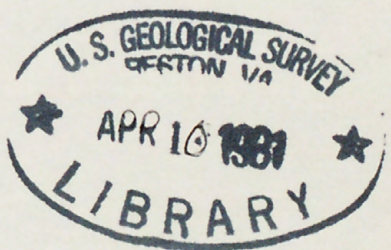
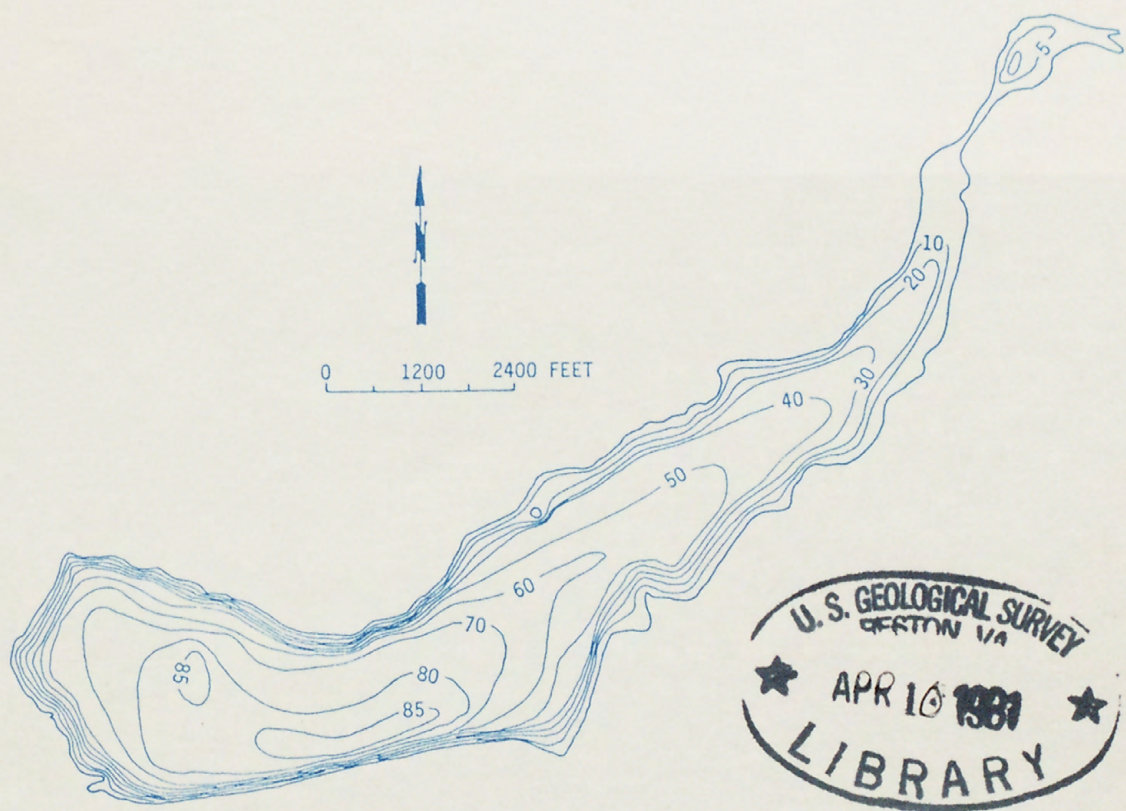


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AN ANALYSIS OF RESERVOIR STORAGE CONTENTS FOR THE PROPOSED ENLARGEMENT OF BUMPING LAKE IN WASHINGTON



U.S. GEOLOGICAL SURVEY
Open-File Report 80-440



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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

AN ANALYSIS OF RESERVOIR STORAGE CONTENTS FOR THE
PROPOSED ENLARGEMENT OF BUMPING LAKE IN WASHINGTON

By J. H. Bartells

Open-File Report 80-440

Tacoma, Washington
1981

UNITED STATES DEPARTMENT OF THE INTERIOR

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METRIC CONVERSION FACTORS

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
foot (ft)-----	0.3048	meter (m)
square mile (mi ²)----	2.590	square kilometer (km ²)
acre-foot (acre-ft)--	0.001234	cubic hectometer (hm ³)

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ABSTRACT

Month-end contents of the proposed Bumping Lake enlargement were determined for the period 1917-73 by using the historic streamflow record as a basis for inflow to the reservoir and imposing certain operational requirements on reservoir releases. The operational requirements used were those set forth in the Environmental Statement that was prepared for the project by the U.S. Water and Power Resources Service (formerly the U.S. Bureau of Reclamation). The computations show that after starting with an empty reservoir on October 1, 1917, the 458,000 acre-feet capacity of the enlarged lake could be nearly full (384,000 acre-feet) on November 30, 1925, which is the starting scenario given in the Environmental Statement. From 1925 to 1973 the computations compare favorably with those shown in the Environmental Statement, with minor differences due to releases of fish enhancement water. In all cases studied, all fishwater requirements and all existing irrigation requirements were met, and generally from 30,000 to 90,000 acre-feet of extra irrigation water could be available in most years.

INTRODUCTION

Bumping Lake is a storage reservoir that is used to supply irrigation water in the Yakima River basin in south-central Washington. It has a capacity of 33,700 acre-feet and was formed in 1909-1910 by the construction of a dam 45-ft tall at the outlet of a small lake on the Bumping River. The drainage area upstream from the present dam is 69.3 square miles, and the lake capacity is the fifth largest of six storage reservoirs operated in the Yakima River basin by the Water and Power Resources Service (WPRS, formerly U.S. Bureau of Reclamation).

The average annual runoff of the Bumping River at the present Bumping Lake dam (based on the 68-year period of record from 1911 to 1978) is about 213,000 acre-feet. The lowest annual runoff of record was about 92,000 acre-feet in 1977, and the highest was about 327,000 acre-feet in 1956.

WPRS has proposed to enlarge the storage capacity of Bumping Lake to 458,000 acre-feet by building a new dam about a mile downstream to provide additional instream water for fish enhancement and for extra irrigation withdrawals.

Review of the Environmental Statement prepared by WPRS for the enlargement of Bumping Lake has raised a question about the validity of their water-supply analysis because that analysis started with the reservoir about 85 percent full (384,000 acre-feet) on November 30, 1925. The purposes of this study are to determine if the reservoir could have this much storage by late 1925 and to compare the reservoir month-end contents for the period of 1925 to 1973 presented in the Environmental Statement with those determined by this study. The same reservoir operational requirements for Bumping Lake that were used in the analysis for the Environmental Statement were used in this study.

This study was performed by the U.S. Geological Survey (USGS), Tacoma, Washington, and the basic data and computations supporting the data are in the files of the Washington USGS office in Tacoma.

USGS Data

The U.S. Geological Survey has published records of the outflow from the existing Bumping Lake and of the contents of the reservoir in annual Water-Supply Papers for 1910 to 1970 and in annual Water Resources Data Reports for Washington for 1971 to date. The monthly outflow figures, as adjusted for change in storage and previously published, are summarized in Table 1. These adjusted figures represent a close approximation of the natural flow of the Bumping River at the proposed dam site, and were used in the computations for this study.

Environmental Statement Data

The Environmental Statement for the proposed Bumping Lake enlargement presented a chronological graph of month-end contents of the proposed reservoir based on the assumption that the enlarged dam was in place and operating in 1925. The graph starts with the reservoir nearly full (384,000 acre-feet) on November 30, 1925, and proceeds to illustrate the results of imposing certain monthly operational requirements on storage contents through 1973. In effect, the graph represents the cumulative difference between inflow values (adjusted historic quantities of streamflow) and outflow values (the quantities needed to meet old and new operational requirements). These requirements are set forth in the Environmental Statement.

The major requirements on storage, as given in the Environmental Statement, are as follows:

1. The first 33,700 acre-feet of storage is reserved in each irrigation year (November 1 to October 31) to meet the demands of existing irrigation commitments during the year.
2. Of any additional storage available, about 76 percent is for fish enhancement, up to a maximum of 324,300 acre-feet, and about 24 percent is for extra irrigation use, up to a maximum of 100,000 acre-feet.

In addition to those requirements, minimum flows were established for fish enhancement in various sections of the Yakima River and its tributaries. These minimum flow requirements are shown in table 2 as abstracted and converted to units of acre-feet from the Environmental Statement.

TABLE 1.--Monthly discharge of Bumping River at Bumping Lake Dam, adjusted for change in contents of present reservoir

Discharge in thousands of acre feet^{1/}

Yrs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1910-11	12.40	30.40	9.67	8.44	7.65	9.55	19.10	31.40	50.00	14.90	6.10	9.50	209.11
11-12	3.44	11.80	9.24	12.20	12.00	7.44	13.60	48.90	54.00	21.60	7.08	7.30	208.60
12-13	5.91	12.00	9.33	11.00	8.71	8.76	13.60	41.40	66.30	37.50	10.30	7.90	232.71
13-14	9.74	12.60	9.03	26.70	6.00	13.00	28.10	46.10	32.50	13.90	7.80	7.40	212.87
14-15	8.70	30.10	10.30	6.62	3.84	10.00	33.20	20.90	10.80	7.80	6.10	2.01	150.37
15-16	4.55	11.20	9.74	5.54	10.30	19.60	21.90	45.10	79.40	74.80	28.30	10.80	321.23
16-17	5.40	5.85	3.88	4.18	3.56	4.11	6.02	34.40	69.10	56.70	12.60	4.90	210.70
17-18	3.17	3.90	58.80	37.90	10.30	7.79	18.00	32.90	49.90	11.90	5.50	2.60	242.66
18-19	6.28	6.76	15.60	30.60	9.78	6.30	18.20	45.90	46.60	24.10	7.20	4.80	222.12
19-20	2.71	11.10	15.50	17.10	11.40	8.84	6.68	24.90	28.20	11.70	3.90	10.30	152.33
20-21	20.90	18.50	13.60	19.30	18.30	20.30	20.40	47.10	77.50	35.60	8.90	6.40	306.80
21-22	7.64	8.81	40.30	7.60	3.13	3.47	6.54	35.00	62.50	11.50	5.40	2.80	194.69
22-23	4.50	5.00	10.70	22.70	6.80	4.82	21.80	48.50	49.20	26.90	6.90	4.50	212.32
23-24	4.80	6.02	9.61	7.49	32.10	11.40	11.30	49.10	20.50	7.20	5.20	2.80	167.52
24-25	5.57	10.30	19.90	10.20	16.40	7.50	27.40	64.10	42.70	14.00	4.90	2.80	225.77
25-26	2.13	2.45	13.40	11.40	7.62	11.90	27.30	22.40	9.18	3.50	1.90	2.72	115.90
26-27	10.80	10.90	17.20	14.80	8.32	7.09	14.90	44.10	71.90	25.10	6.40	4.50	236.01
27-28	12.30	24.50	16.90	23.20	7.22	15.60	15.70	65.40	35.40	11.70	4.41	4.70	237.03
28-29	4.71	6.26	4.68	3.25	2.55	3.93	6.96	37.20	38.70	11.80	4.80	2.54	127.38
29-30	1.99	1.42	3.98	2.85	13.30	8.27	28.70	30.80	24.10	6.78	4.10	2.10	128.39
30-31	2.13	3.60	2.73	7.06	9.46	10.00	18.40	50.20	18.90	5.80	4.00	1.44	133.72
31-32	2.97	8.23	5.73	7.90	12.80	20.60	21.70	49.50	59.10	22.80	7.30	5.30	223.93
32-33	3.72	27.40	17.70	11.70	5.62	5.92	12.40	32.70	78.80	55.60	13.90	8.30	273.76
33-34	19.42	20.65	66.01	36.44	16.11	35.10	52.44	40.14	18.68	7.63	3.79	3.25	319.66
34-35	14.64	36.23	14.42	18.22	15.46	12.83	12.78	45.56	60.07	19.45	5.79	6.49	261.94
35-36	3.33	3.14	3.39	4.78	3.03	5.07	25.38	71.07	52.63	11.35	5.81	4.79	193.77
36-37	2.82	1.83	5.69	2.82	2.60	3.52	11.59	40.36	68.73	23.05	6.98	2.87	172.86
37-38	4.15	21.23	21.50	16.57	7.18	6.12	25.89	57.77	54.05	13.93	5.58	2.51	236.48
38-39	3.73	4.77	8.66	8.22	4.62	7.38	24.86	48.36	31.85	13.86	5.03	3.56	164.90
39-40	2.69	3.58	17.04	10.76	10.24	16.06	26.18	41.54	18.94	6.83	3.46	2.00	159.32
40-41	3.13	5.94	10.96	6.65	5.27	10.02	21.10	24.91	11.81	4.90	2.58	2.92	110.19
41-42	5.13	11.29	21.89	7.77	4.24	4.72	20.65	30.50	26.25	8.99	4.71	3.54	149.68
42-43	2.16	15.14	14.07	9.25	6.14	8.58	33.15	39.90	58.97	35.90	7.51	4.12	234.89
43-44	3.49	5.36	11.71	4.47	5.47	8.27	13.01	31.32	20.72	6.13	5.05	2.30	117.30
44-45	2.27	4.14	6.33	16.49	13.70	6.45	8.28	51.97	34.38	10.55	4.61	5.83	165.00
45-46	3.44	7.15	8.51	12.09	4.39	5.67	18.50	64.72	61.29	32.47	9.09	3.94	231.26
46-47	7.07	12.81	28.14	9.98	13.21	12.98	26.92	51.81	29.93	11.73	5.49	4.80	214.87
47-48	23.02	17.25	12.98	9.43	7.96	9.53	8.40	48.72	72.23	19.51	6.88	4.50	240.41
48-49	6.47	7.62	8.21	3.29	6.01	11.74	18.73	69.54	59.78	31.00	9.40	4.63	236.42
49-50	8.05	28.69	16.23	9.31	12.20	19.16	17.31	38.74	78.08	54.39	14.70	6.08	302.94
50-51	13.33	24.34	35.44	19.17	24.43	11.31	24.80	58.74	50.32	19.36	6.70	3.52	291.46
51-52	11.70	10.15	10.48	5.52	7.48	5.17	22.37	52.83	38.82	14.71	3.50	2.75	185.48
52-53	1.84	1.87	2.72	29.44	18.83	7.25	12.68	40.78	46.09	36.64	7.91	3.70	209.75
53-54	3.88	9.22	20.85	10.84	6.69	8.71	16.72	53.07	56.07	52.26	14.57	6.47	259.35
54-55	8.18	15.68	9.43	6.78	5.65	5.17	4.88	23.91	68.21	34.79	9.09	5.27	197.04
55-56	19.18	29.58	24.88	12.04	6.12	5.84	21.93	70.27	72.24	48.89	10.41	5.75	327.13
56-57	8.46	10.90	24.60	7.18	7.20	10.55	17.24	68.12	38.31	9.62	4.36	2.74	209.28
57-58	4.42	5.30	7.59	9.80	9.94	9.07	16.46	73.90	39.15	9.25	4.03	3.19	192.10
58-59	5.68	29.87	35.65	19.95	8.68	7.29	21.91	36.85	53.73	20.73	6.08	9.01	255.43
59-60	20.18	25.85	22.90	8.66	11.58	10.80	23.56	37.12	47.78	14.44	4.61	3.13	230.61
60-61	4.33	16.38	8.19	17.39	22.55	13.02	18.99	47.61	70.77	20.29	6.17	4.39	250.08
61-62	5.89	6.60	13.22	17.77	8.96	5.75	26.56	28.78	42.27	19.20	7.06	3.90	185.96
62-63	6.52	22.71	19.32	9.83	25.72	11.31	11.83	30.98	26.43	8.29	4.06	2.77	179.77
63-64	3.36	8.31	9.43	12.01	5.72	4.58	8.23	28.33	72.23	41.31	11.91	5.16	210.58
64-65	6.96	8.91	24.46	13.86	14.50	9.52	28.29	42.21	44.79	14.96	5.65	3.60	217.71
65-66	3.77	6.25	6.84	5.60	3.30	5.29	21.01	48.00	33.63	14.78	4.73	3.42	156.62
66-67	3.62	7.69	22.83	11.56	10.33	6.85	6.47	38.59	68.97	22.16	5.26	3.46	207.79
67-68	14.51	16.51	13.98	22.16	31.90	21.80	11.24	34.80	27.24	19.94	6.20	5.76	226.04
68-69	8.83	19.19	10.24	15.46	4.52	5.55	16.92	66.96	48.83	8.88	3.55	4.44	213.37
69-70	5.82	7.18	5.35	11.97	7.18	9.35	10.11	40.24	56.49	15.01	4.17	3.16	176.03
70-71	3.74	9.13	11.59	13.19	17.49	9.14	10.55	53.89	60.48	49.35	12.46	6.33	257.34
71-72	6.54	8.17	6.39	8.05	14.62	36.84	17.03	60.47	77.96	47.48	15.83	8.91	308.29
72-73	6.79	7.71	22.91	17.74	6.02	5.61	10.81	30.38	20.23	6.62	3.30	2.37	140.49
73-74	4.42	13.83	16.16	36.65	8.08	10.50	16.44	39.80	95.60	54.38	16.52	7.04	319.42
74-75	3.89	6.91	13.15	16.73	8.64	9.95	7.24	40.04	71.94	43.45	10.27	6.37	238.58
75-76	7.78	18.13	47.08	19.42	11.36	6.29	11.65	49.90	47.57	42.41	15.43	7.59	284.61
76-77	4.06	4.72	4.26	6.05	5.52	4.50	13.89	17.96	18.74	4.38	3.16	4.60	91.84
77-78	4.72	21.91	47.50	7.78	5.74	14.58	19.06	33.81	40.06	14.75	5.74	5.75	221.40
Max.	23.02	36.23	66.01	37.90	32.10	36.84	52.44	73.90	95.60	74.80	28.30	10.80	327.13
Min.	1.84	1.42	2.72	2.82	2.55	3.47	4.88	17.96	9.18	3.50	1.90	1.44	91.84
Ave.	6.82	12.48	16.19	13.07	10.06	10.01	18.03	44.07	48.07	22.55	7.24	4.72	213.26

^{1/}Accuracies are to three significant figures for monthly values prior to 1934 and to the nearest ten acre-feet for 1934 and after.

TABLE 2.--Minimum flow requirements for fish enhancement at selected locations in the Yakima River basin

Location	Minimum Flows (acre-feet per month)					
	Nov, Apr, June	Dec, Jan, Mar, May	Feb	Jul, Aug, Oct	Sept	
1. Yakima River near Martin	1490	1540	1390	1540	1490	
2. Kachess River near Easton	0	0	0	0	0	
3. Yakima River near Easton	5950	6150	5550	6150	5950	
4. Cle Elum River near Roslyn	1490	1540	1390	1540	1490	
5. Yakima River at Cle Elum	8330	8610	7780	8610	8330	
6. Teanaway River below Forks	NATURAL FLOW					
7. Yakima River near Bristol	9220	9530	8610	9530	9220	
8. Yakima River at Umtanum	11900	12300	11110	12300	11900	
9. Little Naches River near Nile	NATURAL FLOW					
10. Bumping River near Nile	2980	3070	2780	6390	6190	
11. Naches River near Oak Flat	2980	3070	2780	6390	6190	
12. Tieton River at Tieton Dam	2980	3070	2780	3070	2980	
13. Tieton River below Tieton Canal	2980	3070	2780	3070	2980	
14. Naches River below Tieton River	4170	4300	3890	7620	7380	
15. Yakima River below Parker	10710	11070	10000	14390	13920	
16. Yakima River below Prosser Diversion	14880	15370	13880	18690	18090	
17. Yakima River at Kiona	17850	18450	16660	18450	17850	

The above operational requirements represent, in essence, design specifications for water management with the enlarged reservoir, and those requirements were the guidelines for this study.

METHOD OF ANALYSIS

The method of analysis employed in this study was to sequentially add monthly reservoir inflow to, and subtract monthly reservoir outflow from, the appropriate storage accounts for the period of years from 1917 to 1973. The analysis was based upon the chronological historical flow sequence. That is, no attempt was made to change the historical order in which runoff events occurred.

Monthly inflow from table 1 was added first to the storage account for existing irrigation until that account was full. Any additional monthly inflow was then added to the combined accounts for fish enhancement and extra irrigation in accord with the specified percentages.

Reservoir outflow releases (subtractions from storage) were made monthly in the same order of priority as inflow. The first priority was given for releases to meet the existing irrigation demand. During the months of June through September of each year, a total of 33,700 acre-feet was subtracted from the storage account for existing irrigation.

Monthly releases were then additionally made from any amounts remaining in the storage accounts for fish enhancement and extra irrigation. Extra irrigation water was released in the summer months, but only as available from that 24-percent account. Fish enhancement water was released from that 76-percent account to meet minimum flow requirements throughout each year, never less than the minimum for the Bumping River and never more than the minimum for the Yakima River below Prosser or at Kiona, whichever was greater during a given month (table 2).

Increased evaporation losses for the enlarged reservoir are not taken into account in this study, as the increased losses would be small even if the entire enlarged surface area were always exposed. Using full surface exposure, the additional evaporation losses are estimated to be about 6,000 acre-feet per year, or less than 3 percent of the average annual inflow of the Bumping River, based on records for an evaporation pan located at the existing lake.

RESULTS OF ANALYSIS

Reservoir Contents During Filling

Many alternative inflow and outflow specifications can be imposed as conditions for first filling the reservoir, and a few of these have been examined. Specifying that the enlarged reservoir should be initially filled as rapidly as possible, the approach is to maximize additions to storage by constraining outflows to the minimum that will meet only the most necessary downstream requirements. This specification would require releases for existing irrigation and for fish enhancement only the Bumping River. Using these criteria, if filling were to occur during a period similar to 1933-34, when the highest flows were recorded during the 1911-78 period, the filling time would be 20 months. If runoff conditions were similar to those of 1939-45, the lowest flow period of 7 consecutive years, the filling time would be 68 months.

Realistically, reservoir releases would not likely be curtailed so severely during filling, therefore less severe requirements were imposed on releases from storage to simulate a record of month-end contents during filling of the reservoir to a capacity of 384,000 acre-feet by November 30, 1925. For this examination the following requirements were imposed on the flow releases:

- (1) The usual release of stored water was made to meet existing irrigation requirements.
- (2) Release of additional fish enhancement water was made to meet:
 - (a) Established minimum flow for Bumping River during the months of November through May,
 - (b) Established minimum flow for Yakima River at Prosser during the months of June through September,
 - (c) Established minimum flow for Naches River below Tieton River during the month of October.
- (3) Release of extra irrigation water was made depending on availability of water in that account.

The above requirements were chosen because they closely follow the releases used in the Environmental Statement during the period 1945-49 when the reservoir started at almost empty (about 6,000 acre-feet) and filled to 325,000 acre-feet.

Using the above criteria and beginning storage on November 1, 1917, the reservoir first filled in June 1925, or 92 months later. Figure 1 shows the month-end contents for this period. During the filling period, the existing irrigation requirements were met, fish flow requirements were met except during the first month, and extra irrigation water releases ranged between 30,000 and 45,000 acre-feet per year, averaging about 36,000 acre-feet per year. The average annual inflow during the filling period was about 216,000 acre-feet or 101 percent of the 68-year average.

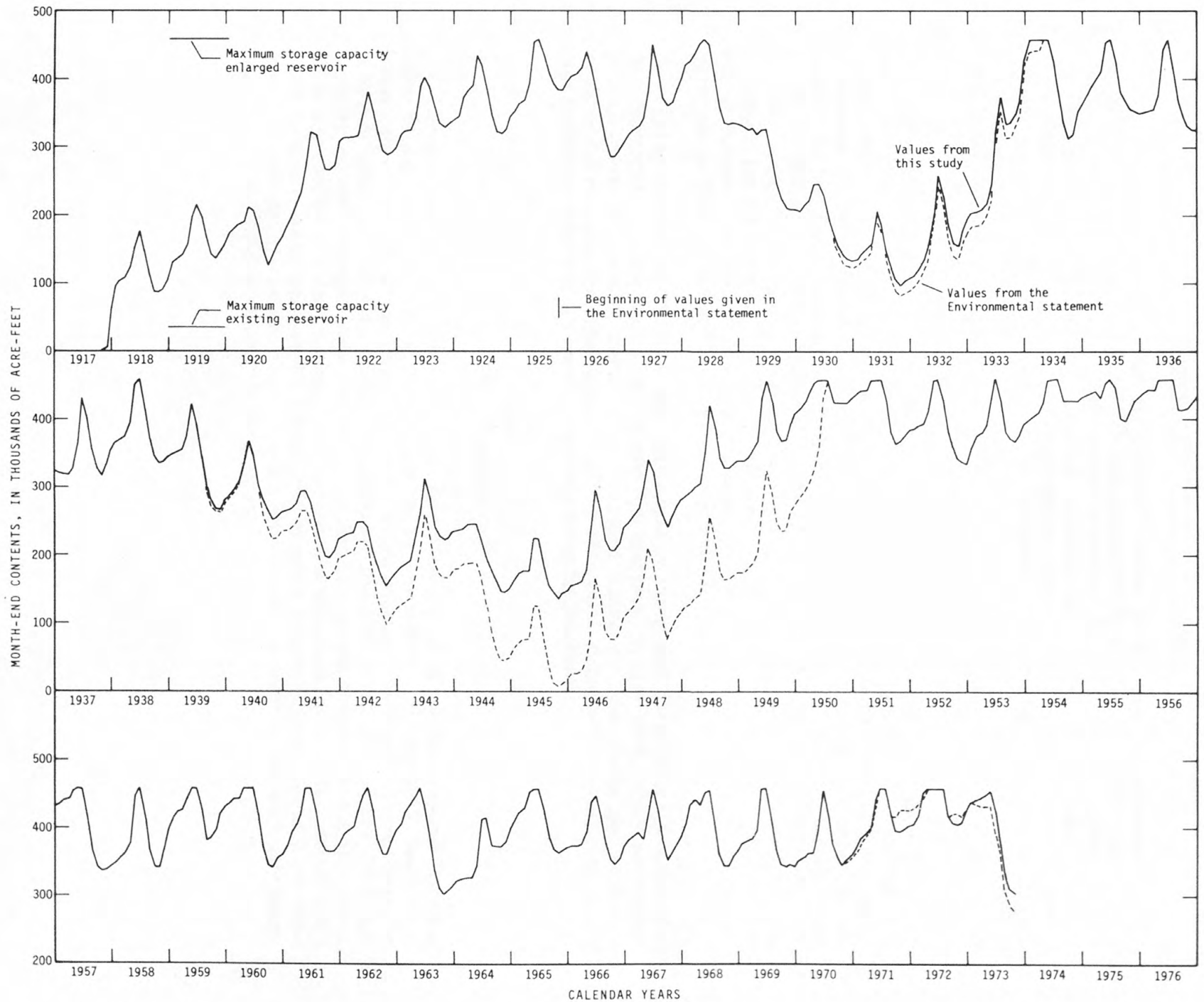


FIGURE 1.--Simulated hydrographs of month-end contents for an enlarged Bumping Lake reservoir, based on recorded historic flows.

Reservoir Contents After Filling

As described under "Method of Analysis", inflow to the enlarged reservoir for the period following initial filling in 1925 was simulated by using values from table 1 and allocating those values to the three storage accounts. Reservoir outflow releases from the storage accounts were also simulated according to the general guidelines described under "Method of Analysis", but additionally were made to agree, with certain exceptions, with the releases used in the Environmental statement. The releases were made to agree because the Environmental Statement analysis gives consideration to the operational scheme for other reservoirs in the Yakima river basin, and there was no basis to alter that scheme as long as the requirements for Bumping Lake water were met.

The simulated record of month-end contents is shown in figure 1 and is compared with the month-end contents given in the Environmental Statement when the two records differ enough to show. During two periods, 1930-34 and 1939-50, differences in month-end contents are apparently due to differences in releases of fish enhancement water. In the Environmental Statement, water was apparently released during those periods at rates greater than the established minimums (table 2). In the post-filling part of this study, water for fish enhancement was in general released in accord with minimums for the Bumping River near Nile for November through May, the Yakima River below Prosser Diversion or at Kiona for June through September, and either the Naches River below Tieton River or the Bumping River near Nile for October.

During one period, 1970-73, the differences in month-end contents are probably due to differences in inflow values used in the two analyses. In late 1970, USGS publication policies were temporarily modified for Bumping Lake, and the discharges were not adjusted for changes in storage contents of the reservoir. Accordingly, unadjusted values may have been inadvertently used in the Environmental Statement.

SUMMARY

Computations to simulate a record of month-end contents for the proposed Bumping Lake enlargement were made for the period of years from 1917 to 1973 based on a historical record of streamflow and on a set of storage allotment requirements for reservoir outflow releases. These computations indicate that the 458,000 acre-feet capacity of the enlarged reservoir could, as described in the Environmental Statement, meet all requirements for existing irrigation and fish enhancement and also provide some extra irrigation water each year. The amount of extra irrigation water would differ from year to year, but the computations indicate that annual amounts might generally range from 30,000 to 90,000 acre-feet for most years.

REFERENCES

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