sediment density of 47 pounds per cubic foot. Therefore, a total of 904,800 tons of sediment have been deposited in the lake for an average annual deposition of 28,700 tons. This represents an average annual sediment yield per acre of watershed of 4.2 tons. The average annual sediment yield per acre of watershed has varied from 5.9 tons (1961-1974) to a low of 0.7 tons (1985-1992).

ACKNOWLEDGMENTS

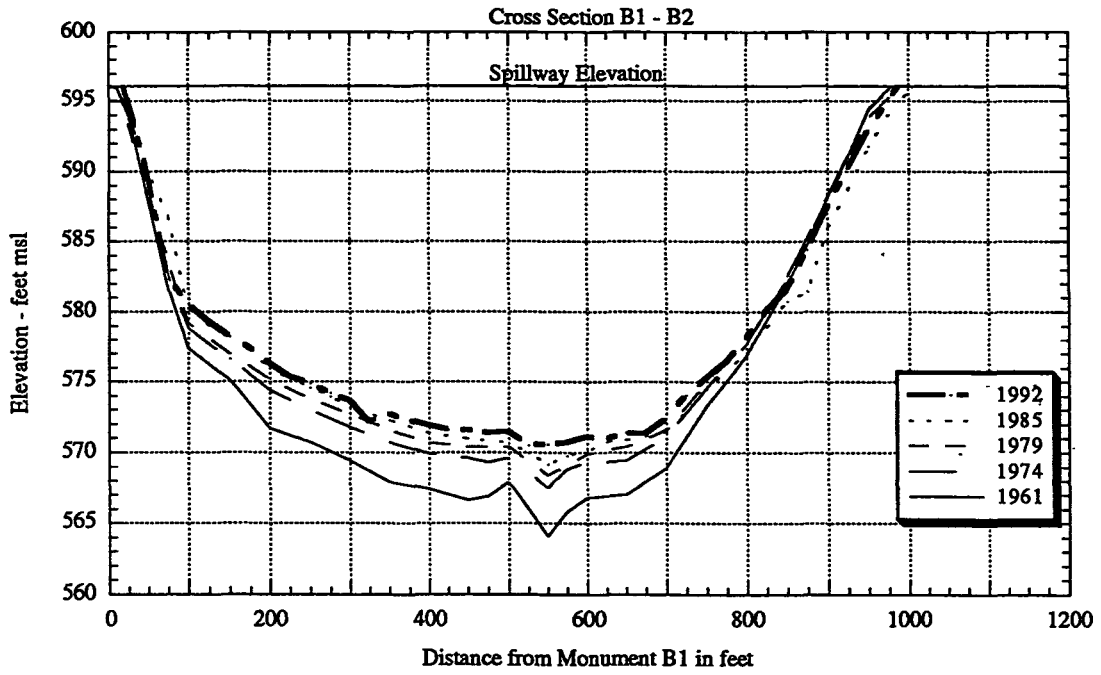
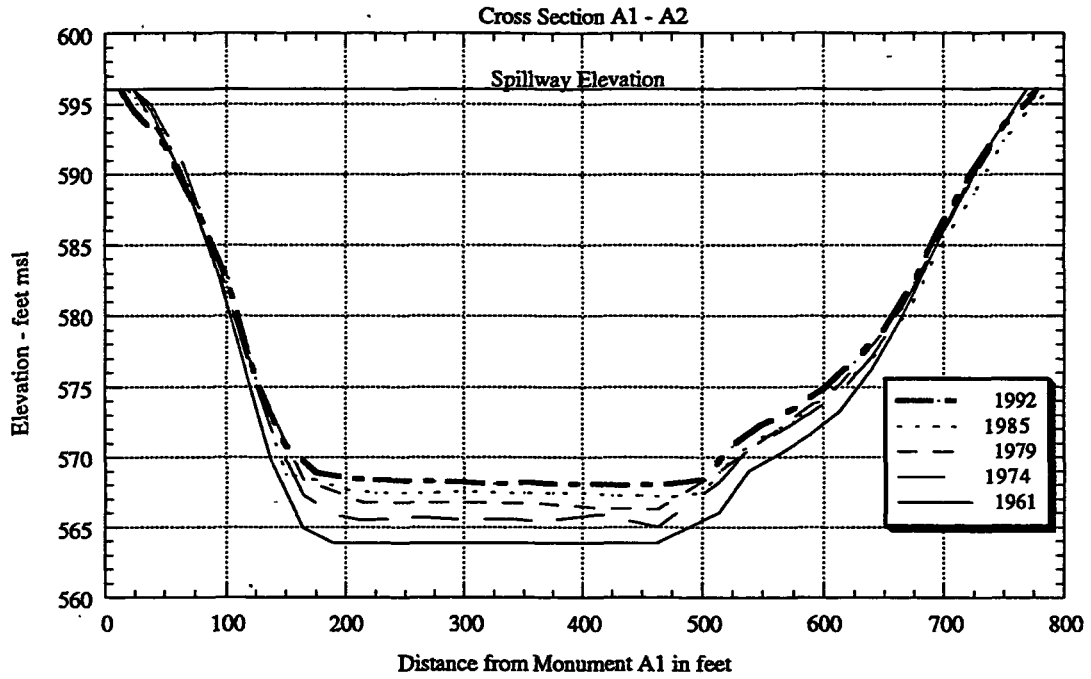
This project was conducted under the administrative guidance of Mark Peden, Acting Chief, and Misganaw Demissie, Director of the Office of Sediment & Wetland Studies. John Beardsley, Office of Water Quality Management, and Jarvis Schultz, Office of Sediment & Wetland Studies, assisted in the field data collection. Yi Han, Office of Sediment & Wetland Studies, analyzed the sediment core samples.

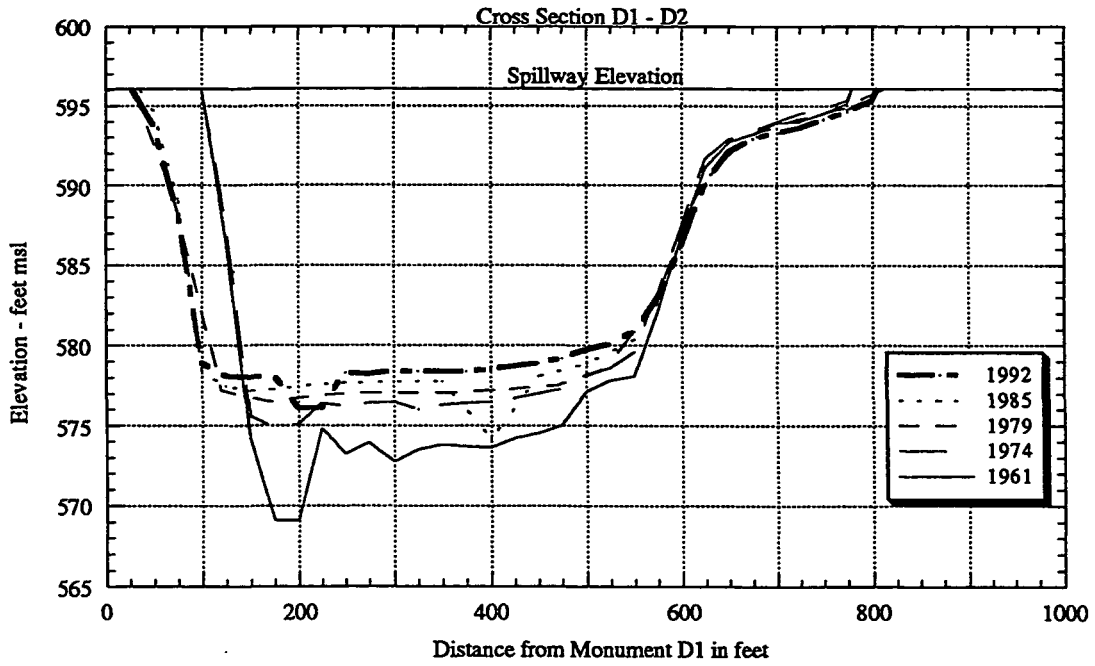
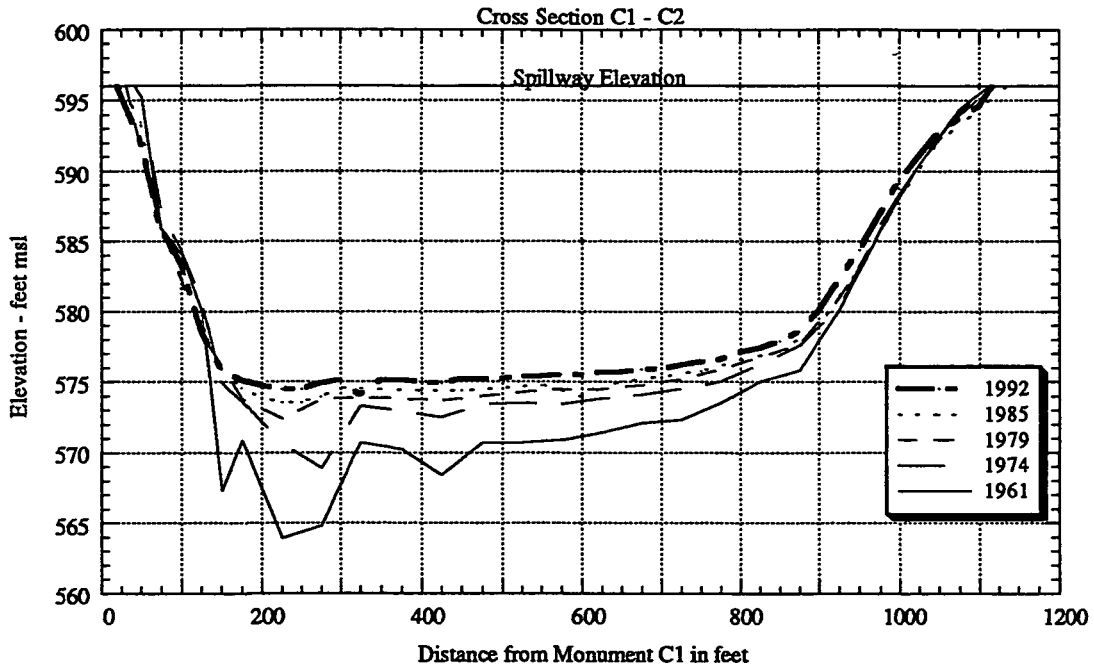
Eva Kingston edited the report. Linda Hascall prepared the figures for publication, and Becky Howard prepared the camera-ready text.

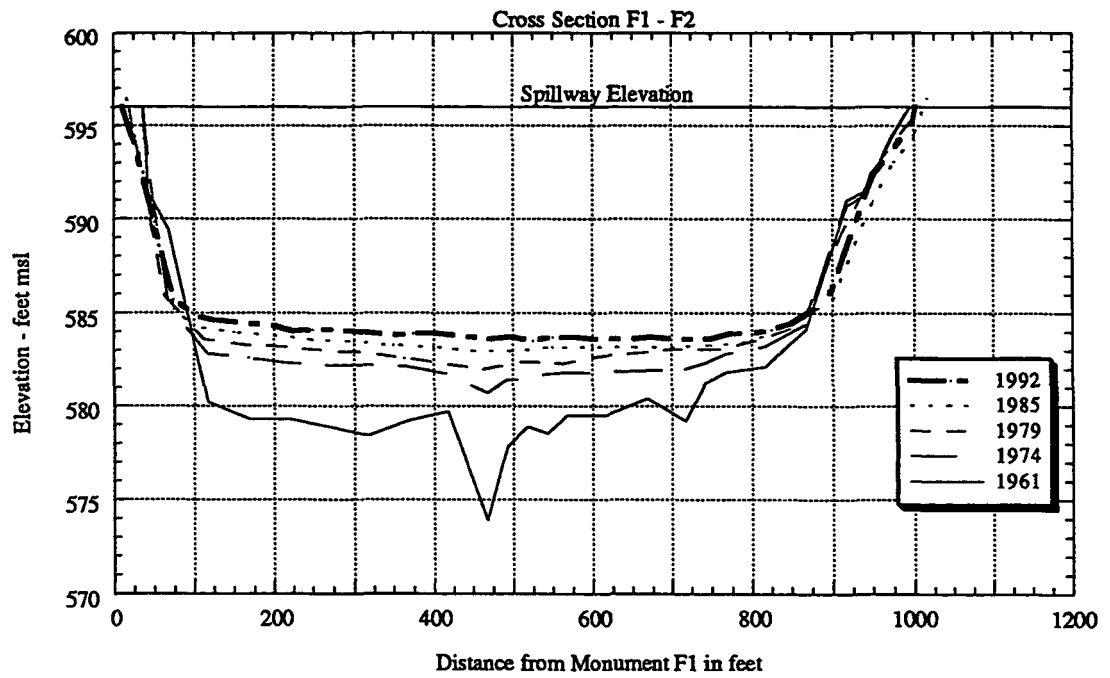
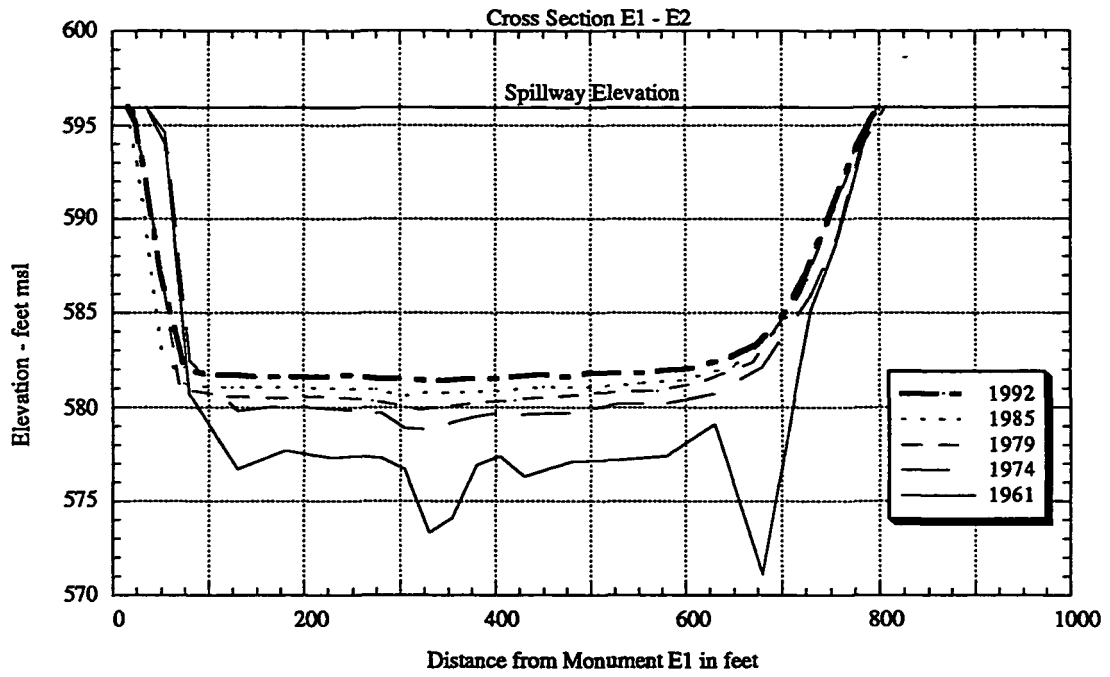
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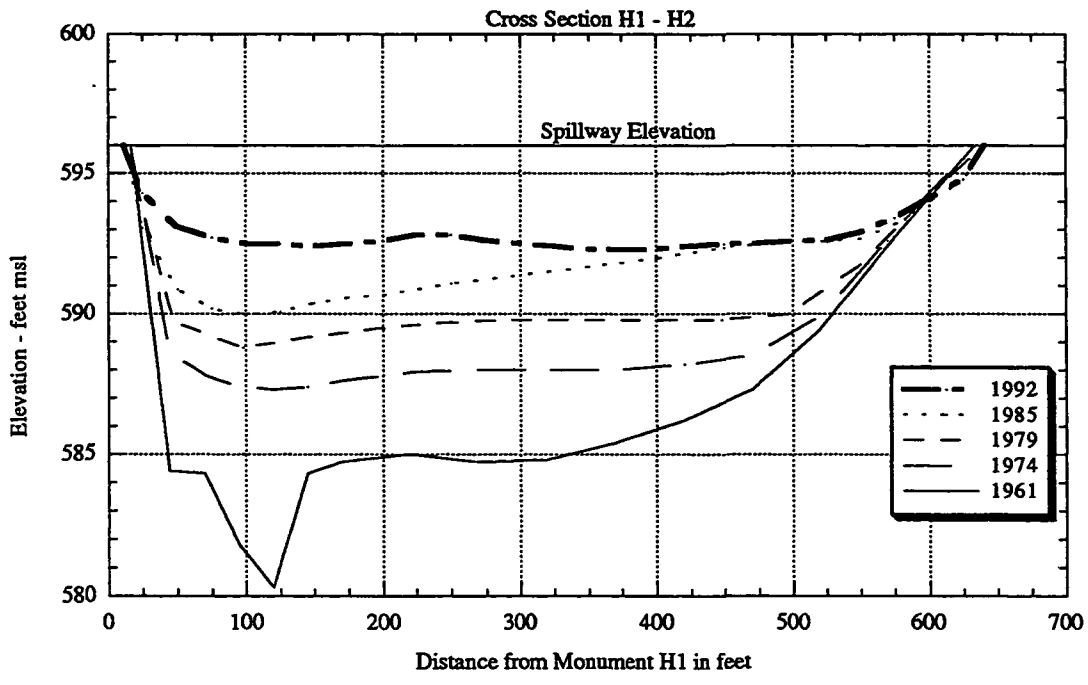
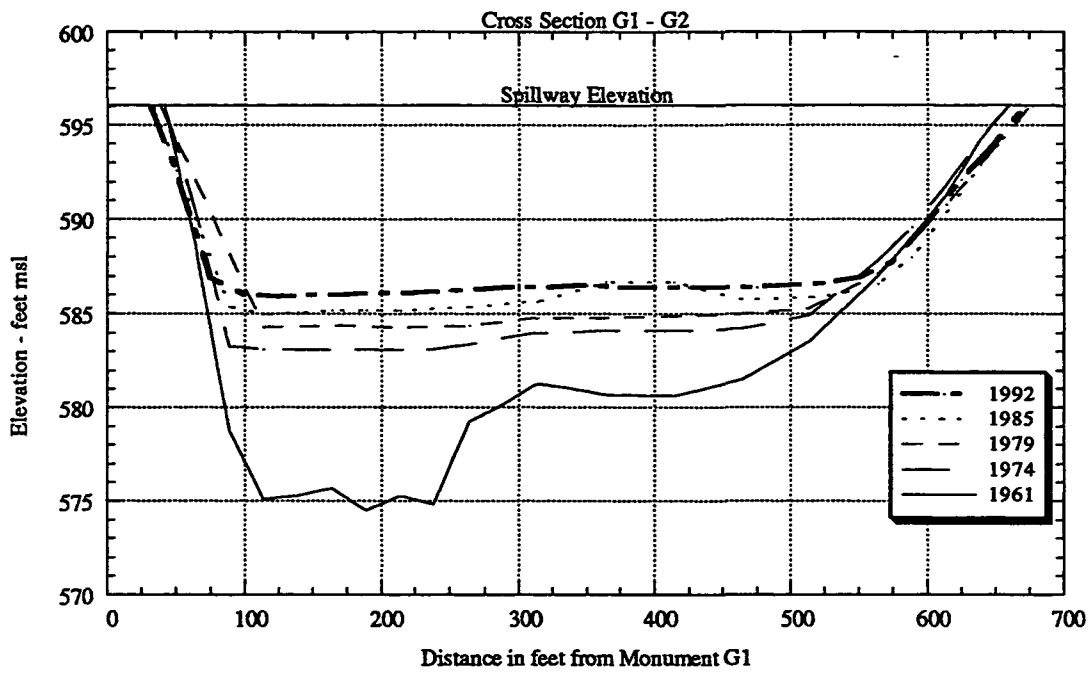
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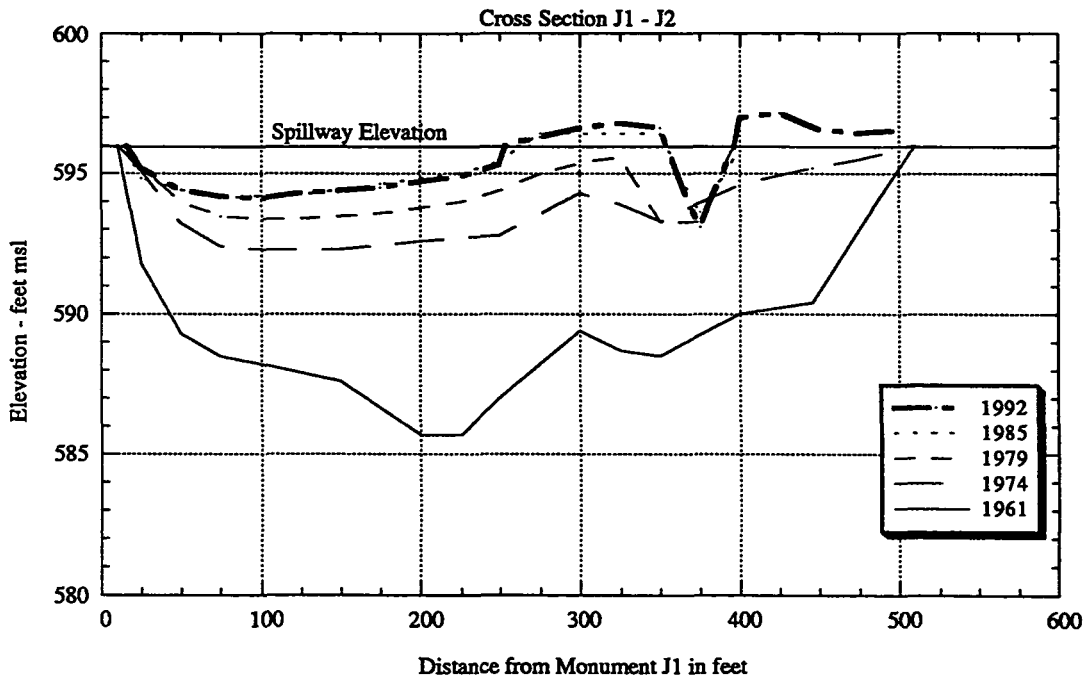
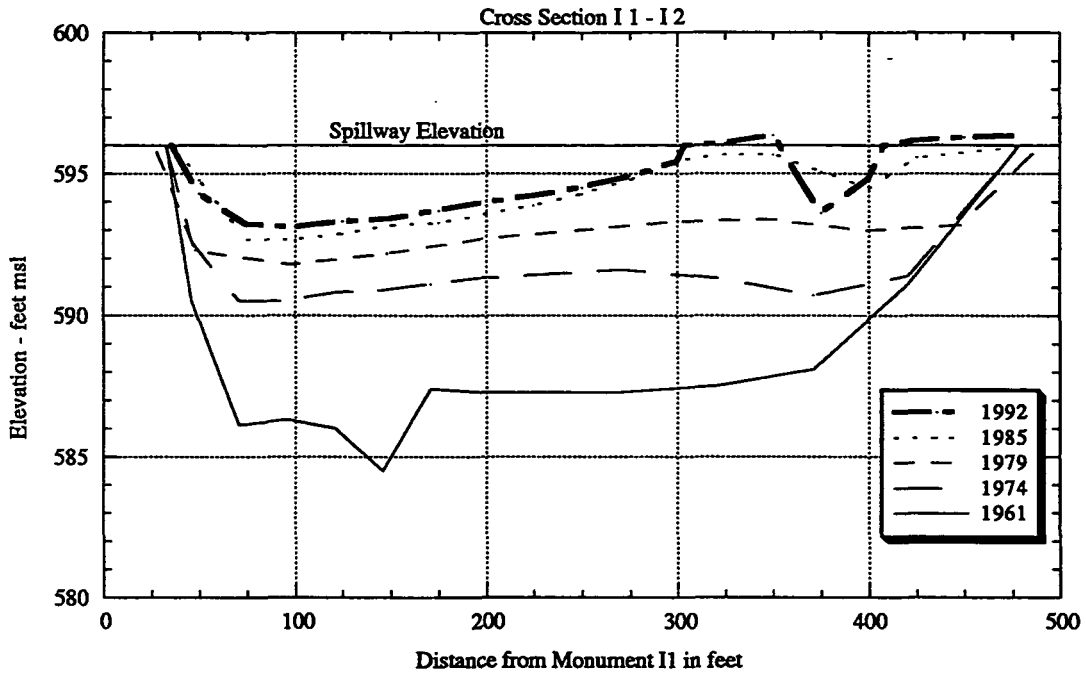
Appendix I:
Cross-sectional Hots of Surrey Range lines for Lake Pittsfield

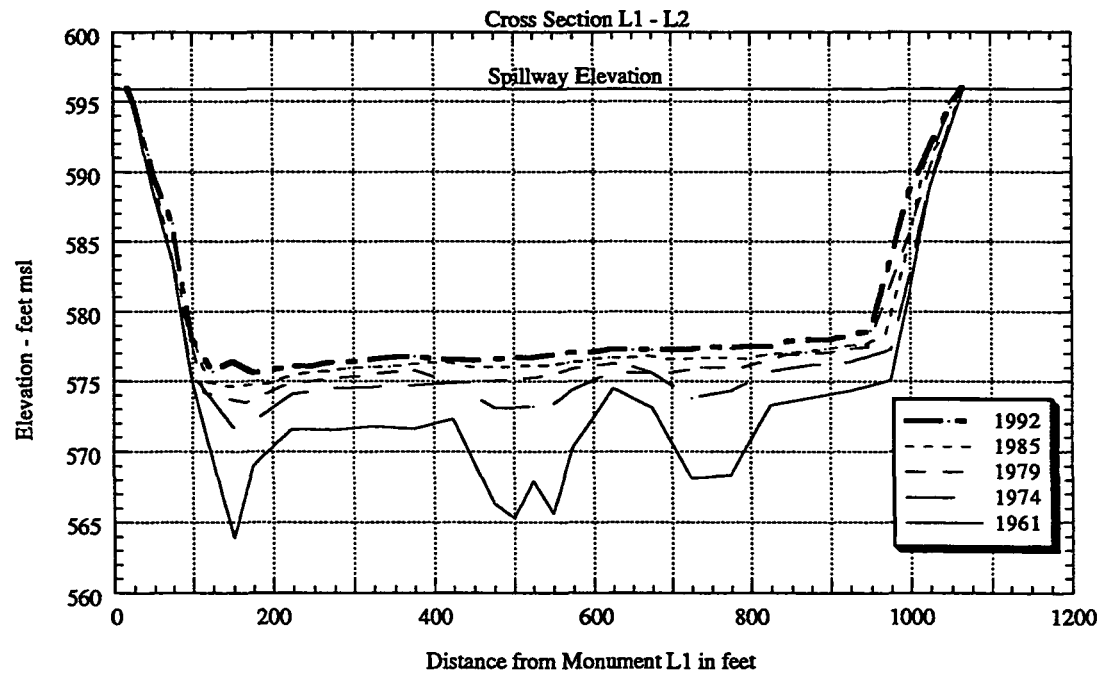
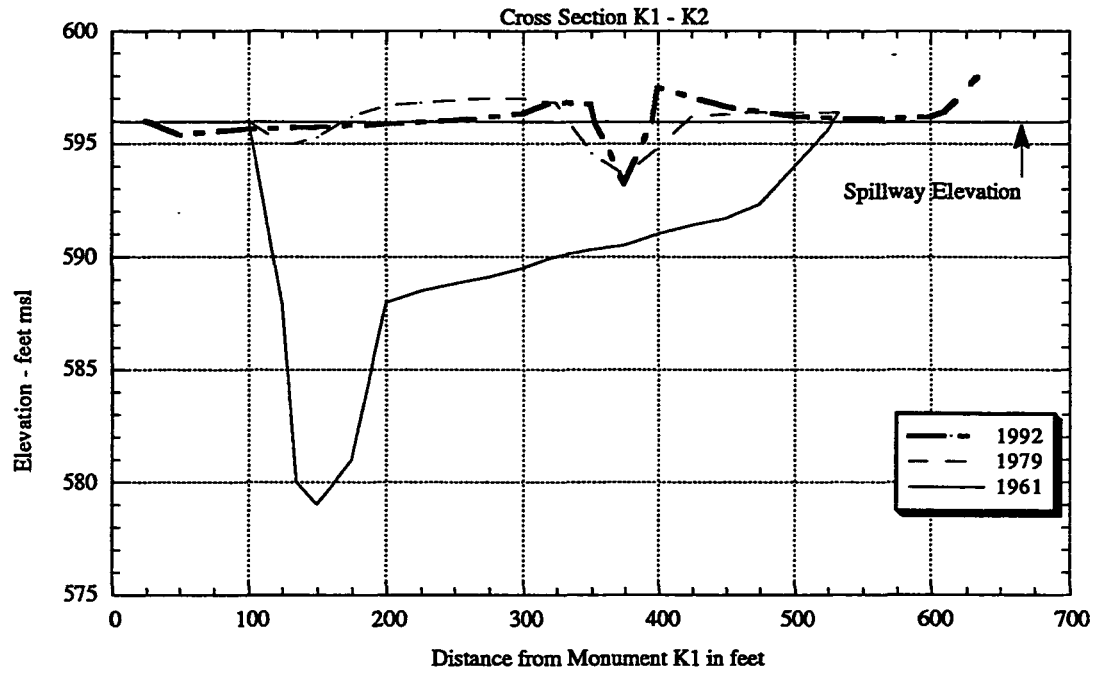


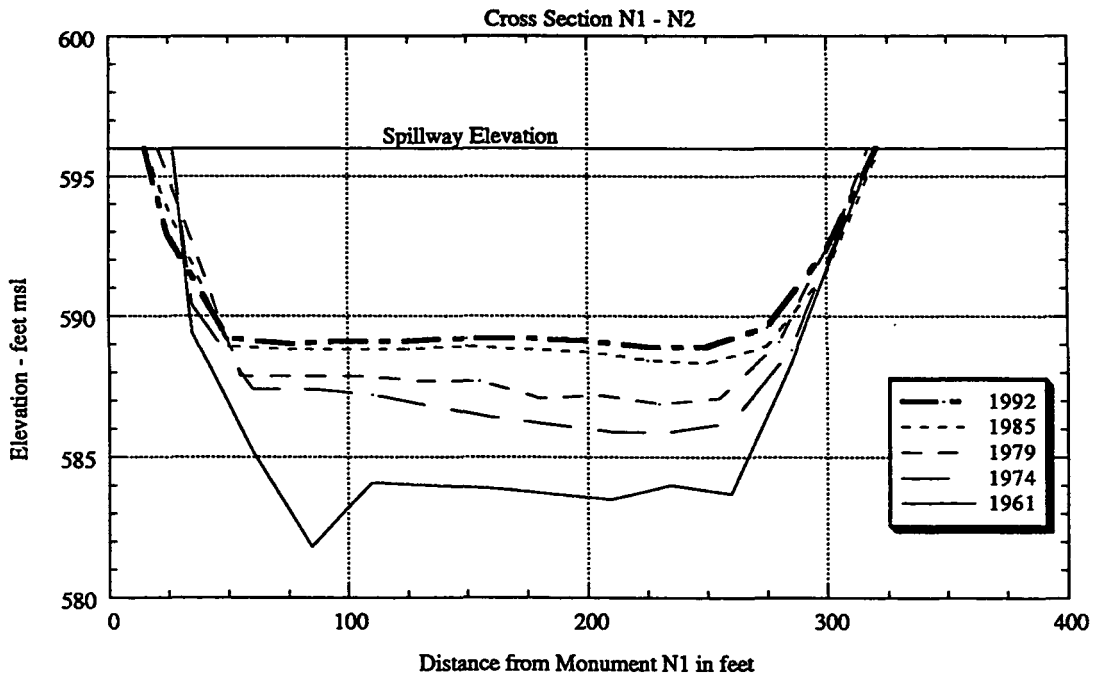
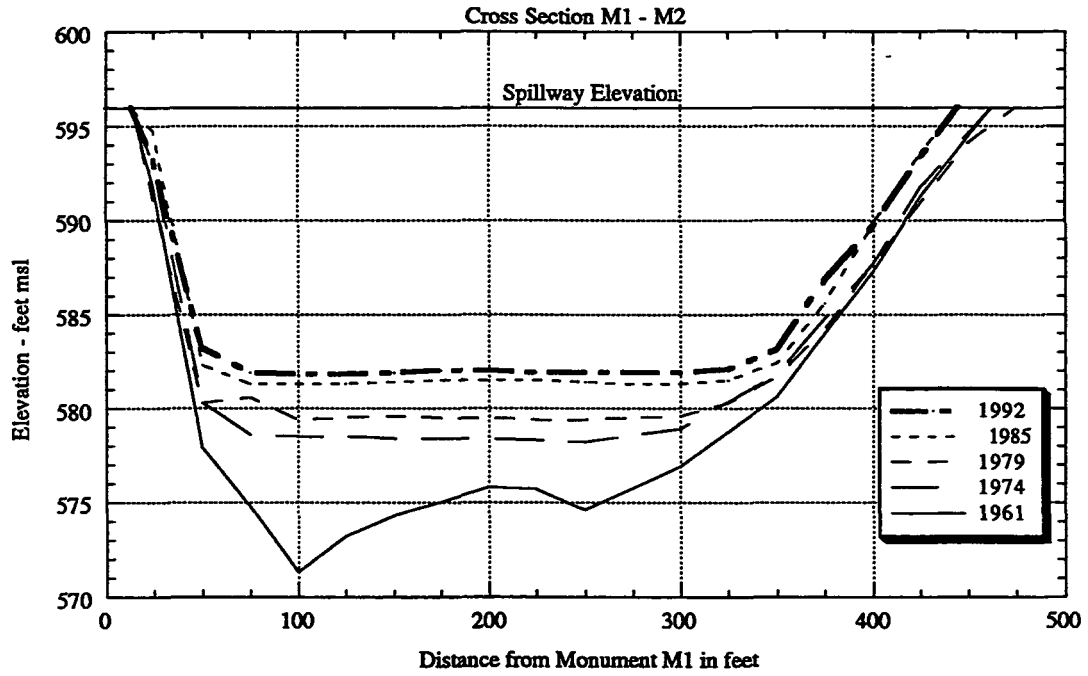












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