BUMPING LAKE

1990 Reservoir Survey

U.S. Department of the Interior
Bureau of Reclamation

7-2090 (4-81)
Bureau of Reclamation

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE Bumping Lake 1990 Reservoir Survey		5. REPORT DATE January 1992 6. PERFORMING ORGANIZATION CODE D-5753
7. AUTHOR(S) Ronald L. Ferrari		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Bureau of Reclamation Denver Office Denver CO 80225		10. WORK UNIT NO. 11. CONTRACT OR GRANT NO. 13. TYPE OF REPORT AND PERIOD COVERED
12. SPONSORING AGENCY NAME AND ADDRESS Same		14. SPONSORING AGENCY CODE DIBR

15. SUPPLEMENTARY NOTES

Microfiche and hard copy available at the Denver Office, Denver, Colorado. Ed: TH

16. ABSTRACT

Bumping Lake was surveyed in 1990 to compile field data for developing a reservoir topographic map and computing the present storage-elevation relationship. This was the first survey to determine the natural lake capacity inundated due to construction of Bumping Lake Dam. The original active capacity was based on topography collected prior to construction and did not include areas below the natural lake's water surface. The 1990 bathymetric survey utilized sonic depth recording equipment interfaced with an automated microwave positioning system that gave continuous depth and sounding positions. The above-water reservoir area was calculated from close interval cross sections measured from aerial photography flown in 1986. A new reservoir contour map was developed by the computer graphics program SURFACE II using the collected data.

As of June 1990, at reservoir spillway crest elevation (ft) 3426.2, the surface area was 1,382 acres with a total capacity of 61,359 acre-feet and an active capacity of 35,434 acre-feet.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS-- *reservoir area and capacity/ *sedimentation/ reservoir surveys/ sonar/ contour area/ reservoir area/ reservoir survey

b. IDENTIFIERS-- Bumping Lake

c. COSATI Field/Group ***COWRR:*** ***SRIM:***

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (THIS REPORT)	21. NO. OF PAGES
Available from the National Technical Information Service, Operations Division, 5285 Port Royal Road, Springfield, Virginia 22161.	UNCLASSIFIED	16
	20. SECURITY CLASS (THIS REPORT) UNCLASSIFIED	22. PRICE

BUMPING LAKE

1990 RESERVOIR SURVEY

by

RONALD L. FERRARI

BUREAU OF RECLAMATION
EARTH SCIENCES DIVISION
SURFACE WATER BRANCH
SEDIMENTATION SECTION
DENVER OFFICE

DENVER, COLORADO

January 1992

ACKNOWLEDGMENTS

The Bureau of Reclamation prepared and published this report under the supervision of Robert I. Strand, Head, Sedimentation Section, Earth Sciences Division. Ronald Ferrari and Steve Hughes of the Denver Office conducted the hydrographic survey. Personnel from the Columbia Basin Project Office of the Pacific Northwest Region assisted during the hydrographic survey and performed the required land survey for the hydrographic and aerial data collection. Personnel from the Sacramento Office of the Mid-Pacific Region transcribed the aerial data for computer processing. Special thanks to Doug Schmidt, Gerald Schultz, and Tom Stevenson for the field and office help on the hydrographic survey. Ronald Ferrari completed the data processing needed to generate the new topographic map and area-capacity tables. Robert I. Strand, James O. Blanton, Joseph K. Lyons, Curtis J. Orvis, Timothy J. Randle, and Dave Zimmer consulted in the engineering computations, topographic map development, and report preparation.

Bumping Lake Dam and Bumping Lake

CONTENTS

TABLES

Table

FIGURES

Figure

INTRODUCTION

Bumping Lake Dam, one of six storage features of the Yakima Project, is located on the Bumping River in Yakima County, Washington (fig. 1). The damsite is within the Snoqualmie National Forest, 2.2 miles southwest of Goose Prairie, 19 miles west of Nile, and about 60 miles northwest of Yakima, Washington.

Construction of Bumping Lake Dam was authorized under the Tieton and Sunnyside Divisions of the Yakima Project by the Secretary of the Interior on December 12, 1905. Construction of the dam began in 1909 and was completed in 1910. Closure of the dam and first reservoir storage occurred on November 3, 1910.

Bumping Lake Dam is an earthfill structure constructed by hydraulic fill methods (fig. 2). At dam crest elevation 3,435.0 (ft) the embankment has a structural height of 61 feet, a hydraulic height of 38 feet, a crest width of 20 feet, and a crest length of 2,925 feet. The reservoir impounded by the dam inundated a natural lake on the Bumping River. The dam and reservoir provide storage for irrigation water, although the reservoir is operated to provide flood control storage insofar as irrigation water supplies are not jeopardized. At elevation 3426.2 the reservoir extends 4.3 miles up the Bumping River and has a average width of 0.47 miles.

The spillway, an uncontrolled concrete weir with a concrete and wooden chute, is located at the left abutment. It has a crest length of 235 feet and a crest elevation of 3426.2. In previous documents the spillway crest elevation has been reported as 3426.0 feet. The design capacity of the spillway is 3,760 ft^3/s (cubic feet per second) at water surface elevation 3429.0. The spillway discharges into a rock-lined stilling pool in the Bumping River.

The outlet works is in the left river channel and consists of:

- an intake gate tower structure
- a steel footbridge
- two emergency slide gates
- two service slide gates
- a circular concrete conduit through the embankment
- a concrete-lined trapezoidal outlet channel leading to a stilling basin in the Bumping River

The outlet discharge capacity was designed for 1,500 ft^3/s (at water surface elevation 3426.2) but has been restricted to the 800-ft^3/s capacity of the lined outlet channel.

In 1910, Bumping Lake had a calculated active capacity of 33,700 acre-feet with a measured surface area of 1,303 acres at the reported spillway crest elevation of 3426.0. The original capacity of the natural lake (dead capacity) was unknown.

SUMMARY AND CONCLUSIONS

This report presents the 1990 results of the first extensive survey of Bumping Lake by the Bureau of Reclamation since construction of Bumping Lake Dam. The primary objective of the 1990 survey was to gather necessary data for computing the current total and active capacities of Bumping Lake. This was the first detailed survey to determine the area and capacity of the natural lake inundated by the reservoir created by the dam.

Standard land surveying methods were used to establish horizontal and vertical control points for the aerial and hydrographic surveys. A local horizontal grid system was established for both surveys using monumented control points located on the dam. The bathymetric survey was run using sonic depth recording equipment interfaced with an automated survey system consisting of a line-of-sight microwave positioning unit capable of determining sounding locations within the reservoir. The system continuously recorded reservoir depth and horizontal coordinates as the survey boat was steered across close-spaced gridlines covering the reservoir area. The positioning system provided information to allow the boat operator to maintain course along these gridlines. Water surface elevations measured by the land surveyors at the time of data collection were used to convert the sonic depth measurements to true reservoir bottom elevations.

The 1990 surface areas at predetermined 5-foot contour intervals were generated by a computer graphics program that produced a new contour map of the reservoir (fig. 3). The ACAP85 computer program computed the reservoir capacity and surface area at prescribed increments of elevations by using a curve-fitting technique from the generated contour surface areas [1].*

The 1990 survey determined that the reservoir has a surface area of 1,382 acres at the spillway crest elevation of 3426.2, providing a total capacity of 61,359 acre-feet, and an active capacity of 35,434 acre-feet. The survey measured a reservoir dead storage of 25,925 acre-feet. In 1910, Bumping Lake had a calculated active capacity of 33,700 acre-feet with a measured surface area of 1,303 acres at the reported spillway crest elevation of 3426.0. It has since been determined that the spillway crest is at elevation 3426.2 feet. The active capacity lies between outlet

* Numbers in brackets refer to bibliography.

works sill elevation 3389.0 and spillway sill elevation 3426.2. The 1990 survey calculated an active capacity of 35,434 acre-feet with a surface area of 1,382 acres at elevation 3426.2.

Several factors contributed to the increase in the 1990 measured area and resulting capacity. The original topography of the reservoir area was developed from a plane table survey performed prior to clearing of dense timber and construction of the dam. The heavily timbered area would have made it difficult to obtain an accurate survey, so part of the surface area difference is probably due to the two different survey methods. Also, it is assumed that some bank erosion occurred since construction of the reservoir, causing the eroded material on the steep south side of the reservoir to settle in the natural lake area. This erosion can not be documented because this was the first survey of the natural lake area.

Table 1 contains a comprehensive summary of the reservoir data and watershed characteristics for the 1990 survey. A summary of reservoir sediment data was not presented because this was the first survey to compute the total reservoir capacity.

Due to low sediment production in the drainage area, a resurvey of Bumping Lake should not be necessary unless major sediment inflow occurs in the future.

DESCRIPTION OF WATERSHED

The drainage area of the Bumping Lake basin (above the dam) is 69.3 square miles (fig. 4). The western and southern boundaries of the basin are formed by the Cascade Divide, the eastern boundary by the Nelson Ridge, and the northern boundary by the American Ridge. The elevation of the basin ranges from elevation 3389.0 at the intake gate tower of the dam to elevations in excess of 7500 feet at mountain peaks along the eastern divide. The minimum elevation of the natural lake, which was inundated by the reservoir, was measured to be 3309.6 feet.

The watershed is characterized by high mountains with steep side slopes. The basin is heavily timbered and dotted with numerous small natural lakes. The mountain peaks are mostly bare with rock outcrops. The main vegetative cover throughout the basin is a dense growth of lodgepole pine with associated undergrowth of grass and brush. Larch (tamarack) are interspersed among the lodgepole pines in the lower elevations with some Douglas fir and cedar noted in the upper elevations. The soil mantle is thin with little plasticity. The soil is fairly porous; however, the rock outcrop areas, the thin soil mantle, and the thick vegetation in the drainage area promote a low sediment production.

Bedrock within the subbasin consists principally of low-permeability volcanic and metamorphic formations. Unknown thicknesses of permeable sand and gravel deposits of Quaternary age underlie the valley. A glacial moraine extends across the valley that impounded Bumping Lake. Some subsurface leakage from the reservoir recharges the Quaternary sediments that underlie the valley downstream from the dam. The dam is situated in an eroded canyon modified by alpine glaciation. The foundation of the dam, spillway, and outlet works consists of unconsolidated glacial deposits with lenses of fine sediments. These saturated materials exceed 200 feet in depth.

RESERVOIR OPERATIONS

The reservoir is a multiuse facility having (following values are from June 1990 area-capacity tables):

- 3,957 acre-feet of exclusive flood control storage between elevations 3426.2 and 3429.0
- 35,434 acre-feet of active conservation storage between elevations 3389.0 and 3426.2
- 25,925 acre-feet of dead storage (natural lake) between elevations 3309.6 and 3389.0

Records for Bumping Lake show an average unregulated inflow of 210,450 acre-feet per year. The estimated mean annual runoff from the basin is 56.9 inches. Bumping Lake operation ranged from a minimum elevation of 3390.8 feet in February 1949 to a maximum elevation of 3430.5 in June 1925. The monthly inflow and end-of-month stage records in table 1 show the extreme annual fluctuation of the reservoir.

SURVEY METHOD AND EQUIPMENT

The Bumping Lake survey was completed using the contour method as outlined by Blanton [2]. The procedure involved collecting adequate coordinate data for developing a reliable contour map by photogrammetric and bathymetric survey methods. Standard land surveying methods were used by Columbia Basin Project Office personnel to establish horizontal and vertical control points for both survey methods. A horizontal grid system was established for both surveys using monumented points located on the dam. The above-water data was collected by aerial photography in October 1986 with the water surface at elevation 3395.4. The field survey work for the bathymetric survey involved establishing a triangulation network around the reservoir to provide horizontal and vertical control for all required grid lines and shore stations. There were no previously established range lines on the reservoir and it was decided not to establish permanent range lines during this survey. Because of the size and shape of the reservoir, any future survey would also employ the contour method; therefore, permanent range line end markers were not necessary.

The hydrographic survey took place June 6 through June 8, 1990, while the reservoir was spilling. The bathymetric survey was run using sonic depth recording equipment interfaced with an automated survey system consisting of a line-of-sight microwave positioning unit capable of determining sounding locations within the reservoir. This positioning system transmitted line-of-sight microwave signals to fixed shore stations and converted the reply time to range distances, which were used by the system data logger to compute the coordinate position of the sounding boat. The survey system continuously recorded reservoir depth and horizontal coordinates as the survey boat moved across close-spaced gridlines covering the reservoir area. To produce adequate data for developing contours of Bumping Lake, a grid spacing of 300 feet was selected for the main body; 200-foot intervals were used near the dam. The system gave directions to the boat operator to assist in maintaining course along the close-spaced gridlines. During each run, the depth and position data were recorded on a floppy disk for subsequent processing by Denver Office personnel. A graph plotter was used in the field to track the boat and determine adequate coverage during the data collection process. Water surface elevations surveyed at the time of collection were used to convert the sonic depth measurements to true reservoir bottom elevations.

SEDIMENT ANALYSES

The total sediment accumulation in Bumping Lake cannot be computed because this was the first survey of the natural lake area (dead storage) since the dam was constructed. Because of the large reservoir dead storage measured in 1990 and the low sediment production of the drainage area, a resurvey of Bumping Lake should not be necessary unless major sediment inflow occurs in the future.

RESERVOIR AREA AND CAPACITY

Development of 1990 Contour Areas

The 1990 contour surface areas for Bumping Lake were developed by generating a contour map from the collected 1986 aerial and 1990 underwater coordinate data. Five-foot contour intervals of the reservoir area were created by a computer graphics software program [3]. A modification of this program by the Denver Office calculated surface areas of closed contours on the generated map. The final reservoir map shown on figure 3 was prepared by the Denver Office Computer Drafting Unit of the Drafting Section. The map has a scale of 1 inch equals 1,000 feet and 5-foot contour intervals.

1990 Storage Capacity

The storage-elevation relationships based on the 1986 aerial data and the 1990 underwater survey data were developed using the area-capacity computer program ACAP85 [1]. Surface areas at 5-foot contour intervals computed from the 1986 aerial data and the 1990 underwater survey data were used as the control parameters for computing reservoir capacity. The program computes an area at elevation increments of 0.01 to 1.0-foot by linear interpolation between the 5-foot contour intervals. The program begins by testing the initial capacity equation over successive intervals to ensure that the equation fits within an allowable error limit, which was set at 0.000001 for Bumping Lake. Then the capacity equation is used over the full range of intervals fitting within this allowable error limit. For the first interval at which the initial allowable error limit is exceeded, a new capacity equation (integrated from the basic area curve over that interval) tests the fit until it also exceeds the error limit. Thus, the capacity curve is defined by a series of curves, each fitting a certain region of data. Final area equations are derived by differentiating the capacity equations, which are of second order polynomial form:

$$y = a + a_2x + a_3x^2$$

where:

y = capacity,

x = elevation above a reference base,

a = intercept, and

a_2 and a_3 = coefficients.

Results of the 1990 Bumping Lake area and capacity computations are listed in table 1 and plotted on figure 5. A separate set of 1990 area and capacity tables has been published for the 0.01-, 0.1-, and 1-foot elevation increments [4]. The 1990 total capacity is 61,359 acre-feet with a surface area of 1,382 acres at the spillway crest elevation 3426.2.

BIBLIOGRAPHY

[1] *ACAP85 User's Manual*, Bureau of Reclamation, Surface Water Branch, Denver Office, Denver, Colorado, 1985.

[2] Blanton, James O. III, *Procedures for Monitoring Reservoir Sedimentation, Technical Guideline for Bureau of Reclamation*, Sedimentation Section, Denver Office, Denver, Colorado, October 1982.

[3] Sampson, Robert J., *Surface II Graphics System*, Kansas Geological Survey, Lawrence, Kansas, 1984.

[4] "Yakima Project Bumping Lake Washington Area and Capacity Tables," Bureau of Reclamation, Boise, Idaho, June 1990.

RESERVOIR SEDIMENT
DATA SUMMARY

Bumping Lake
NAME OF RESERVOIR

DATA SHEET NO.

DAM	1. OWNER Bureau of Reclamation		2. STREAM Bumping River		3. STATE Washington	
	4. SEC 14 T 16N R12E		5. NEAREST PO Goose Prairie		6. COUNTY Yakima	
	7. LAT 46°52'25" LONG 121°17'57"		8. TOP OF DAM 3435.0		9. SPILLWAY CREST 3426.2	
RESERVOIR	10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE AREA, Ac	13. ORIGINAL CAPACITY, AF	14. GROSS STORAGE ACRE-FEET	15. DATE STORAGE BEGAN
	a. FLOOD CONTROL	3429.0	1,366	4,000	37,700	
	b. MULTIPLE USE	3426.0[1]	1,303	33,700	33,700	Nov. 3, 1910
	c. POWER					
	d. WATER SUPPLY					16. DATE NORMAL OPERATION BEGAN
	e. IRRIGATION					
	f. CONSERVATION	3389.0	627	0	0[2]	
	g. INACTIVE					11/3/10
	17. LENGTH OF RESERVOIR 4.3 MILES			AVG. WIDTH OF RESERVOIR 0.47 MILES		
BASIN	18. TOTAL DRAINAGE AREA 69.3 SQ. MI.			22. MEAN ANNUAL PRECIPITATION 19.0[3] INCHES		
	19. NET SEDIMENT CONTRIBUTING AREA 69.3 SQ. MI.			23. MEAN ANNUAL RUNOFF 56.9[4] INCHES		
	20. LENGTH 10.5 MILES	AV. WIDTH 6.6 MI		24. MEAN ANNUAL RUNOFF 210,450[5] ACRE-FEET		
	21. MAX. ELEV. 7585	MIN. ELEV. 3389		25. ANNUAL TEMP. MEAN 45[3] °F RANGE -17 to 110[6] °F		

SURVEY DATA

26. DATE OF SURVEY	27. PER. YRS	28. ACCL. YEARS	29. TYPE OF SURVEY	30. NO. OF RANGES OR INTERVAL	31. SURFACE AREA, ACRES	32. CAPACITY ACRE-FEET	33. C/I RATIO AF/AF
11/03/1910			Contour(R)		,	,	
6/7/1990	79.6	79.6	Contour(D)[8]	5-ft	1,382	61,359[9]	0.29

26. DATE OF SURVEY	34. PERIOD ANNUAL PRECIP.	35. PERIOD WATER INFLOW, ACRE-FEET			WATER INFLOW TO DATE, AF	
		a. MEAN ANN.	b. MAX. ANN.	c. TOTAL	a. MEAN ANN.	b. TOTAL
6/7/1990	19.0[3]	210,450[5]	326,900[5]	16,751,820[5]	210,450[5]	16,751,820[5]

26. DATE OF SURVEY	37. PERIOD CAPACITY LOSS, ACRE-FEET			38. TOTAL SEDIMENT DEPOSITS TO DATE, AF		
	a. TOTAL	b. AV. ANN.	c. /MI.²-YR.	a. TOTAL	b. AV. ANNUAL	c. /MI.²-YR.
6/7/1990	,			,		

26. DATE OF SURVEY	39. AV. DRY WT. (LB/FT³)	40. SED. DEP. TONS/MI.²-YR.		41. STORAGE LOSS, PCT.		SED. INFLOW, PPM	
		a. PERIOD	b. TOTAL TO DATE	a. AV. ANNUAL	b. TOTAL TO DATE	a. PER.	b. TOT.
6/7/1990							

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE IN FEET BELOW AND ABOVE CREST ELEVATION											
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION											

26. DATE OF SURVEY	44. REACH DESIGNATION PERCENT OF TOTAL ORIGINAL LENGTH OF RESERVOIR													
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-105	105-110	110-115	115-120	120-125
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN REACH DESIGNATION														

Table 1. - Reservoir sediment data summary (page 1 of 2).

45. RANGE IN RESERVOIR OPERATION

WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1911	3426.4	3393.3		1951	3428.1	3393.7	291,700
1912	3426.8	3393.0		1952	3428.4	3393.3	187,900
1913	3427.4	3392.9		1953	3428.3	3392.9	209,900
1914	3427.2	3393.7		1954	3428.2	3393.2	259,400
1915	3428.2	3391.8		1955	3429.3	3394.6	197,200
1916	3427.4	3393.2		1956	3428.1	3394.0	326,900
1917	3427.6	3393.4		1957	3428.3	3395.3	209,200
1918	3429.0	3392.3		1958	3428.3	3397.5	192,000
1919	3429.5	3397.2		1959	3427.7	3397.1	255,400
1920	3430.3	3392.5	151,100	1960	3427.9	3396.6	230,600
1921	3430.4	3394.6	305,800	1961	3427.6	3394.6	250,100
1922	3430.1	3392.6	197,000	1962	3428.2	3396.0	186,100
1923	3429.7	3392.4	212,000	1963	3427.7	3393.4	179,770
1924	3430.2	3393.3	168,300	1964	3428.2	3392.8	210,580
1925	3430.5	3393.3	236,200	1965	3427.6	3395.7	217,710
1926	3430.2	3393.0	116,400	1966	3423.2	3393.7	156,620
1927	3429.5	3393.2	236,300	1967	3427.6	3392.9	207,790
1928	3429.9	3397.4	236,900	1968	3426.8	3394.1	226,040
1929	3430.3	3393.2	127,400	1969	3427.1	3393.2	213,370
1930	3429.9	3393.0	128,900	1970	3427.5	3395.1	176,030
1931	3428.7	3393.0	134,000	1971	3427.9	3393.2	257,340
1932	3429.6	3393.0	241,300	1972	3428.4	3395.1	308,290
1933	3428.4	3395.3	273,900	1973	3421.5	3393.0	140,490
1934	3429.3	3393.1	323,700	1974	3429.0	3393.0	319,420
1935	3427.9	3396.0	261,600	1975	3428.2	3393.1	238,580
1936	3428.1	3393.1	194,000	1976	3428.6	3396.5	282,540
1937	3428.0	3392.9	173,000	1977	3427.4	3395.4	92,100
1938	3428.1	3392.9	236,400	1978	3428.0	3397.1	218,500
1939	3427.6	3393.4	164,700	1979	3427.8	3394.4	135,700
1940	3427.4	3393.0	159,300	1980	3427.3	3394.0	196,000
1941	3422.4	3393.0	110,200	1981	3428.1	3395.6	203,900
1942	3427.5	3393.1	149,700	1982	3427.2	3394.9	248,700
1943	3427.9	3393.3	234,800	1983	3426.4	3397.1	225,800
1944	3427.2	3393.0	117,300	1984	3426.1	3393.5	217,250
1945	3427.7	3392.9	165,100	1985	3427.4	3395.0	161,640
1946	3427.9	3392.4	231,900	1986	3426.7	3395.2	184,590
1947	3427.8	3393.0	214,800	1987	3426.8	3393.9	[6]
1948	3428.5	3398.8	240,400	1988	3426.6	3394.1	[6]
1949	3428.3	3390.8	236,600	1989	3426.2	3395.0	[6]
1950	3428.1	3393.1	303,100	1990	3426.4	3398.9	[6]

46. ELEVATION - AREA - CAPACITY DATA FOR Original and 1990 ACTIVE CAPACITY[10]

ELEV.	AREA	CAP.	ELEV.	AREA	CAP.	ELEV.	AREA	CAP.
Original	Year-1910		3420	1,175	26,300	3400	754	7,259
3389	627	0	3426	1,303	33,700	3405	873	11,327
3395	664	3,900	3429	1,366	37,700	3410	1,009	16,034
3400	725	7,309	Yr 1990[10]	Active	Capacity	3415	1,128	21,377
3405	825	11,200	3309.6	0	0	3420	1,242	27,301
3410	950	15,600	3389	591	0	3426.2	1,382	35,434
3415	1,070	20,700	3395	656	3,734	3429	1,445	39,391

47. REMARKS AND REFERENCES

[1] Originally reported as El. 3426.0 feet, corrected to El. 3426.2 feet.
[2] Constructed reservoir inundated a natural lake. The original area-capacity of the natural lake was unknown.
[3] Climatography of the United States, No. 81, and Climates of the United States, 1931-70, NOAA.
[4] Calculated from mean annual runoff value 210,450 acre-feet, item 24.
[5] Unregulated infow monthly records for water years 1920-1990. Water years 1987-1990 have missing records.
[6] Project data book, USBR, 1981.
[7] Original area-capacity of natural lake inundated by constructed reservoir was unknown. 1990 survey was first to calculate natural lake's (dead storage) capacity.
[8] Reservoir area was measured using data from bathymetric survey and aerial photography.
[9] Total capacity of reservoir at spillway crest elevation 3426.2. Active capacity of 35,434 acre-feet from El. 3389.0 to El. 3426.2.
[10] Following table shows active capacity. A dead capacity (natural lake) of 25,925 acre-feet was computed from 1990 data.

48. AGENCY MAKING SURVEY Bureau of Reclamation
49. AGENCY SUPPLYING DATA Bureau of Reclamation | DATE August 1991

Table 1. - Reservoir sediment data summary (page 2 of 2).

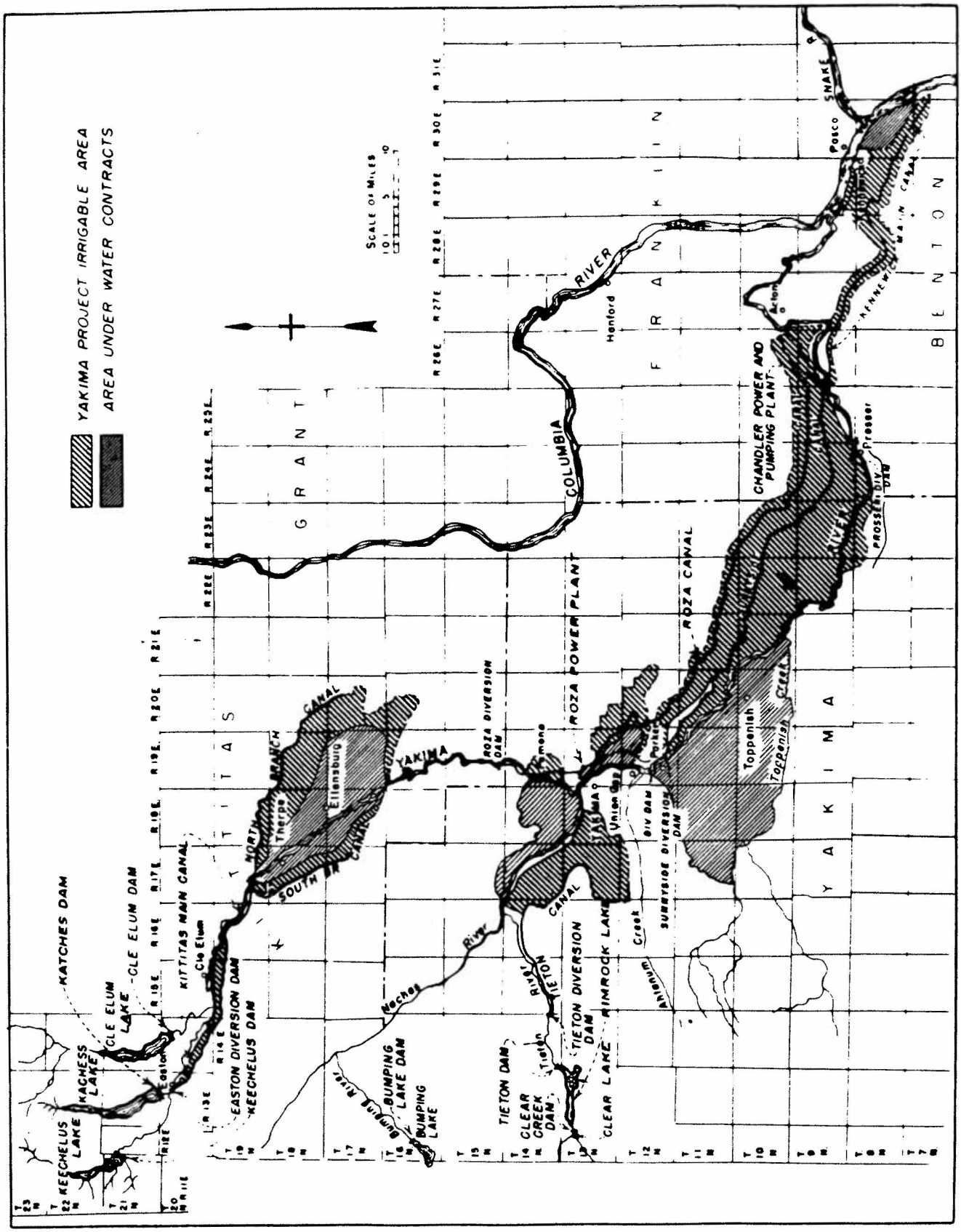

Figure 1. - Bumping Lake location map—Yakima project.

Space intentionally left blank due to security concerns

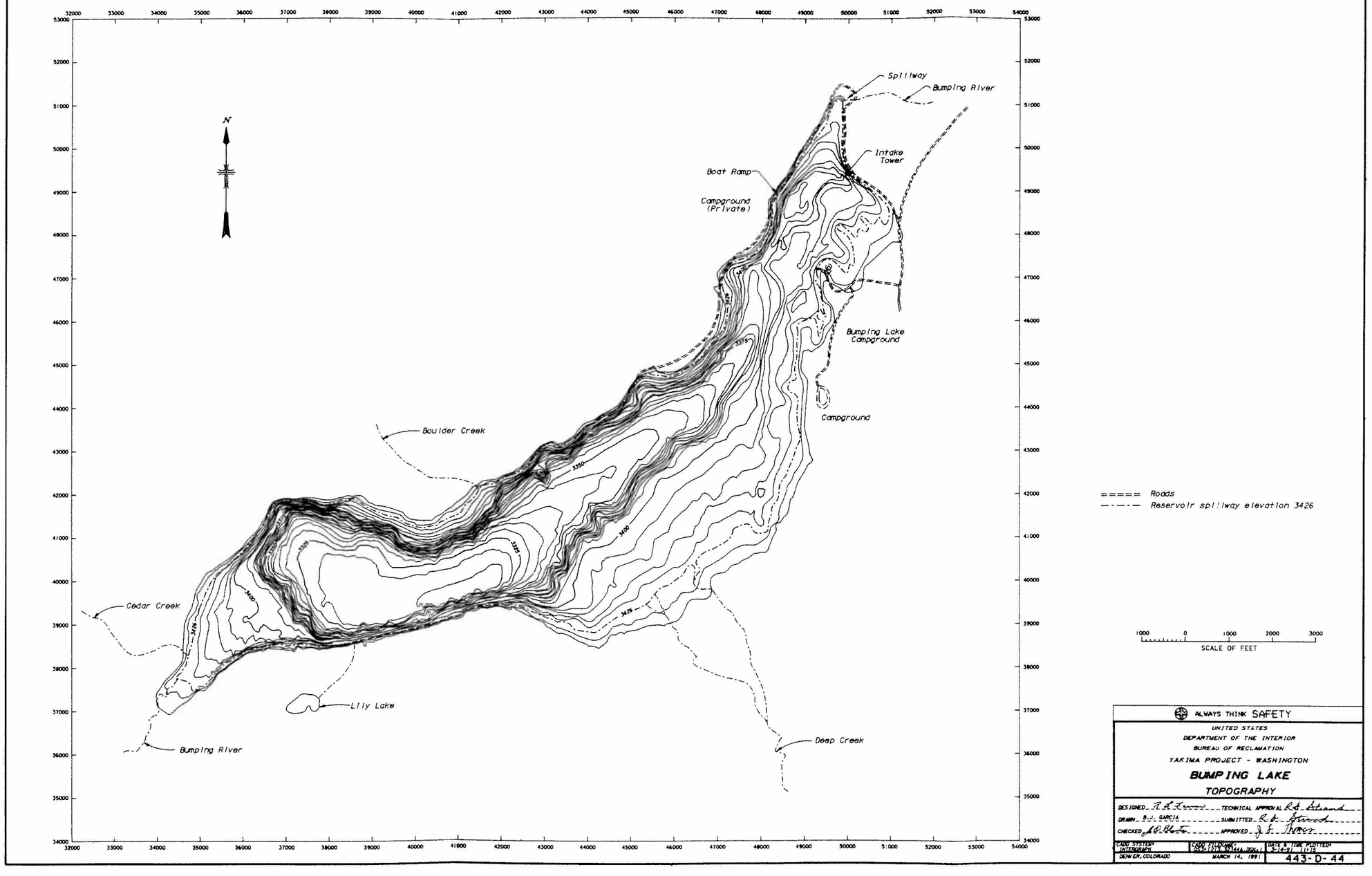

Figure 3. - Bumping Lake topographic map, drawing 443-D-44.

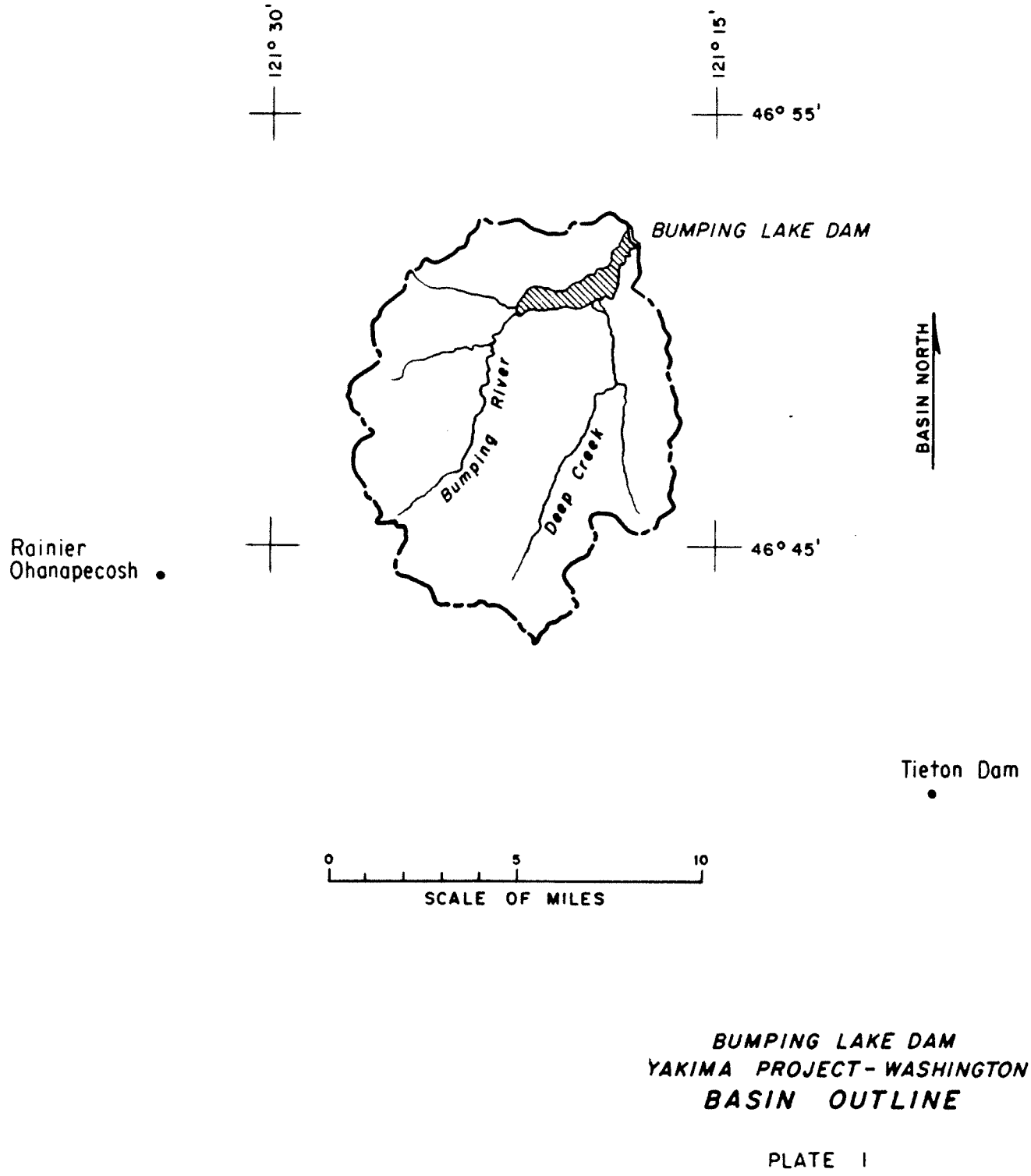

Figure 4. - Basin outline—Bumping Lake Dam, Yakima project.

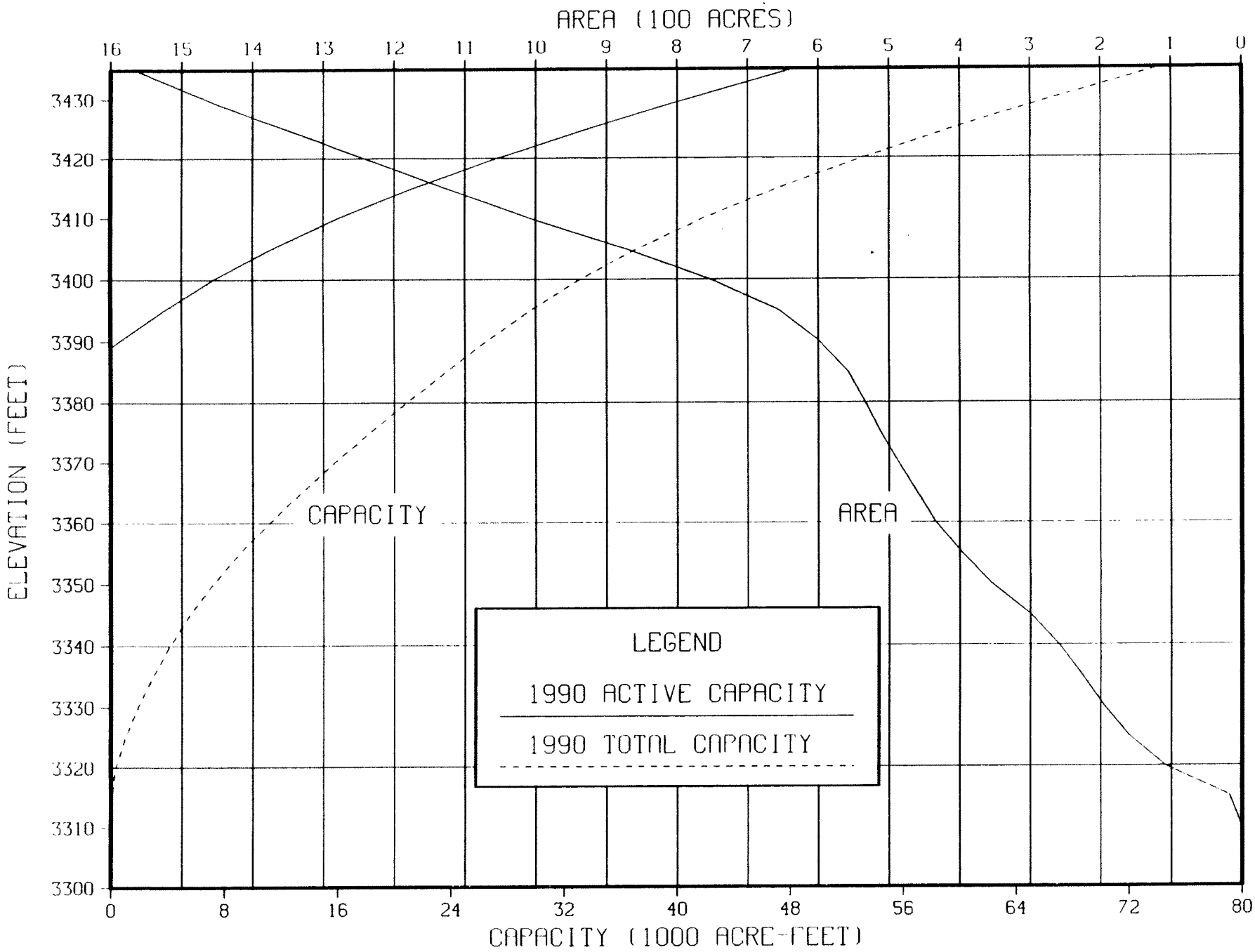

Figure 5. - Area and capacity curves—Bumping Lake, 1990.

U.S. GOVERNMENT PRINTING OFFICE 1992-835-936