UNITED STATES
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ANALYSIS OF OPERATIONAL PLAN FOR LAKE CHIPPEWA NEAR WINTER, WISCONSIN

Open-File Report 75-487

Prepared for the United States Department of the Interior, Bureau of Indian Affairs

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ANALYSIS OF OPERATIONAL PLAN FOR LAKE CHIPPEWA NEAR WINTER, WISCONSIN

By W. R. Krug

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Abstract

Historical inflows into Lake Chippewa for 39 years of record were analyzed to determine the possibility of operating the flowage within a 2-foot (0.6-metre) range of stage while maintaining a minimum discharge of 57 cubic feet per second (1.6 cubic metres per second) and limiting the maximum discharge to 7,000 cubic feet per second (200 cubic metres per second). This proposed operating plan could be followed successfully most of the time. Some periods of low flow, mainly in winter, would require drawdowns below the minimum stage to maintain the minimum discharge. Occasional large floods occurring about once in 5 years would require surcharges over the maximum stage to limit the maximum discharge. The flowage could be filled from minimum to maximum stage within 45 days (frequently fewer) starting from April 1.

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Introduction

The Secretary of the Interior, on behalf of the Lac Courte Oreilles Band of Lake Superior Chippewa Indians, has recommended that the United States recapture the Chippewa Reservoir Project No. 108 (Lake Chippewa, commonly called Chippewa Flowage) and limit the fluctuation of water level on the Chippewa Flowage to a maximum of 2 ft (0.6 m). The United States Forest Service is preparing a comprehensive land-use plan for the Flowage and adjacent lands and has requested an analysis of a proposed operational plan that would maintain the Flowage at specified constant elevation and still meet other operating restrictions.

The purpose of this report is to present the results of a hydrologic evaluation of a proposed operational plan for Lake Chippewa. The study was done in cooperation with the Bureau of Indian Affairs.

Lake Chippewa is in northwestern Wisconsin (fig. 1). The Flowage has a total basin area of 775 mi^2 (2,007 km^2) and is drained mainly by

Figure 1 (caption next page) near here.

the East Fork Chippewa River and the West Fork Chippewa River (fig. 2).

Figure 2 (caption next page) near here.

The basin includes extensive marshlands and lakes, especially in the area drained by the West Fork Chippewa River.

Figure 1.--Location of Lake Chippewa in Wisconsin.

Figure 2.--Drainage basin of Lake Chippewa.

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The operating plan studied included the following constraints:

1. A constant winter-pool elevation of 1,310.0 ft (399.29 m).
2. A constant summer-pool elevation of 1,312.0 ft (399.90 m).
3. A uniform rise of pool elevation from winter to summer in April and May.
4. A legal minimum discharge of 57 ft^3/s (1.6 m^3/s) (with several alternatives studied if this legal requirement is changed).
5. A maximum discharge of 7,000 ft^3/s (200 m^3/s) (assumed because historic operation has not greatly exceeded that discharge).

The timing of drawdown in the fall was not specified, as there should be no problems involved in making the drawdown.

Four potential problems were studied:

1. Maintaining a constant pool elevation while releasing at least the legal minimum discharge.
2. Filling the pool to its summer elevation in the prescribed time.
3. Maintaining a constant pool elevation without exceeding the maximum discharge.
4. Minimizing adjustments to the gates at the dam in winter, when they are frozen, while maintaining the pool elevation.

It was determined that the constraints could not be met exactly for each potential problem. This report presents the probability of failure to meet these constraints.

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

Multiply English unit	By	To obtain metric unit
feet (ft)	0.3048	metres (m)
square miles (mi^2)	2.590	square kilometres (km^2)
cubic feet per second (ft^3/s)	2.832×10^{-2}	cubic metres per second (m^3/s)

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Streamflow Data

The data analyzed in this study were obtained from the Inland Lakes Demonstration Project (Dave Daniel, written commun., 1975). These data had been computed from records of daily streamflow collected just downstream from the dam by the U.S. Geological Survey and from daily stage on the Flowage. Outflow records were adjusted for daily change in storage to produce net inflow into the Flowage for the period June 1, 1930, to December 31, 1968.

The daily computed net inflow often changed erratically from day to day. This was caused by the nature of the stage records. Stage has normally been read to tenths of a foot (0.03 m) only. The Flowage is so large that a change of 0.1 ft (0.03 m) in a day is equivalent to a flow of about 700 ft^3/s (20 m^3/s), nearly the mean flow for the river. In addition, wind setup can make the stage at the dam noticeably higher or lower than the mean stage of the Flowage. This produces fluctuations in the computed net inflow that are completely fictitious.

The computed net inflow for any date may be in error by $\pm$ 700 ft^3/s (20 m^3/s) or even more, but the average of several consecutive days should be nearly correct. The errors introduced in converting changes in stage on the Flowage into discharge will average to zero over a period of time. The errors also will be relatively small when flow is large. Therefore, the values of daily discharge for flood peaks will be good.

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Maintaining Minimum Discharge

The computed net-inflow data were analyzed by digital computer to determine the storage required to maintain the minimum release in each year. In every year, some drawdown below the desired stage would be required to maintain a legal minimum release of 57 ft^3/s (1.6 m^3/s). In half of the years, a drawdown of 0.32 ft (0.10 m) or greater would be required to maintain that release. In 1 year in 10 a drawdown of 0.81 ft (0.25 m) or greater would be required. If the minimum release were increased to 100 ft^3/s (2.8 m^3/s), the required drawdowns would increase to 0.50 ft (0.15 m) or more once in 2 years, and 1.08 ft (0.33 m) once in 10 years. Frequency curves of drawdown versus recurrence interval for several minimum release rates are shown in figure 3.

Figure 3 (caption next page) near here.

The drawdown curves are computed assuming the pool started at the winter elevation of 1,310.0 ft (399.29 m), because the minimum annual inflow occurs in winter nearly every year.

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Figure 3.--Frequency of drawdown required to maintain minimum discharge.

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Filling Reservoir

Mean flows in April and May were studied to determine the probability of filling the Flowage to 1,312.0 ft (399.90 m) within various periods of those months. For these analyses, a minimum outflow of 57 ft^3/s (1.6 m^3/s) was used. This flow has been used in previous investigations as the legal minimum release that is defined as 25 percent of the natural low flow.

Flow for the period May 1-31 would fail to fill the Flowage to the summer elevation of 1,312.0 ft (399.90 m) about 2 years in every 17 years and would fail to fill the Flowage to an elevation of 1,311.0 ft (399.59 m) about 1 year in 50. Using flows from the period April 16-May 15, the Flowage would fail to be filled about 1 year in 50. Flow from the period April 1-30 would fail to fill the Flowage about 1 year in 80. Flows for the longer period April 1-May 15 would fill the Flowage every year.

To fulfill these probabilities in actual operation would require advance knowledge of future flows. To approach these probabilities would require filling the Flowage more rapidly early in the period in anticipation of a possible flow deficiency later in the filling period.

Frequency curves of the elevation to which the Flowage could be filled while maintaining the minimum release versus recurrence interval for these four periods are shown in figure 4.

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Figure 4.--Frequency of elevation to which Flowage could be filled within the indicated periods, assuming a constant release of 57 cubic feet per second (1.6 cubic metres per second) and a starting elevation of 1,310 feet (399.29 metres) above mean sea level.

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Maintaining Pool Elevation Without Releasing More Than 7,000 ft^3/s (200 m^3/s)

—Five floods in the 39-year period of record had inflows of more than 7,000 ft^3/s (200 m^3/s). All of these would have required a surcharge above the desired pool elevation if outflow had to be maintained less than or equal to 7,000 ft^3/s (200 m^3/s). The surcharge would be 0.2 ft (0.06 m) or more 1 year in 10, 0.5 ft (0.15 m) or more about 1 year in 22, and 1.0 ft (0.3 m) or more about 1 year in 40.

A frequency curve of the surcharge required to limit maximum discharge to 7,000 ft^3/s (200 m^3/s) is shown in figure 5. The surcharges

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Figure 5 (caption next page) near here.

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shown in figure 5 were computed assuming the Flowage to be at 1,312.0 ft (399.90 m) at the start of the flood.

Some quantitative flood-warning system would be required for successful operation of the Flowage in time of floods. Such a system could include continuous streamflow monitoring on the principal tributaries (for instance, the East Fork Chippewa River and the West Fork Chippewa River) and several recording rain gages within the basin. These would be able to give sufficient warning of approaching major floods to enable the operators to begin opening the gates before the Flowage level begins to rise. These gaging stations, equipped with a telemetering system, also would be beneficial for the daily operation of the Flowage.

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Figure 5.--Frequency of surcharge required to limit maximum discharge.

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Winter Operation

Winter operation of the Flowage to maintain a constant pool elevation presents some problems. Freezing of the gates makes it difficult to change the outflow during the winter. The problem is eased somewhat by the fact that inflow is more constant in winter than in summer.

An analysis of mean flows for December, January, and February showed that the mean January inflow averaged about one-half of the mean December inflow, and the mean February inflow averaged about one-half of the mean January inflow. Based on this fairly constant recession rate, it would be possible to predict inflow to the Flowage for any given period during the winter provided the inflow for the preceding 30 days was known. Using these relations to set the gates on January 1 and February 1, the elevation of the Flowage would rise or fall less than 0.5 ft (0.15 m) in January and less than 0.7 ft (0.2 m) in February for two-thirds of the time. The greatest rises and falls in the period of record (if this operating procedure had been used) would have been about 1-1/4 ft (0.4 m).

If some deviation from the target elevation of 1,310.0 ft (399.29 m) can be permitted, operation of the gates could be minimized. A relation similar to the one above could be developed in more detail and used to set the gate openings. The gates then could be left unchanged until deviation from the target elevation becomes excessive. Then a new projection of discharge could be computed and the gates adjusted accordingly.

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Summary

In most cases, the operational plan for the Flowage could be followed successfully. On some occasions, there would be too much or too little inflow to satisfy all of the constraints in the operation plan. Day-to-day operation of the Flowage according to the operational plan would require continuous streamflow monitoring on major tributaries to the Flowage.

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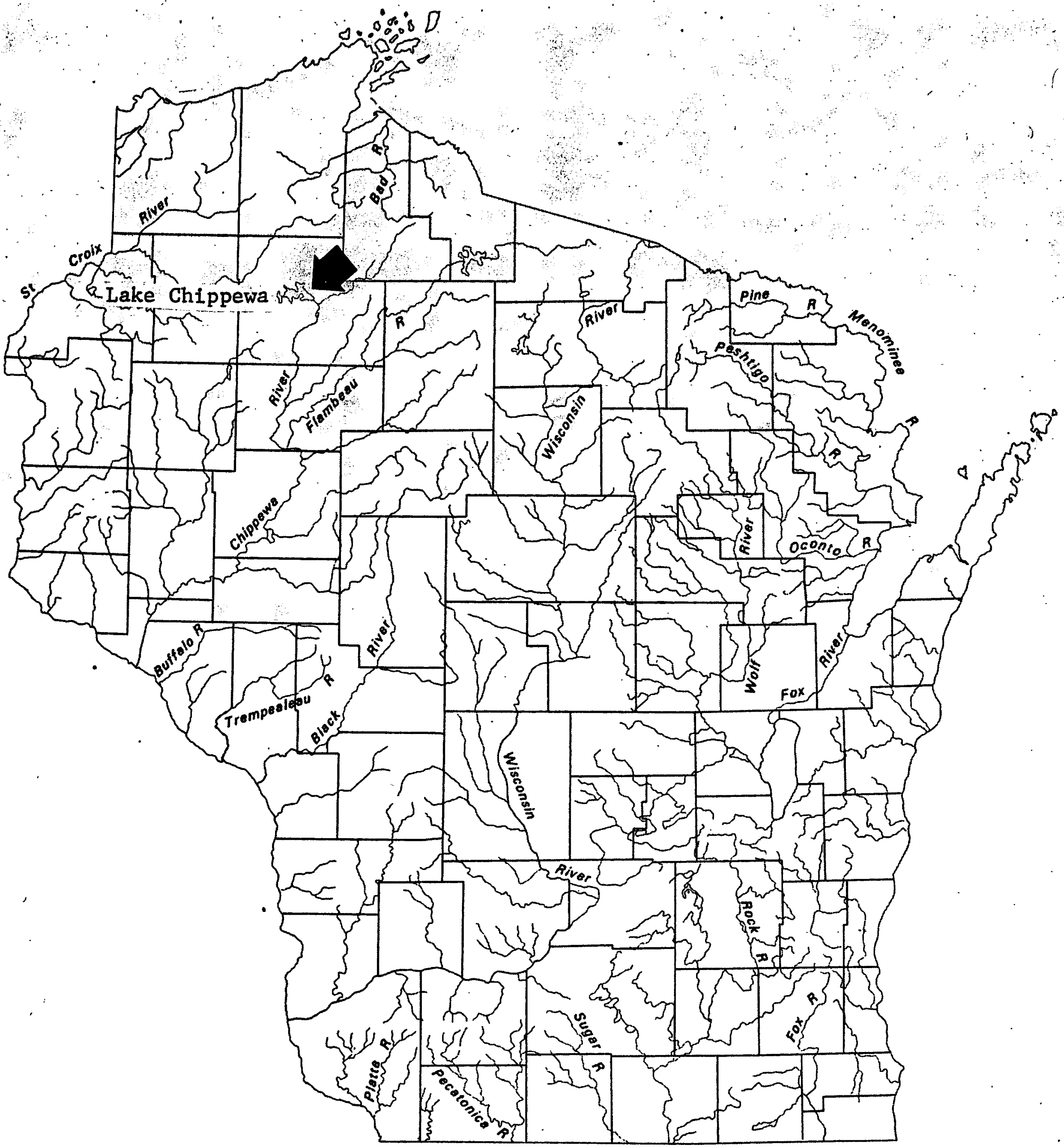

Figure 1. Location of Lake Chippewa in Wisconsin.

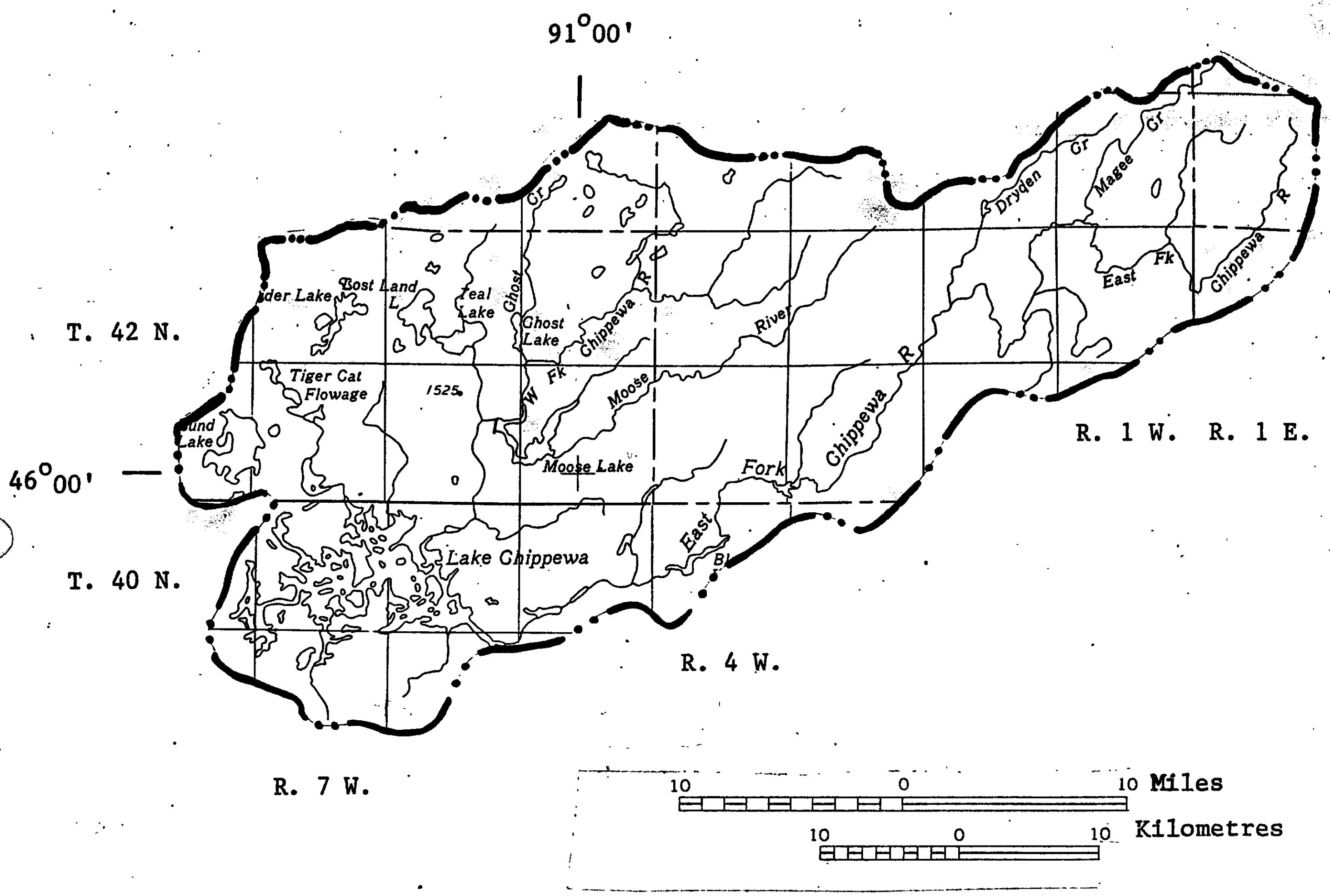

Figure 2. Drainage basin of Lake Chippewa.

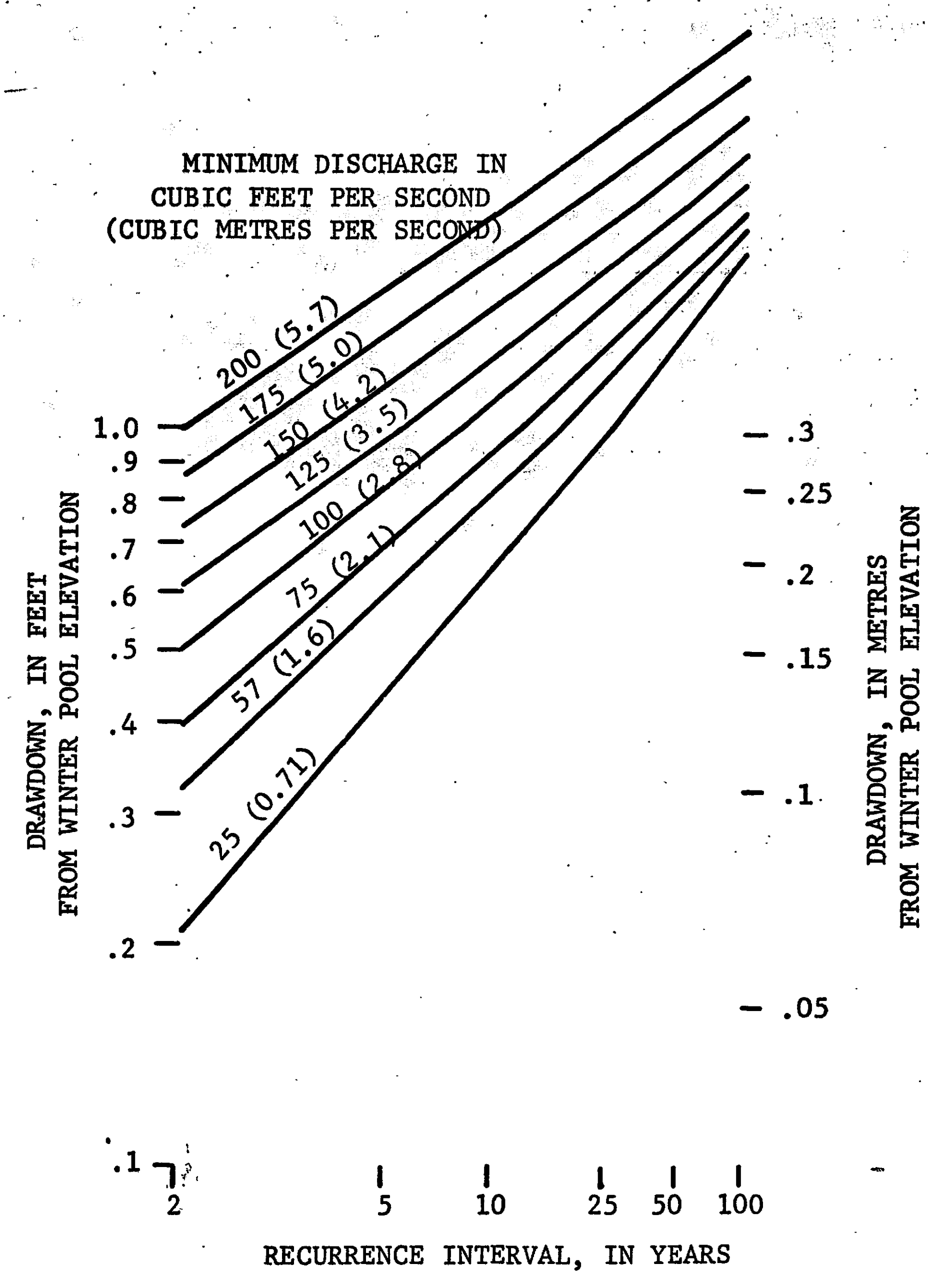

FIGURE 3.--Frequency of drawdown required to maintain minimum discharge.

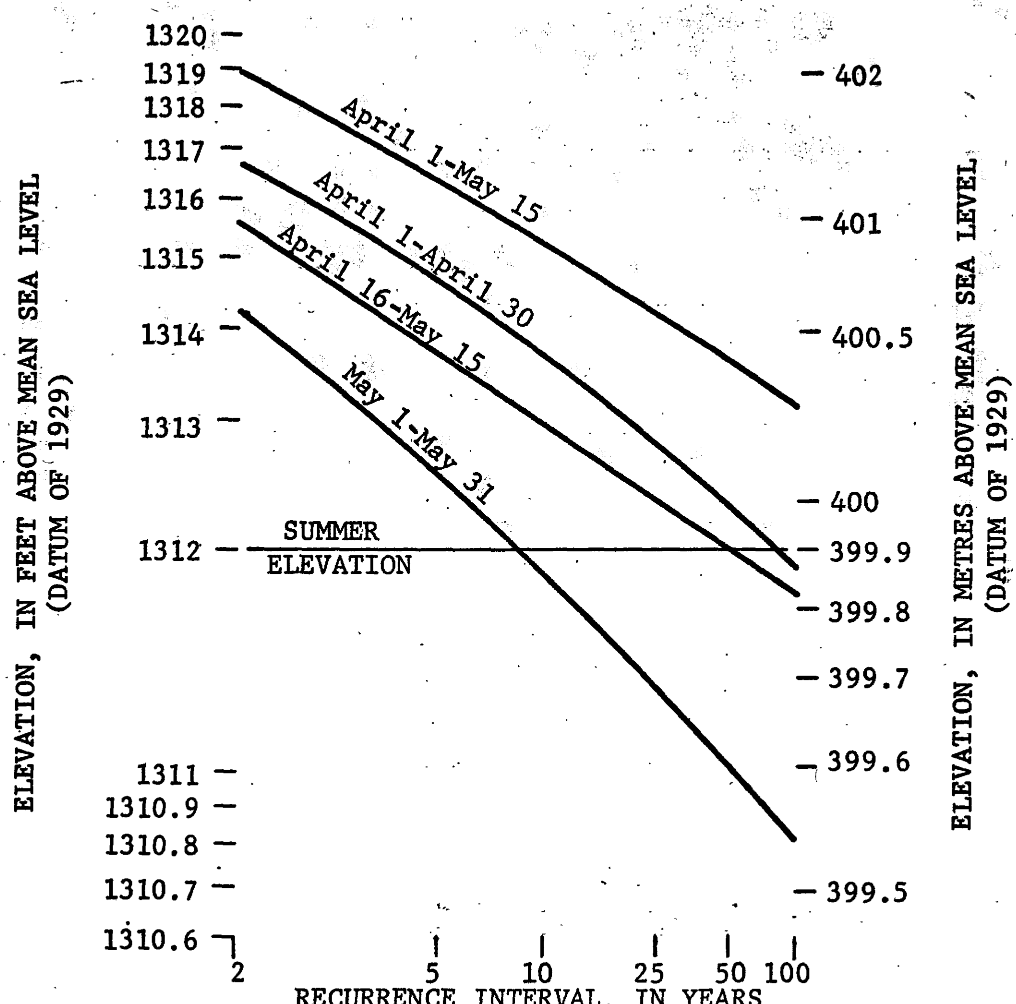

FIGURE 4.--Frequency of elevation to which Flowage could be filled within the indicated periods, assuming a constant release of 57 cubic feet per second (1.6 cubic metres per second) and a starting elevation of 1310 feet (399.29 metres) above mean sea level.

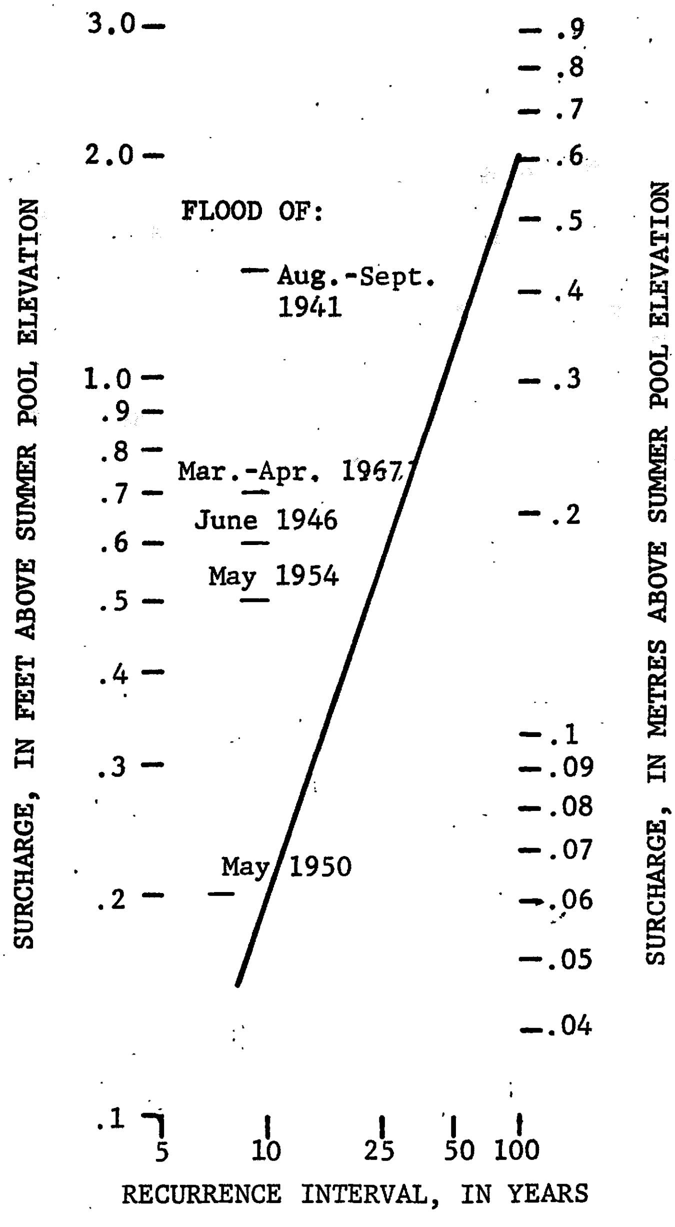

FIGURE 5.--Frequency of surcharge required to limit maximum discharge.