

# GROSS RESERVOIR HYDROELECTRIC PROJECT NO. 2035-030

Hydrology – November 7, 2008

## STUDY AREA BOUNDARY

This study area includes the current FERC project boundary and the areas where the proposed enlargement would extend past the current FERC boundary.

## DATA SOURCES

Denver Water's raw water operations section maintains daily records and water rights accounting sheets for Gross Reservoir elevation, contents, and outflow.

## EXISTING ENVIRONMENT

The South Boulder Creek watershed elevation rises to approximately 11,000 feet along the Continental Divide. The catchment area has steep, rugged slopes and is heavily timbered. Snowfall is responsible for most of the surface runoff. The drainage area of South Boulder Creek above Gross Reservoir is approximately 59,675 acres.

Gross Reservoir, about 5 miles southwest of Boulder in Boulder County, provides storage for Denver Water's trans-mountain diversions through the Moffat Tunnel and for native flows in South Boulder Creek. West Slope water is conveyed through the Moffat Tunnel to South Boulder Creek and then down to Gross Reservoir. Water released from Gross Reservoir flows downstream about 4.8 miles to the South Boulder Diversion Intake Dam. From there, the water is transported about 10 miles by conduit to Ralston Reservoir, which provides operational storage for Denver Water's northern treatment system. Denver Water passes water belonging to other entities with senior water rights through Gross Reservoir and by the South Boulder Diversion Intake Dam.

South Boulder Creek just upstream of Gross Reservoir is approximately 25 feet wide. Immediately downstream from Gross Reservoir, South Boulder Creek is approximately 25 feet wide with a gradient of 6 percent. Average water depths in South Boulder Creek are less than 2 feet. Two additional drainages, Forsythe Canyon and Winger Gulch, provide perennial flow to Gross Reservoir (Plate 5.1.1).

Gauging points on South Boulder Creek include a parshall flume below Gross Reservoir, a USGS gage below the South Boulder Diversion Intake Dam near Eldorado Springs, a Denver Water gage at Moffat Tunnel, and a gage maintained by Denver Water at Pinecliffe.

On December 12, 1980, the Colorado Water Conservation Board (CWCB) appropriated a summer in-stream flow of 15 cfs and a winter flow of 6 cfs in South Boulder Creek from the outlet of Gross Reservoir to the USGS gage just downstream from the Denver Water diversion. The segment from the USGS gage to the South Boulder Creek Road Bridge has a minimum in-stream summer flow of 15 cfs and winter flow of 2 cfs. These are the only minimum in-stream flow rights for South Boulder Creek.

### Gross Reservoir

Gross Reservoir first began storing water on June 19, 1955. It has an active capacity of 41,810 acre-feet and serves as combination storage and regulating facility for water diverted through the Moffat Tunnel.

Figures 1 to 12 of Appendix A illustrate the mean historical daily reservoir contents by month. Figure 13 illustrates the mean monthly contents of Gross Reservoir. Figures 14 to 25 illustrate the mean daily reservoir elevation by month. Figure 26 illustrates the mean monthly elevation at Gross Reservoir for the period 1955 to 1991. Data used to develop these figures are from past hydrologic records. These Figures were provided to the FERC in Denver Water's recent re-licensing effort for Gross Reservoir.

No daily records were located for water stored in Gross Reservoir for the period June 19, 1955, through June 30, 1956. The only record of Gross Reservoir contents was from semimonthly readings for Gross Reservoir starting June 30, 1955, and going through March 31, 1956. The daily contents for Gross Reservoir were estimated from these semimonthly readings by calculating the change in storage at Gross and subtracting water diverted at South Boulder Canal (below Gross Reservoir) from Moffat Tunnel (above Gross Reservoir) water flows. The resulting contents were, in turn, adjusted to conform with the semimonthly readings. For the period July 1, 1956, through September 30, 1991, Gross Reservoir contents are those values recorded on Denver Water's raw water operations section's Gross Reservoir Accounting Sheets.

Gross Reservoir elevation data come from Denver Water's raw water operations section Gross Reservoir Accounting Sheets. No adjustments were made to these data.

### South Boulder Creek Below Gross Reservoir

A parshall flume located below Gross Reservoir is used to measure the outflow from Gross Reservoir. In the early years of Gross Reservoir's operation, a 1-foot parshall flume was temporarily installed within the main parshall flume during winter months to measure low flow periods.

Figures 27 to 38 of Appendix A illustrate the mean daily outflow from Gross Reservoir by month, and Figure 39 illustrates the mean monthly outflow from Gross Reservoir.

The source of the Gross Reservoir outflows are those values recorded on the Gross Reservoir Accounting Sheets in the column labeled "South Boulder Creek, Gage Below Gross Dam – Charts." If the Chart column was blank, the column labeled "South Boulder Creek, Gage Below Gross Dam – Telephone" was used. The chart value is considered to be more accurate because it is read directly from the gage chart, whereas the telephone value is read daily by field personnel and phoned into Denver Water's raw water operations office for daily operations purposes.

### Proposed Operational Hydrology

Operation of the hydropower portion of the project will be ancillary to the operation of Gross Reservoir for municipal water supply purposes (see Section 4.2). The proposed increase in dam height (125 feet) would increase the reservoir volume to approximately 114,000 acre-feet. Fluctuation patterns in reservoir level and content would be similar to existing operations. The reservoir would be at its lowest level at the end of April and reach its highest level in June or July (Appendix B, Figures 1 to 12). Then, the reservoir would be drawn down through the late summer, fall, and winter months. However, the proposed increase would provide a more reliable water supply and allow Denver Water to operate the Moffat Treatment Plant at 30 mgd during the winter. Without this additional supply, the plant would need to be shut down for a portion of the winter. The year-round operation of the Moffat Treatment Plant would reduce the storage in Gross Reservoir by approximately 4,000 acre-feet per month in the winter months of December through February. The greatest differences in reservoir contents would occur during wet years following a drought as the reservoir is refilled.

Figures 1 to 12 of Appendix B illustrate the mean daily reservoir contents by month for the proposed project. Figure 13 illustrates the mean monthly contents of Gross Reservoir. Figures 14 to 25 illustrate the mean daily reservoir elevation by month. Figure 26 illustrates the mean monthly elevation at Gross Reservoir. These figures were developed using data developed by Denver Water's Platte and Colorado Simulation Model (PACSM) and uses past hydrology to predict what may occur in the future.

Outflow patterns from Gross Reservoir would be similar to existing conditions. From May through August outflow is increased to meet Moffat Treatment Plant demand. Then, in the remainder of the year, outflow is reduced to reflect the decreased demand typically seen during the non-irrigation season. Outflows from Gross Reservoir would increase on average as the total volume of water delivered from Gross Reservoir to Ralston Reservoir via the South Boulder Canal would increase. However, the maximum and minimum flows, and the ramping guidelines currently in place would not be modified by the proposed project.

Figures 27 to 38 of Appendix B illustrate the mean daily outflows by each month. Figure 39 shows the mean monthly reservoir outflow. Mean Monthly Natural flow is shown in Figure 40 and Frequency Exceedance curves for Outflow, Reservoir contents and Reservoir Elevation are shown in Figures 41 to 43. These figures were also developed using data developed by PACSM and uses past hydrology to predict what may occur in the future.

#### DESCRIPTION OF PROPOSED STUDIES AND THE PROPOSED METHODOLOGIES TO BE EMPLOYED

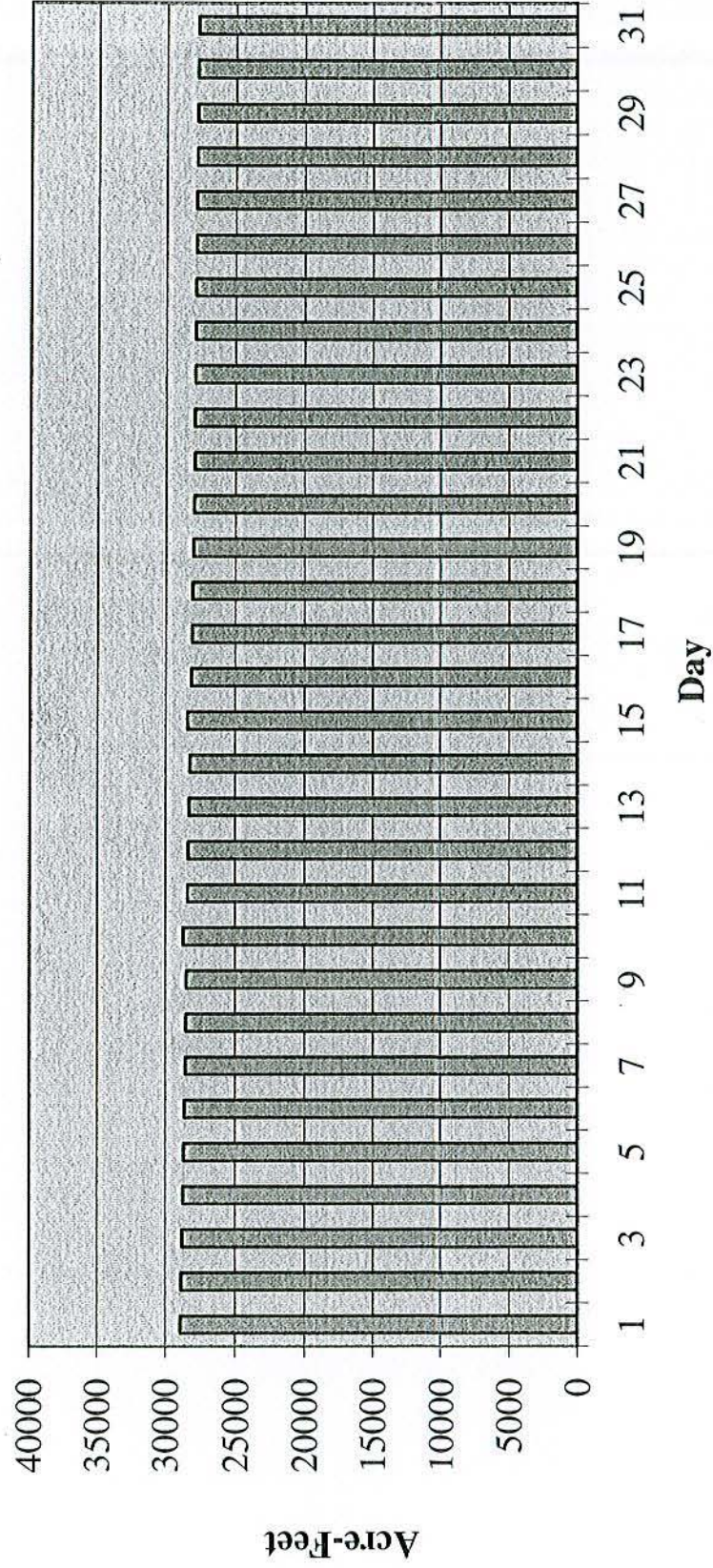
Nearly 50 years of hydrological data on project operations are available from Denver Water records, and South Boulder Creek flows are currently gaged in a number of locations described above. Because there are operational changes proposed for Gross Reservoir under the license amendment, including hydroelectric generating capabilities, and an increase in the volume of water delivered to the South Boulder Canal, new studies to describe project hydrology are planned.

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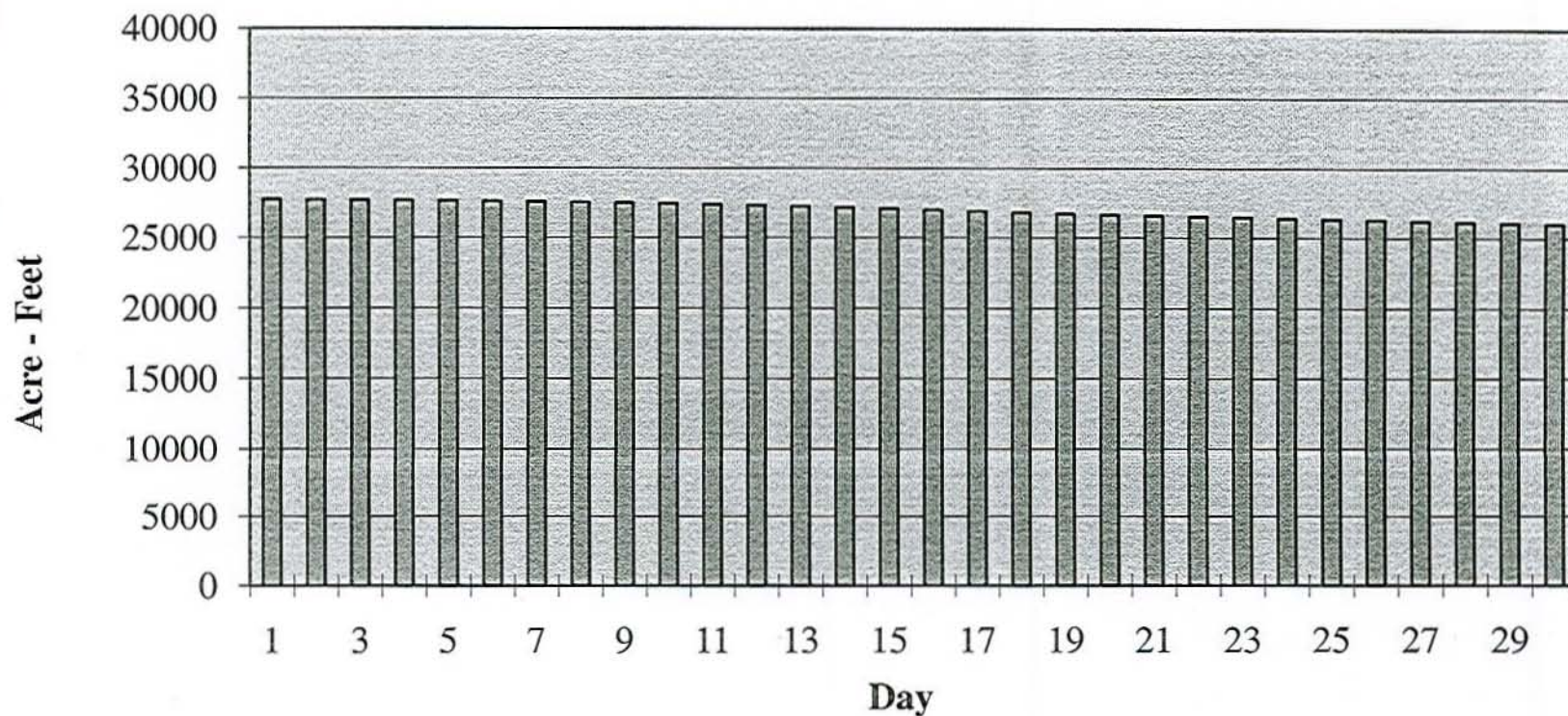
Appendix A

# Mean Daily Gross Reservoir Contents for October (Water Years 1955 through 1991)



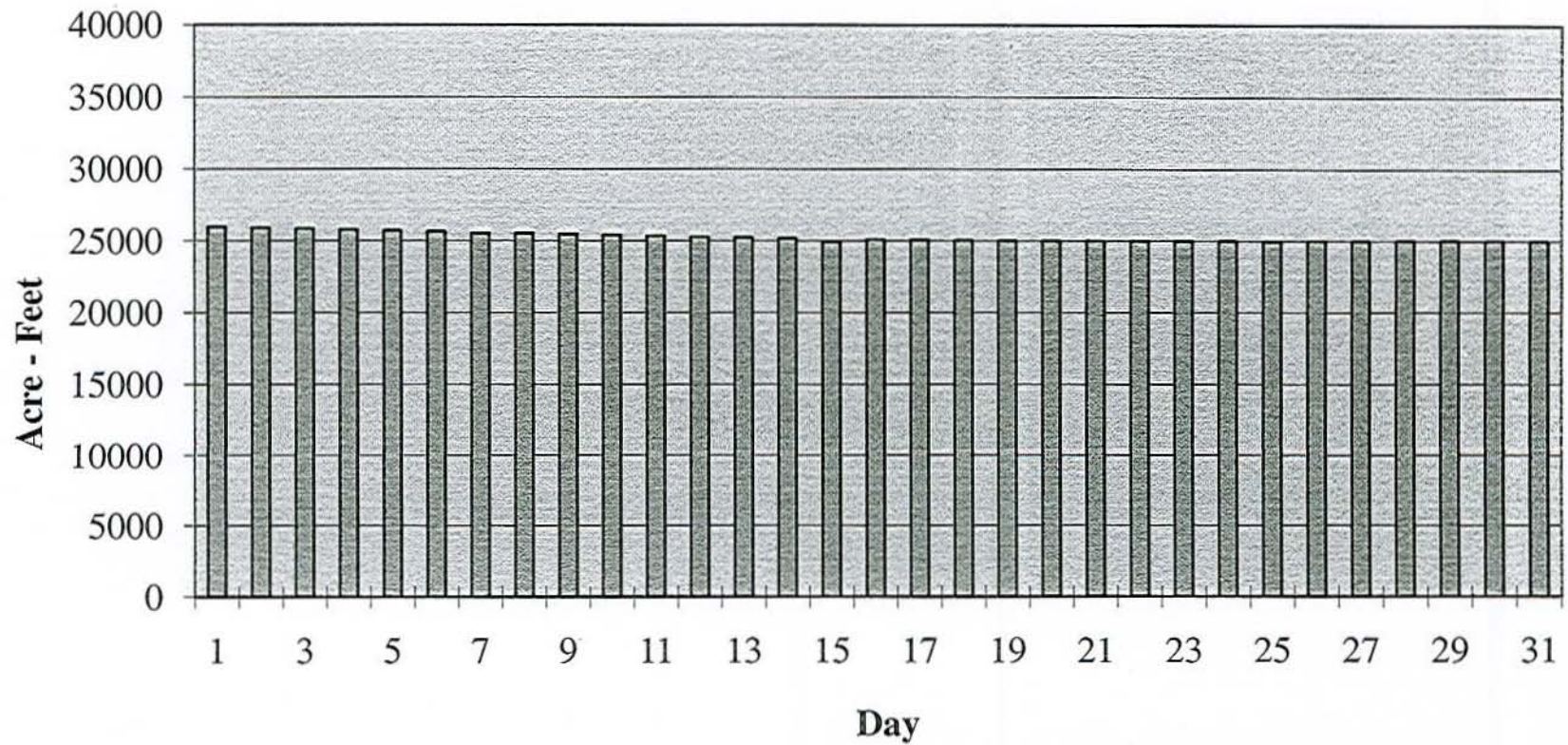
Note: Storage began on June 19, 1955.

### Mean Daily Gross Reservoir Contents for November (Water Years 1955 through 1991)



Note: Storage began on June 19, 1955.

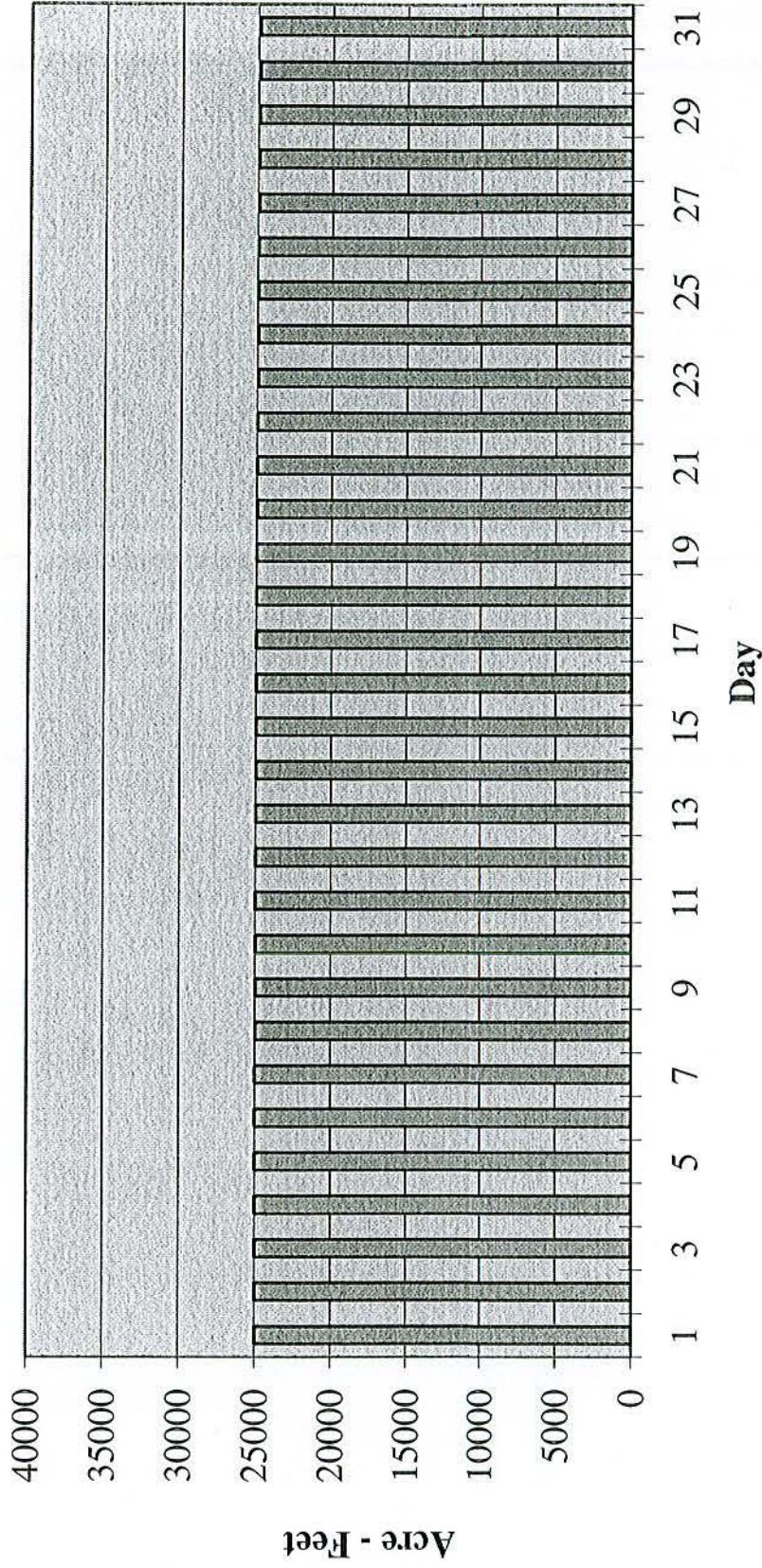
### Mean Daily Gross Reservoir Contents for December (Water Years 1955 through 1991)



Note: Storage began on June 19, 1955.

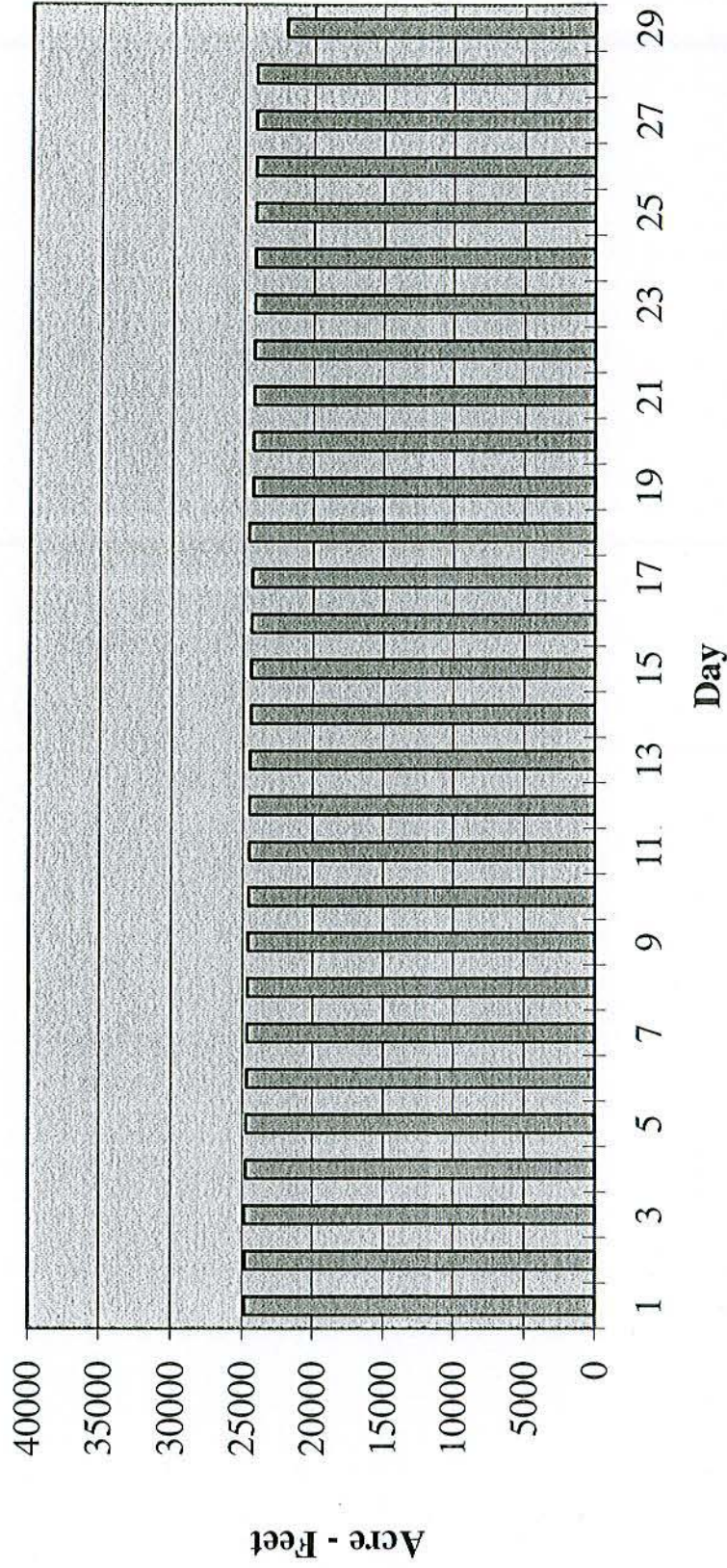


**Mean Daily Gross Reservoir Contents  
for January  
(Water Years 1955 through 1991)**



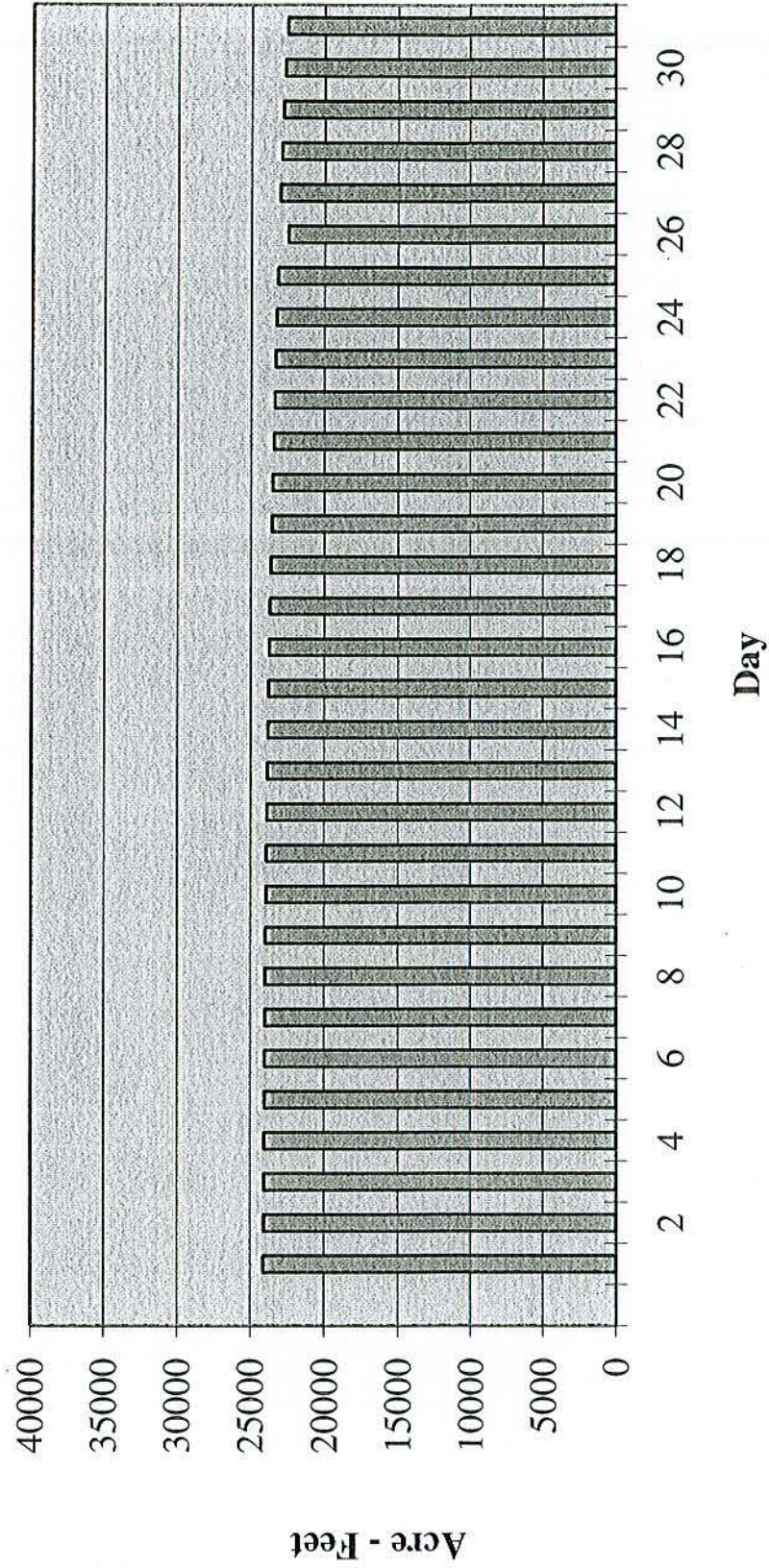
Note: Storage began on June 19, 1955

## Mean Daily Gross Reservoir Contents for February (Water Years 1955 through 1991)



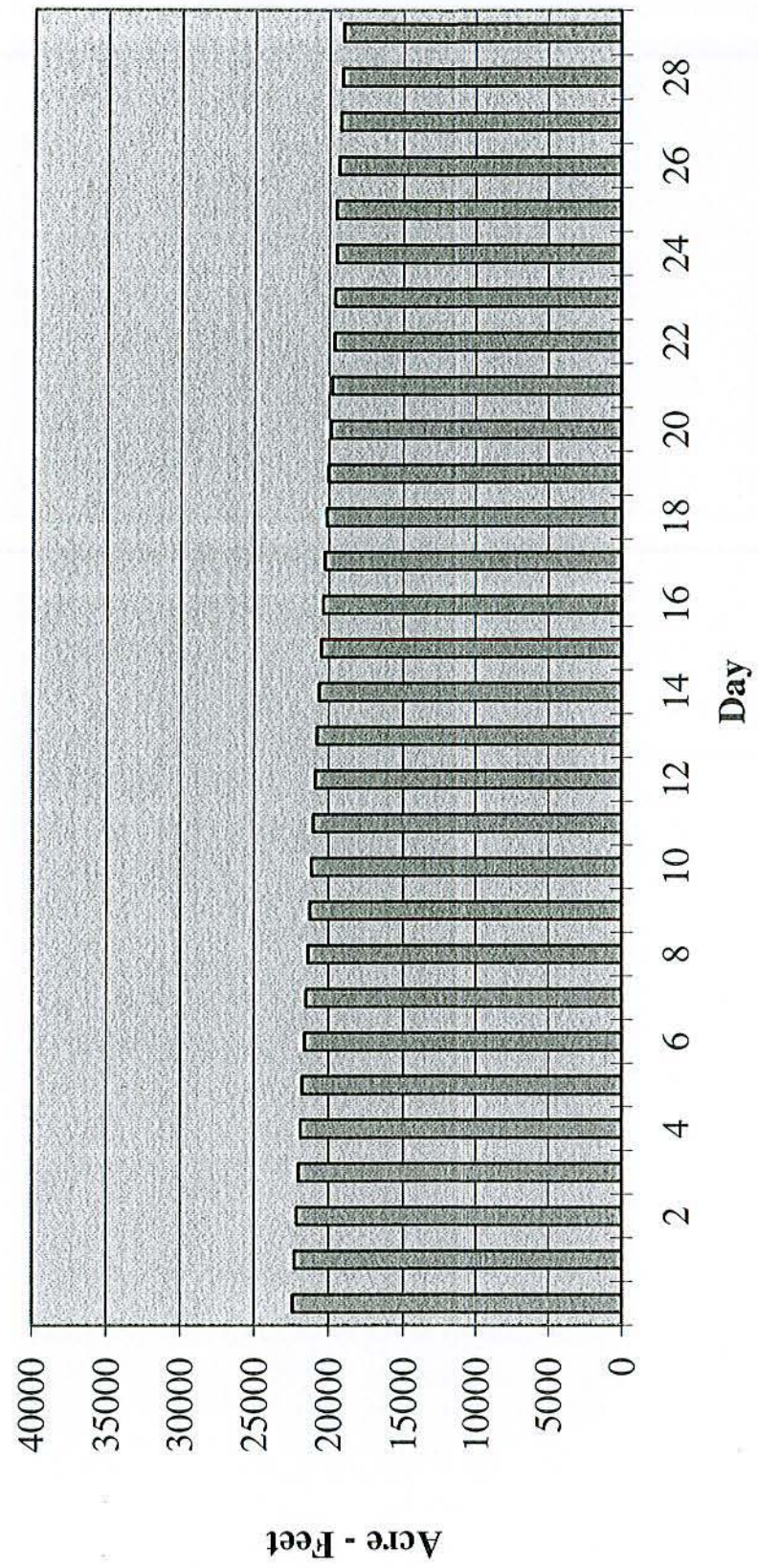
Note: Storage began on June 19, 1955.

## Mean Daily Gross Reservoir Contents for March (Water Years 1955 through 1991)



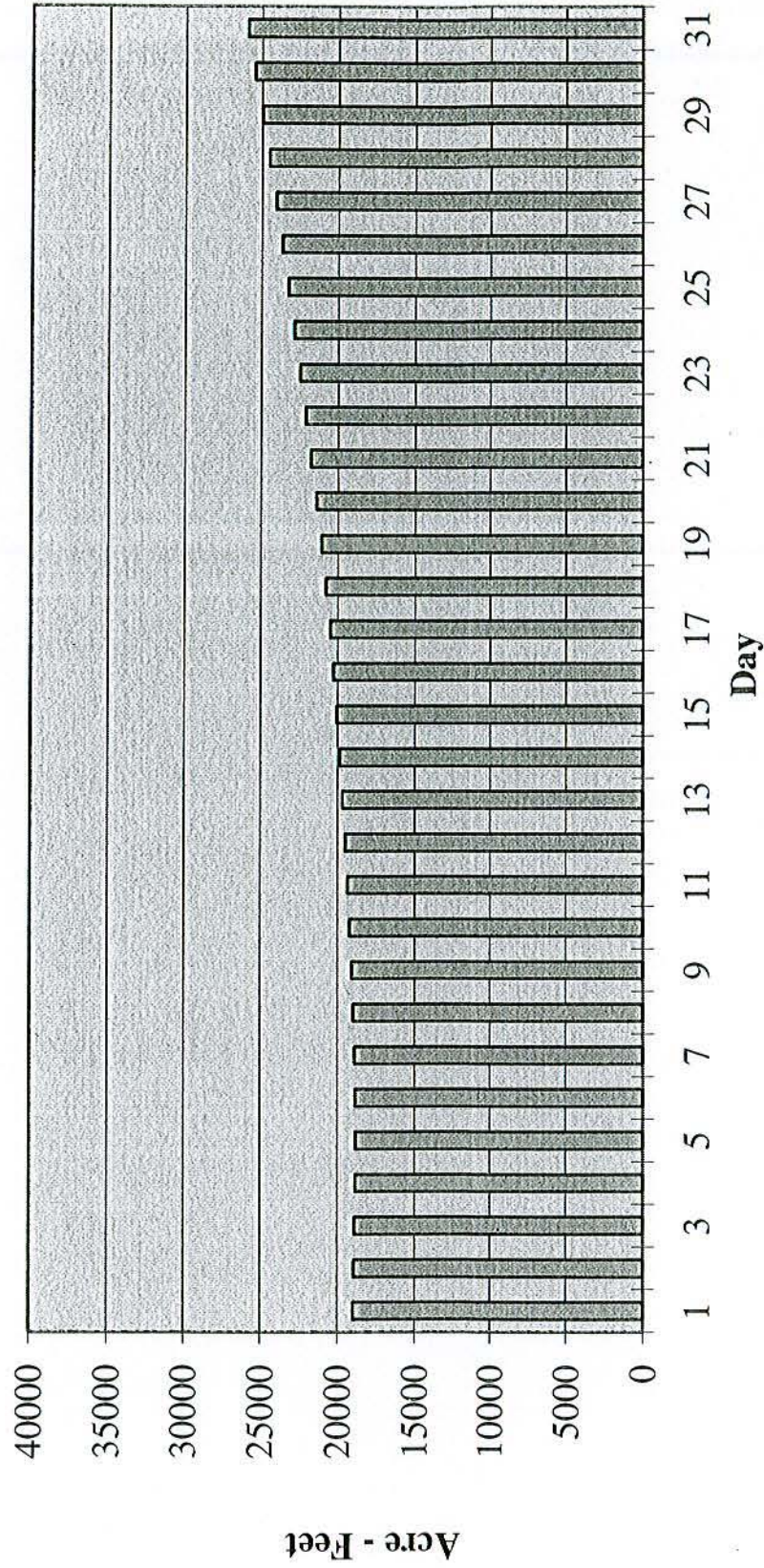
Note: Storage began on June 19, 1955.

**Mean Daily Gross Reservoir Contents  
for April  
(Water Years 1955 through 1991)**



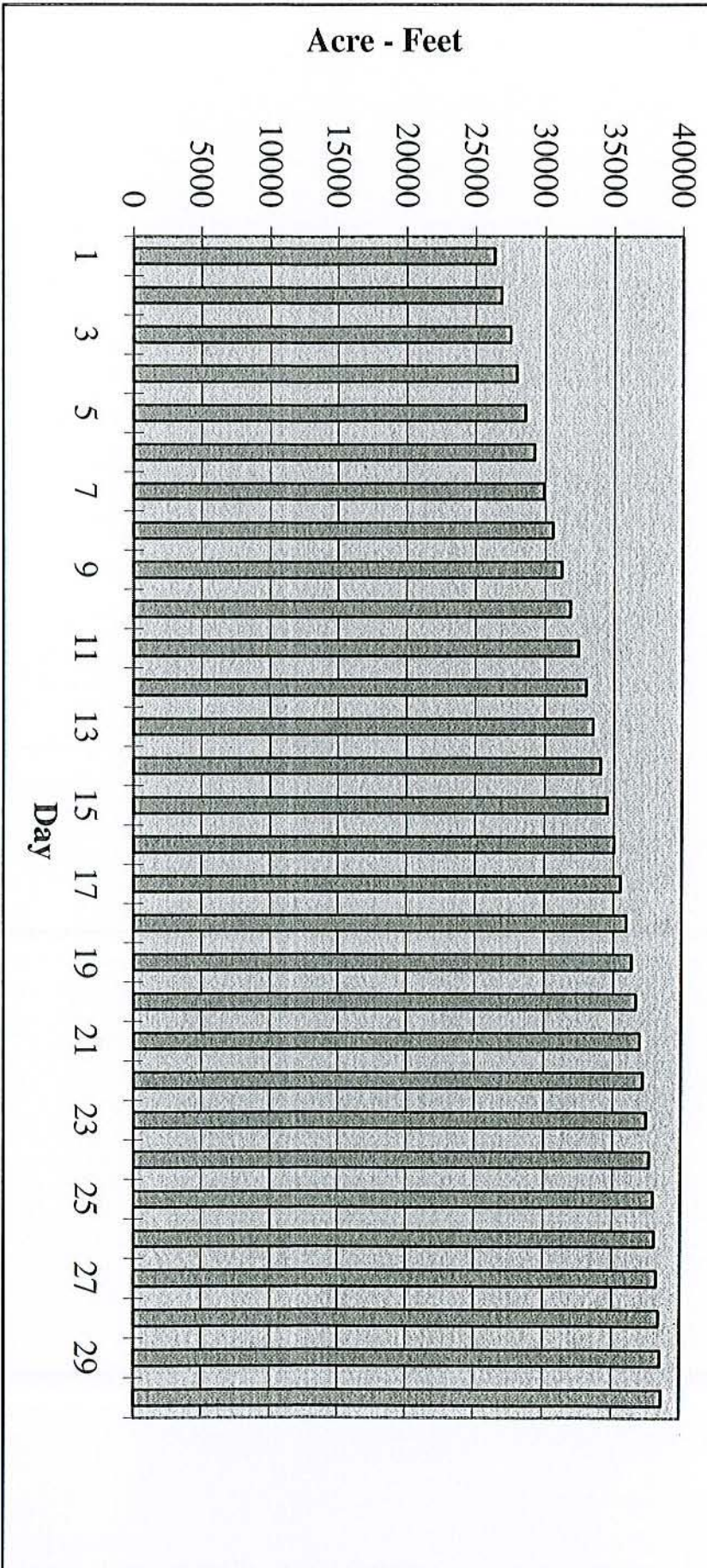
Note: Storage began on June 19, 1955.

**Mean Daily Gross Reservoir Contents  
for May  
(Water Years 1955 through 1991)**



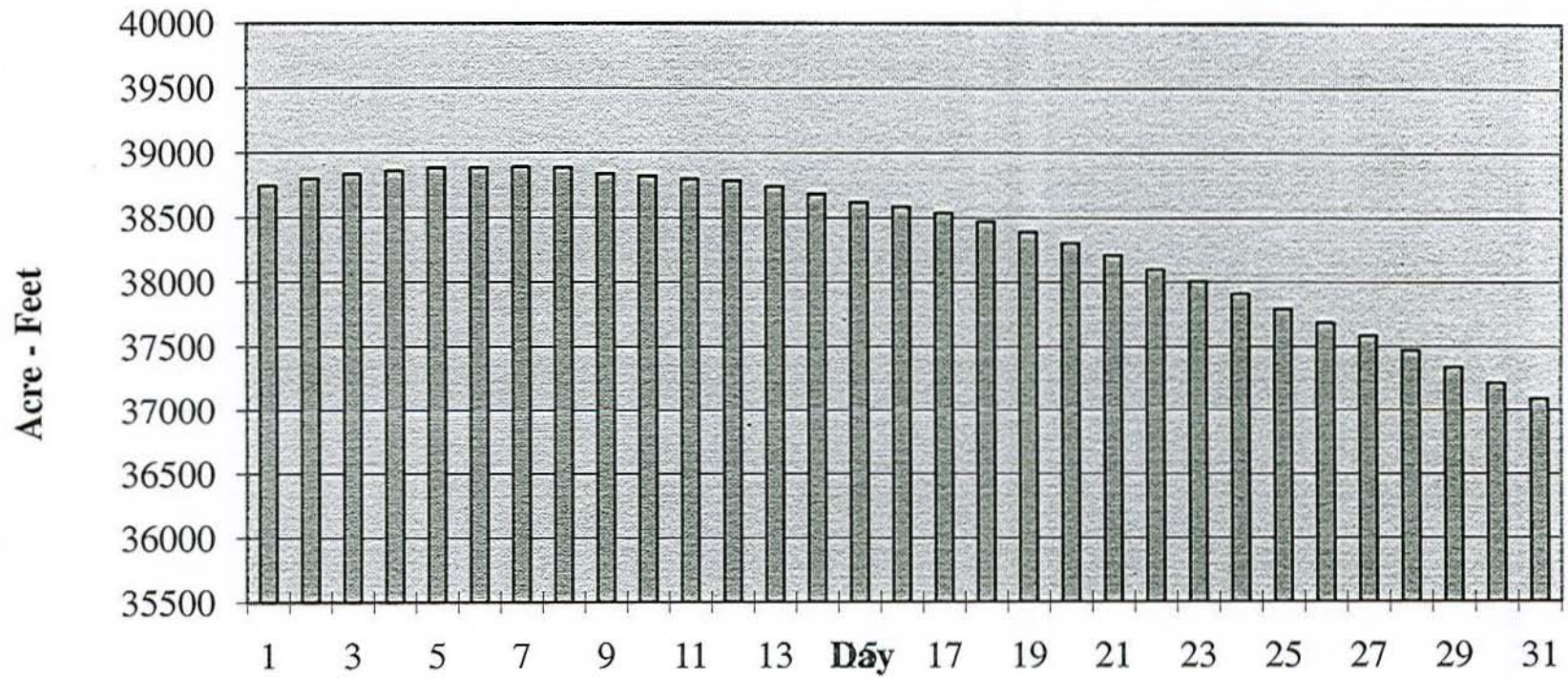
Note: Storage began on June 19, 1955.

## Mean Daily Gross Reservoir Contents for June (Water Years 1955 through 1991)



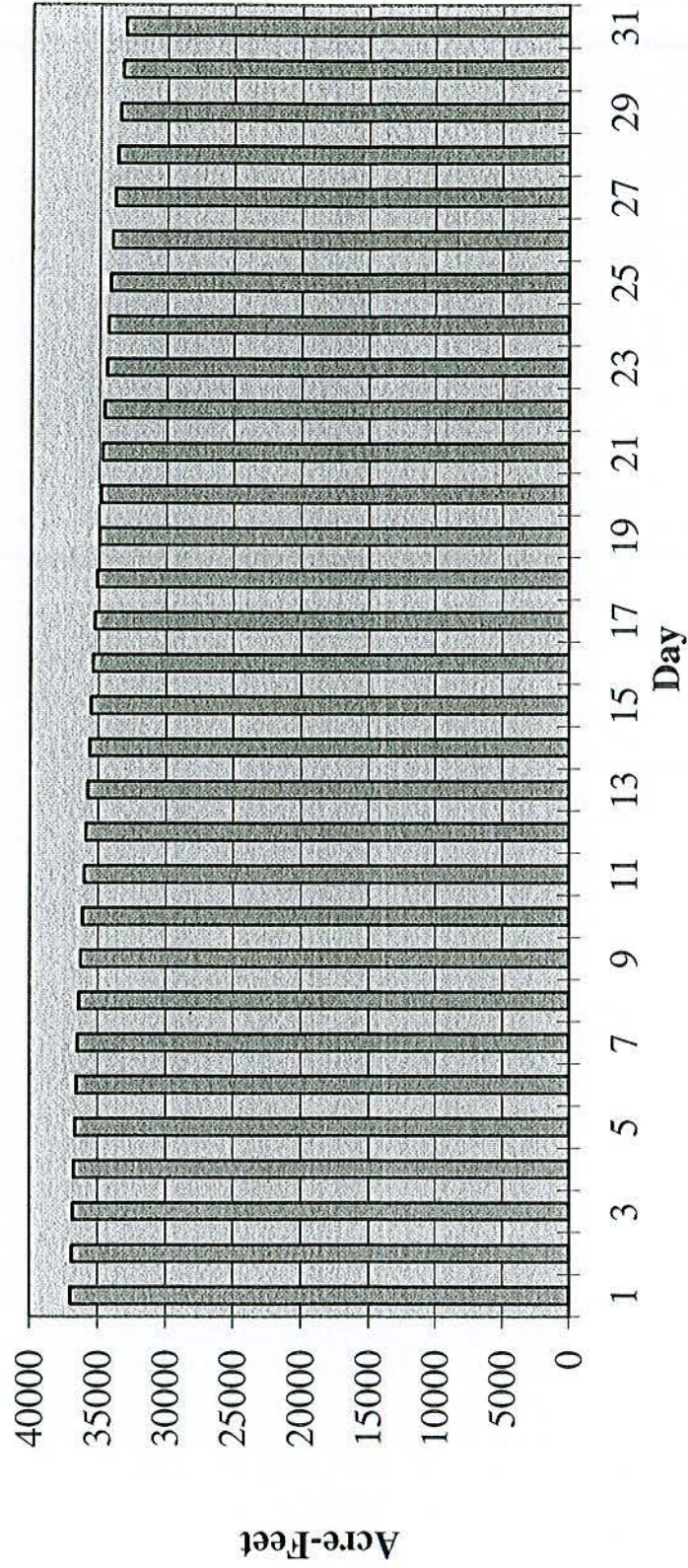
Note: Storage began on June 19, 1955.

## Mean Daily Gross Reservoir Contents for July (Water Years 1955 through 1991)



Note: Storage began on June 19, 1955.

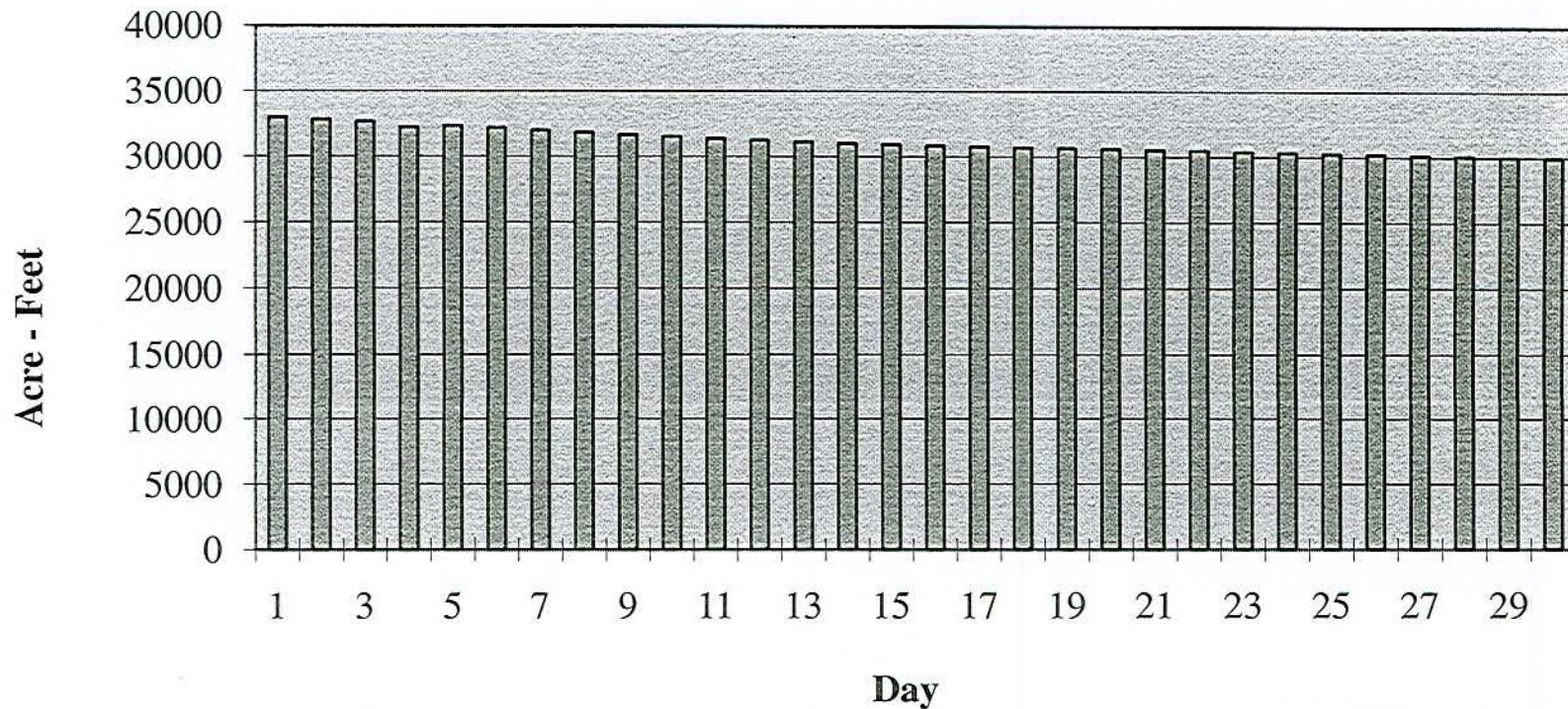
**Mean Daily Gross Reservoir Contents  
for August  
(Water Years 1955 through 1991)**



Note: Storage began on June 19, 1955.

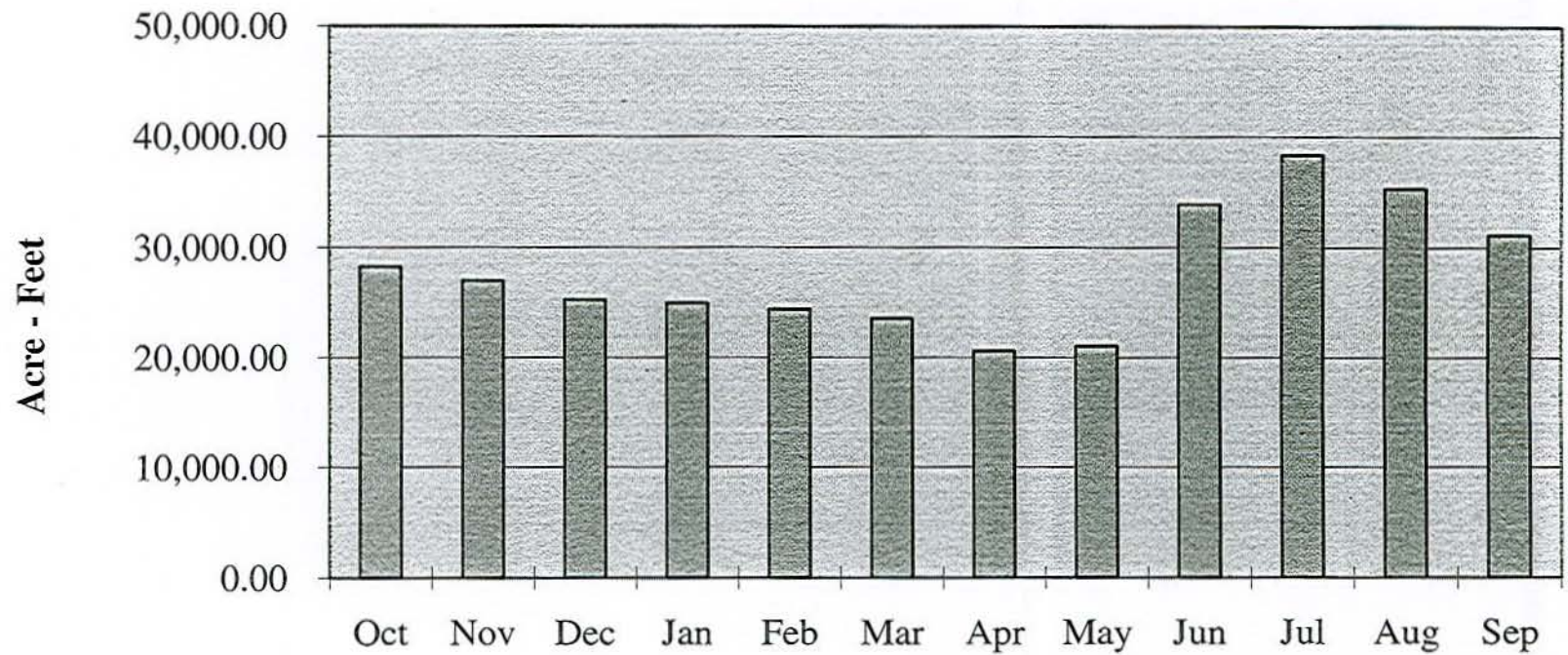


### Mean Daily Gross Reservoir Contents for September (Water Years 1955 through 1991)



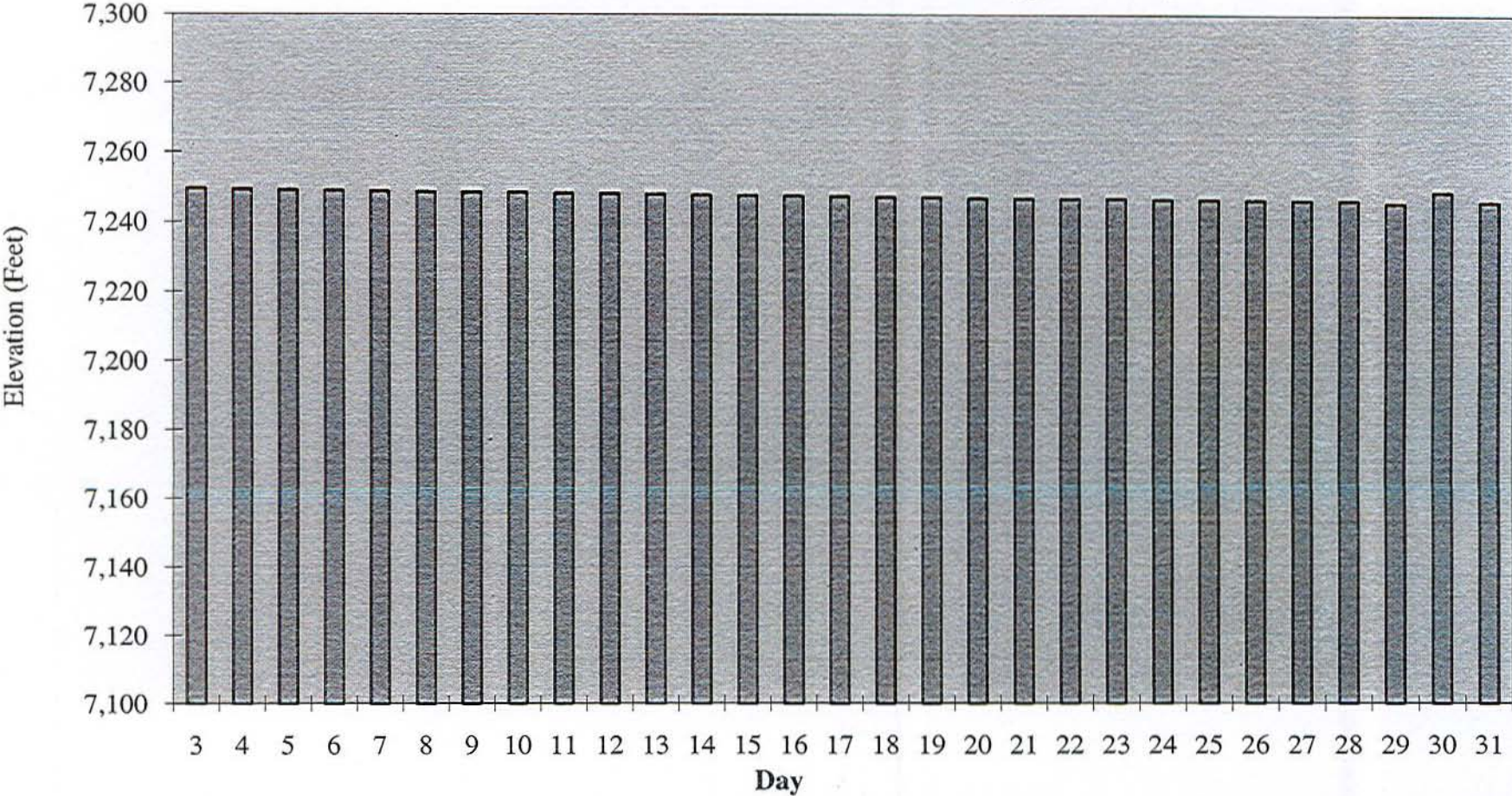
Note: Storage began on June 19, 1955.

### Mean Monthly Gross Reservoir Contents For Water Years 1955 Through 1991



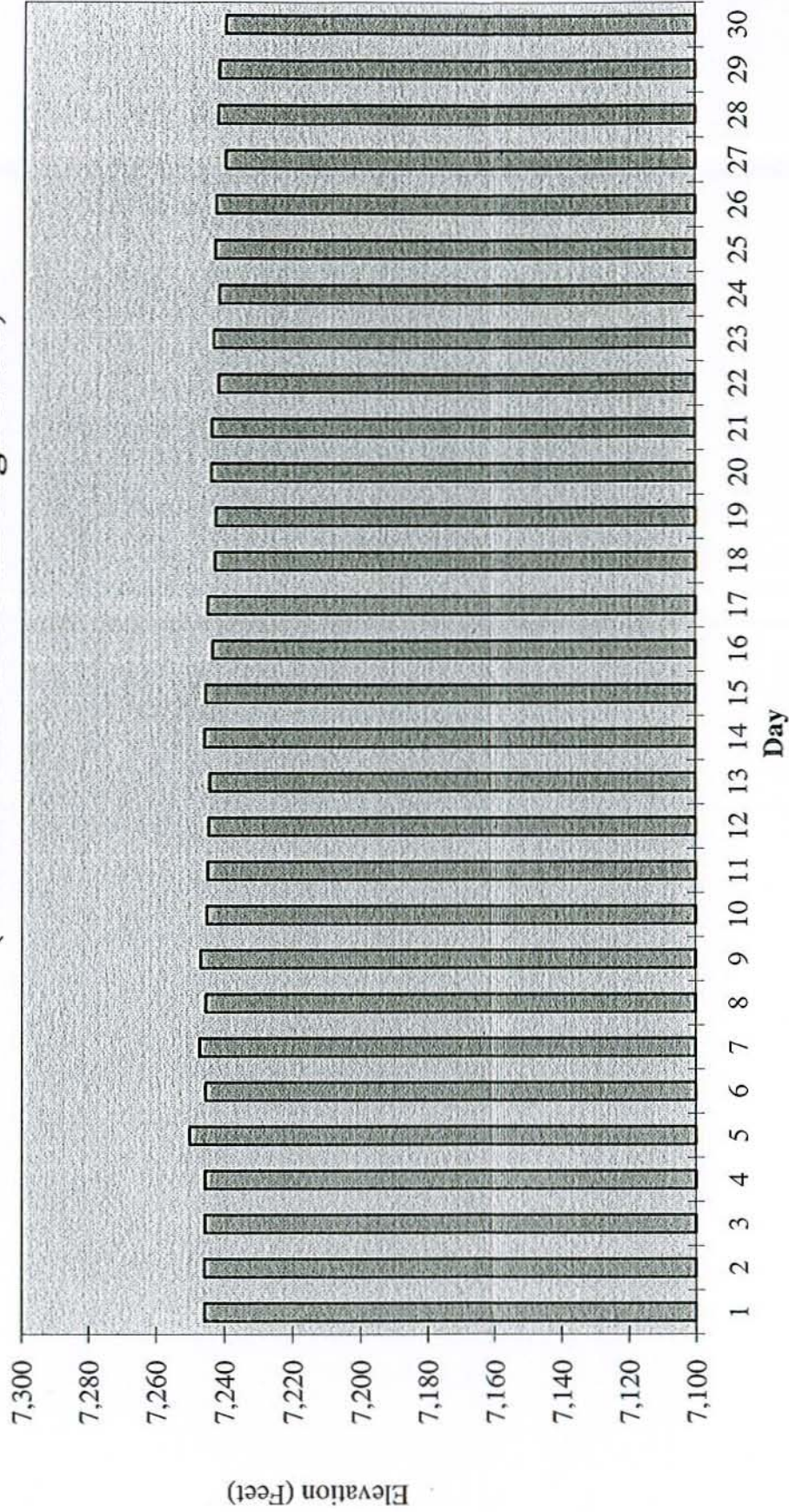
Note: Storage began on June 19, 1955.

### Gross Reservoir Mean Elevations for October (Water Years 1956 through 1991)



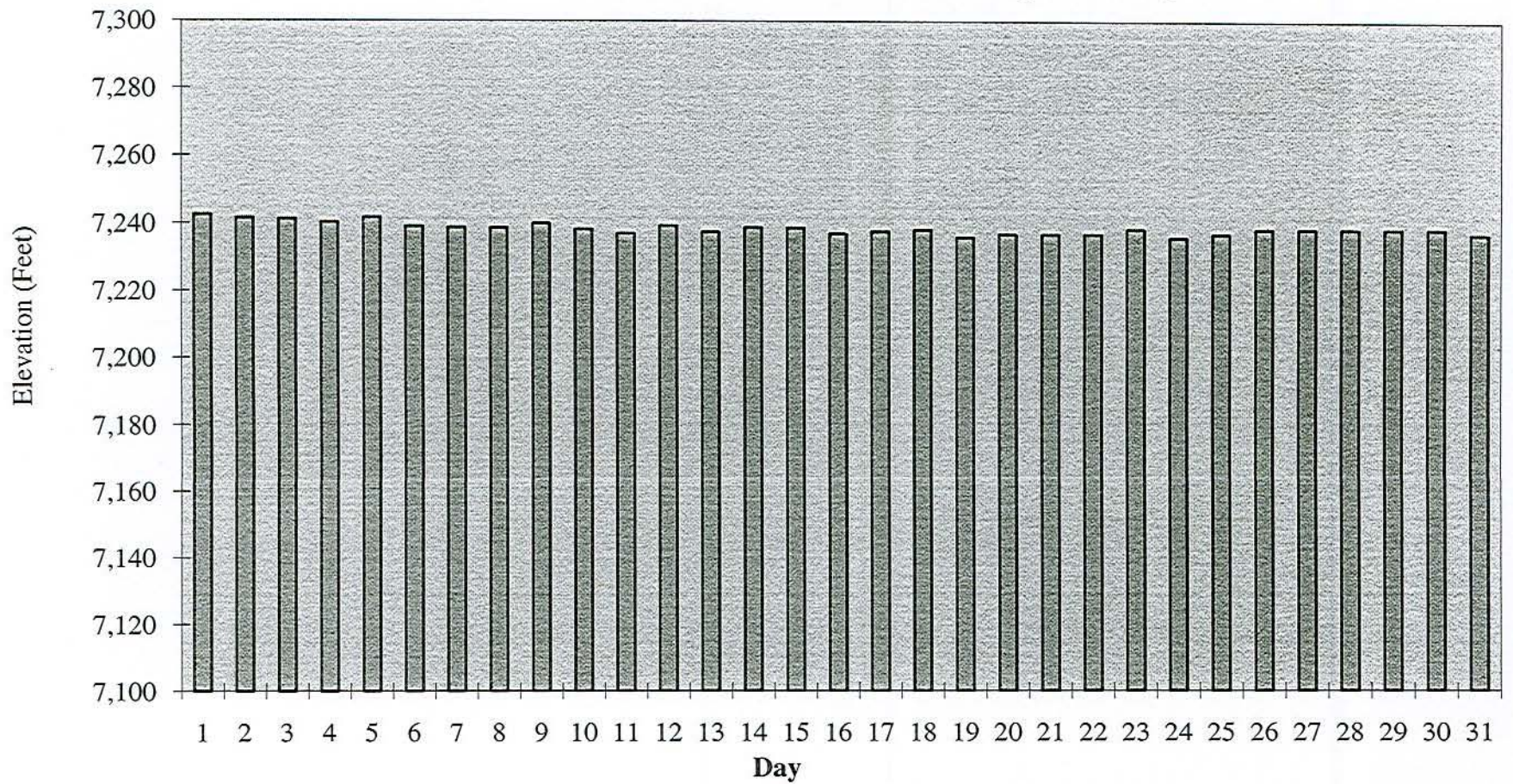
Note: Gross Reservoir Storage began on June 19, 1955.

## Gross Reservoir Mean Daily Elevations for November (Water Years 1956 through 1991)



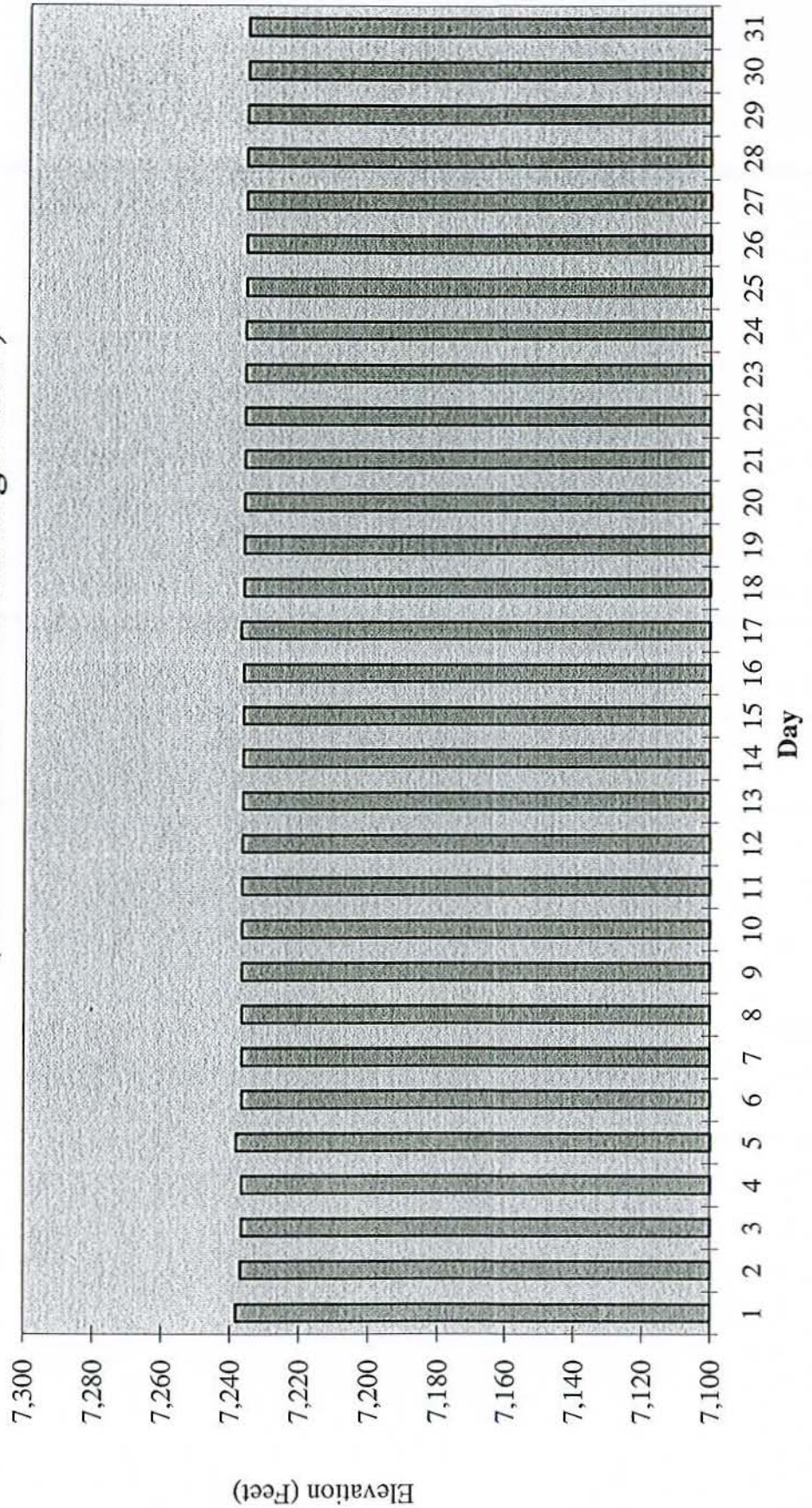
Note: Gross Reservoir Storage began on June 19, 1955.

### Gross Reservoir Mean Elevations for December (Water Years 1956 through 1991)



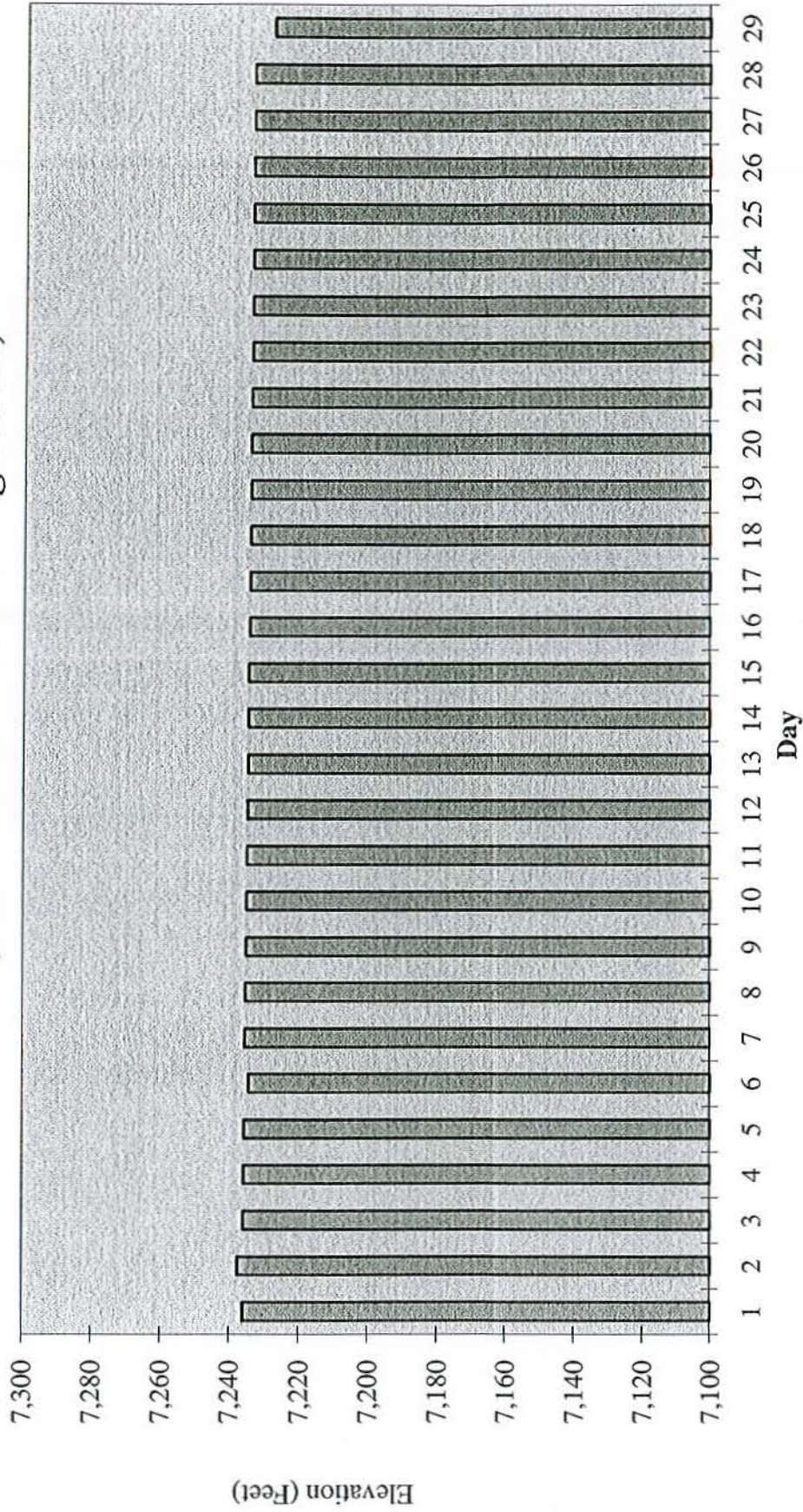
Note: Gross Reservoir Storage began on June 19, 1955.

## Gross Reservoir Mean Elevations for January (Water Years 1956 through 1991)



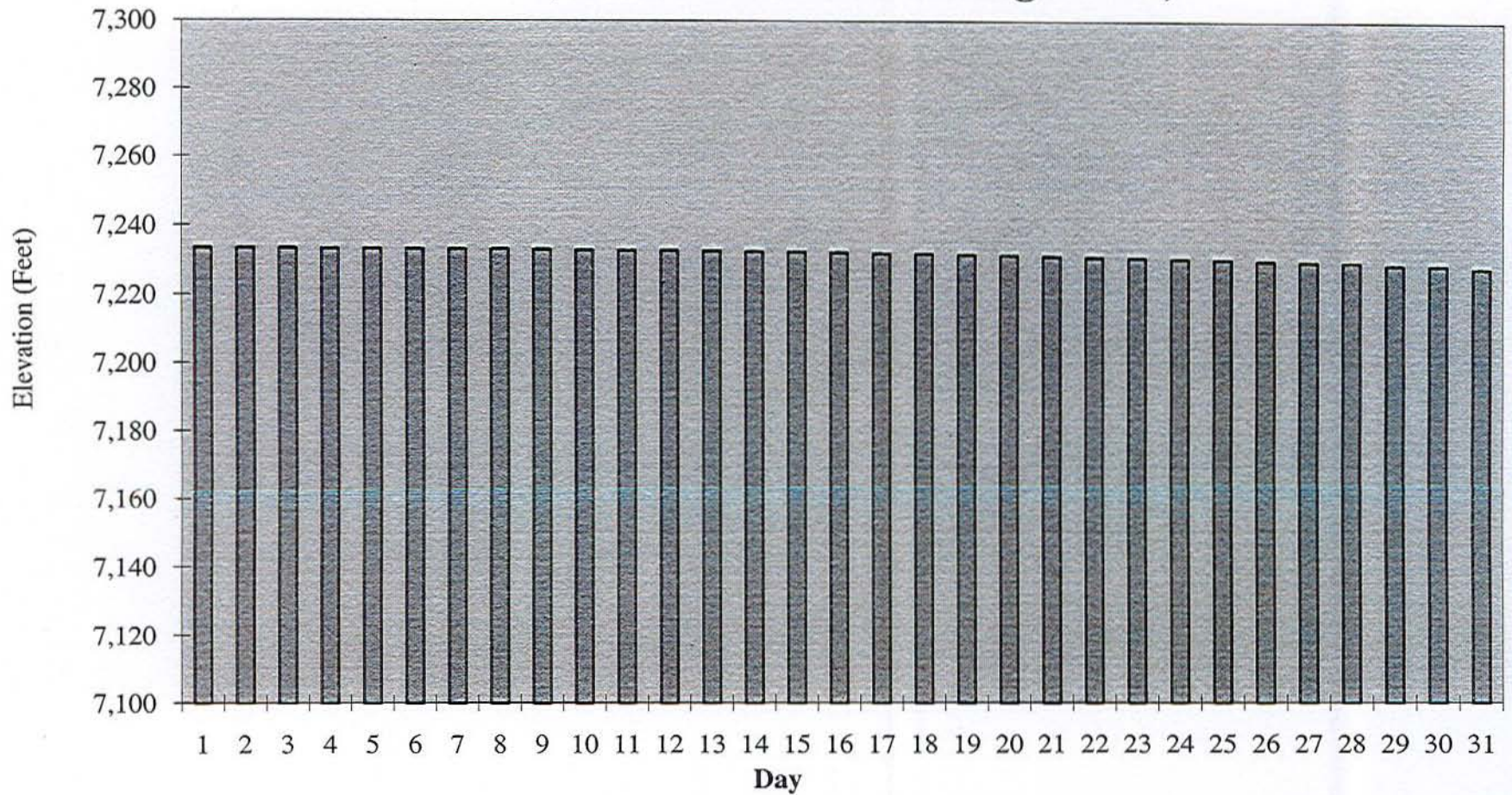
Note: Gross Reservoir Storage began on June 19, 1955.

## Gross Reservoir Mean Elevations for February (Water Years 1956 through 1991)



Note: Gross Reservoir Storage began on June 19, 1955.

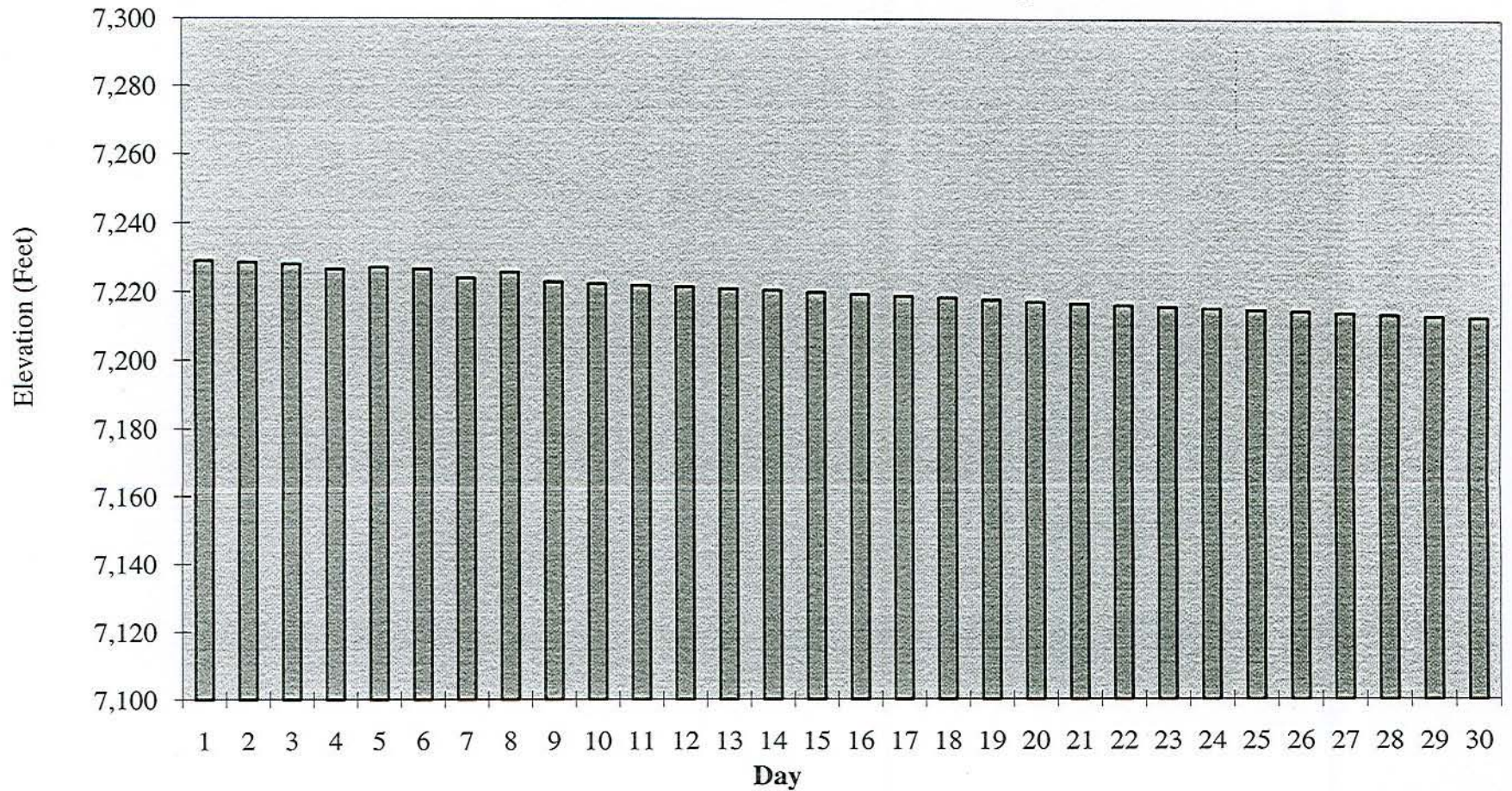
### Gross Reservoir Mean Elevations for March (Water Years 1956 through 1991)



Note: Gross Reservoir Storage began on June 19, 1955.

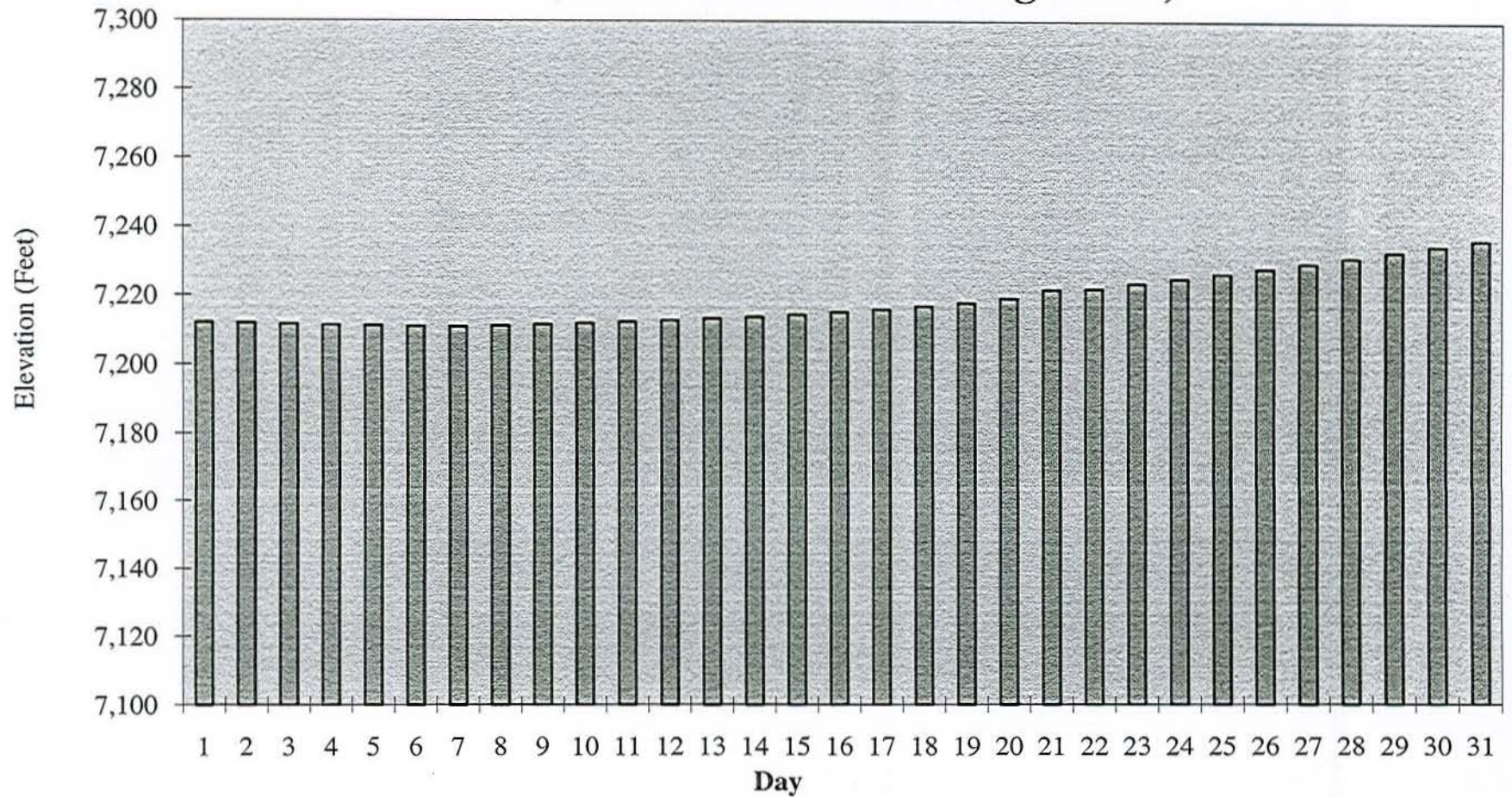


### Gross Reservoir Mean Elevations for April (Water Years 1956 through 1991)



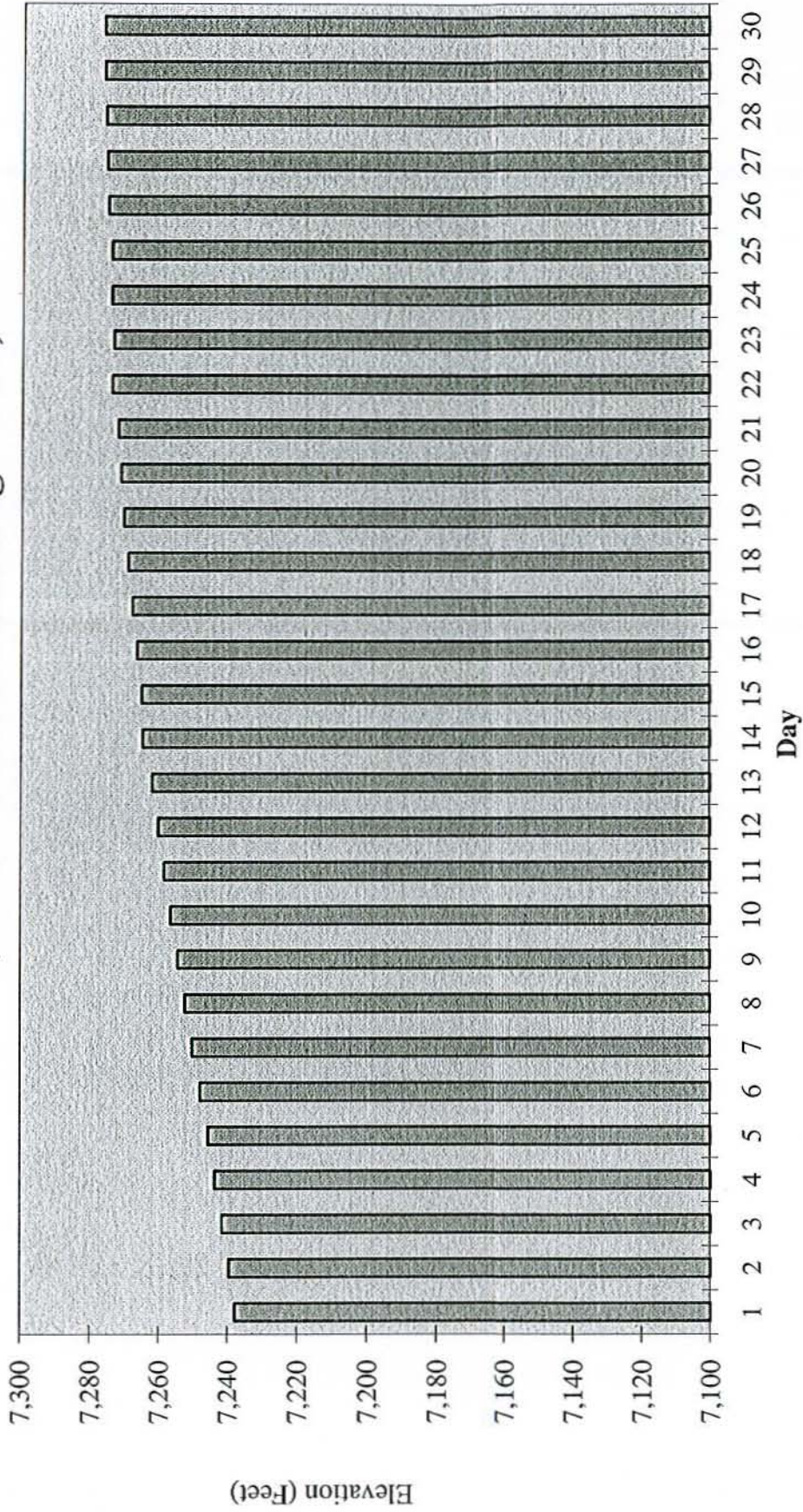
Note: Gross Reservoir Storage began on June 19, 1955.

### Gross Reservoir Mean Elevations for May (Water Years 1956 through 1991)



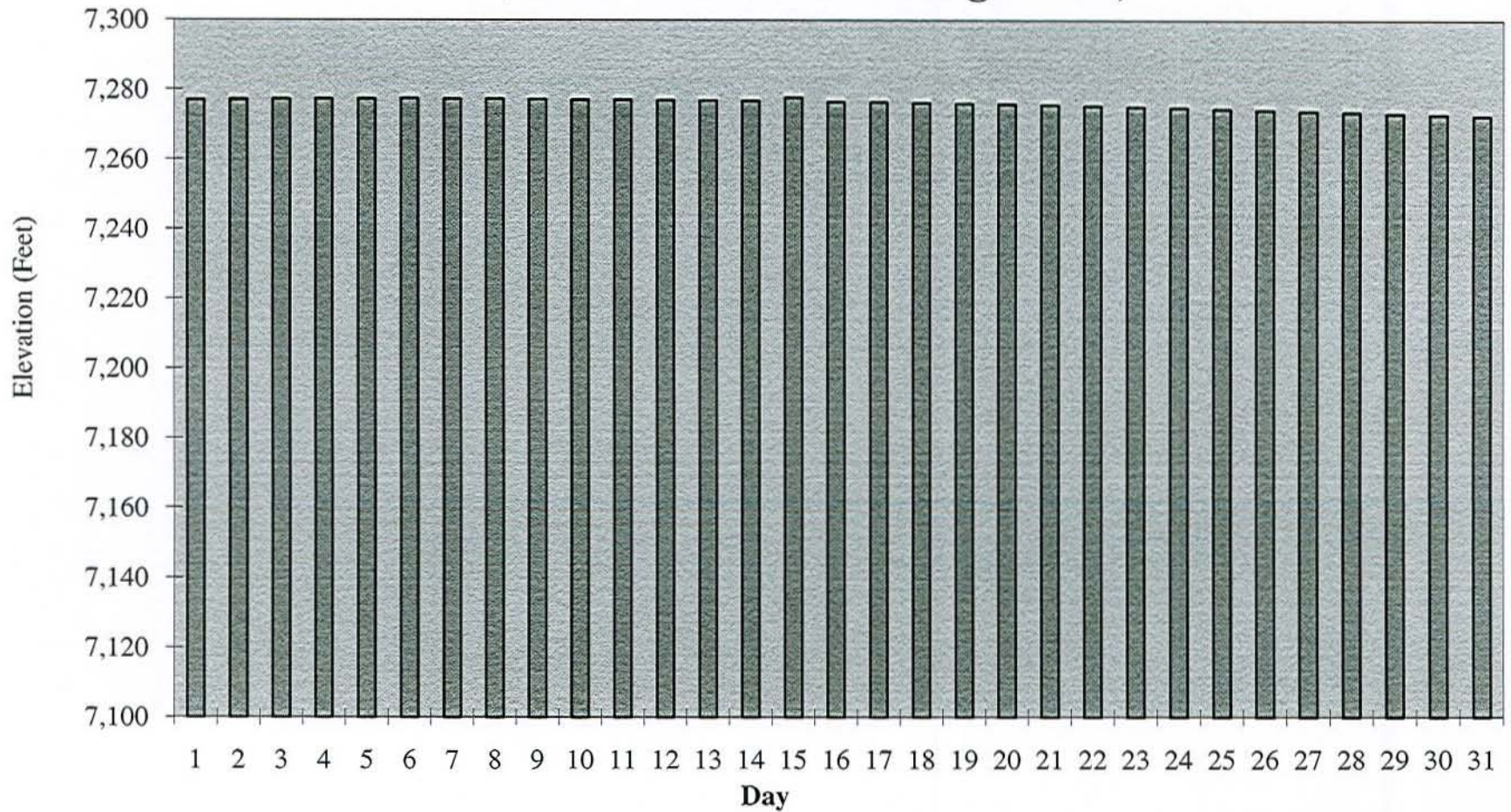
Note: Gross Reservoir Storage began on June 19, 1955.

## Gross Reservoir Mean Elevations for June (Water Years 1956 through 1991)



Note: Gross Reservoir Storage began on June 19, 1955.

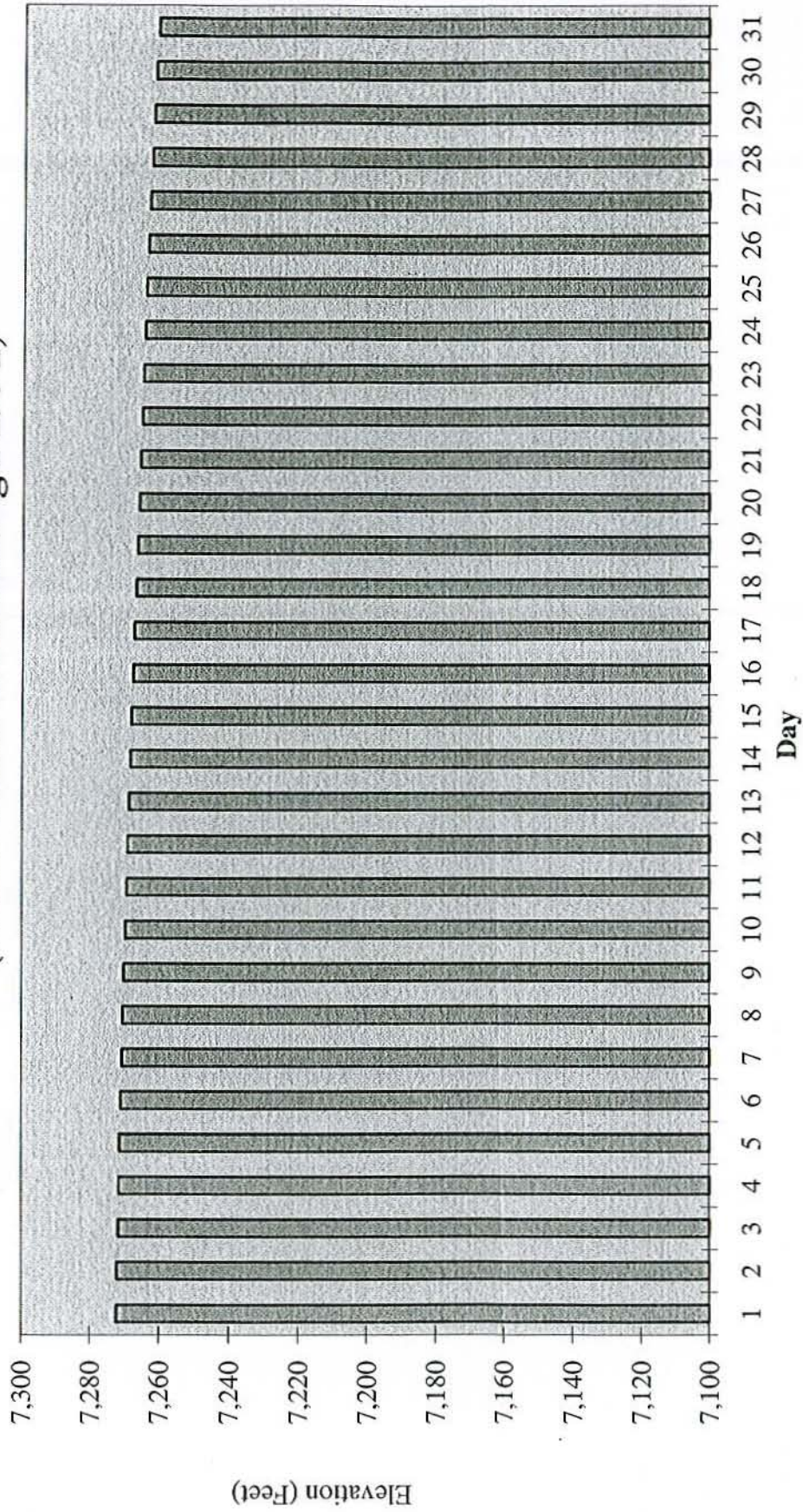
### Gross Reservoir Mean Elevations for July (Water Years 1956 through 1991)



Note: Gross Reservoir Storage began on June 19, 1955.

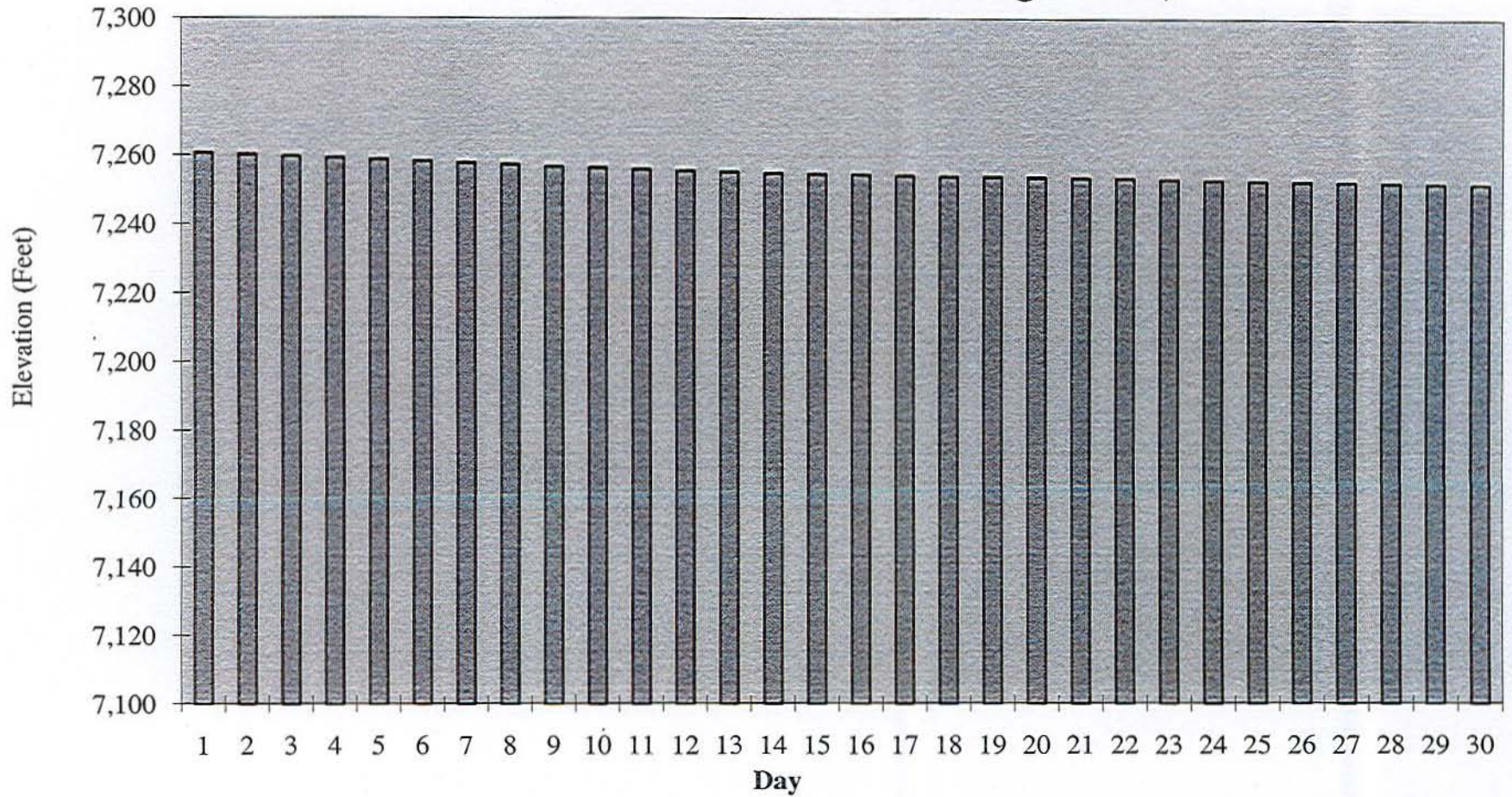
Appendix A, Figure 23

## Gross Reservoir Mean Elevations for August (Water Years 1956 through 1991)



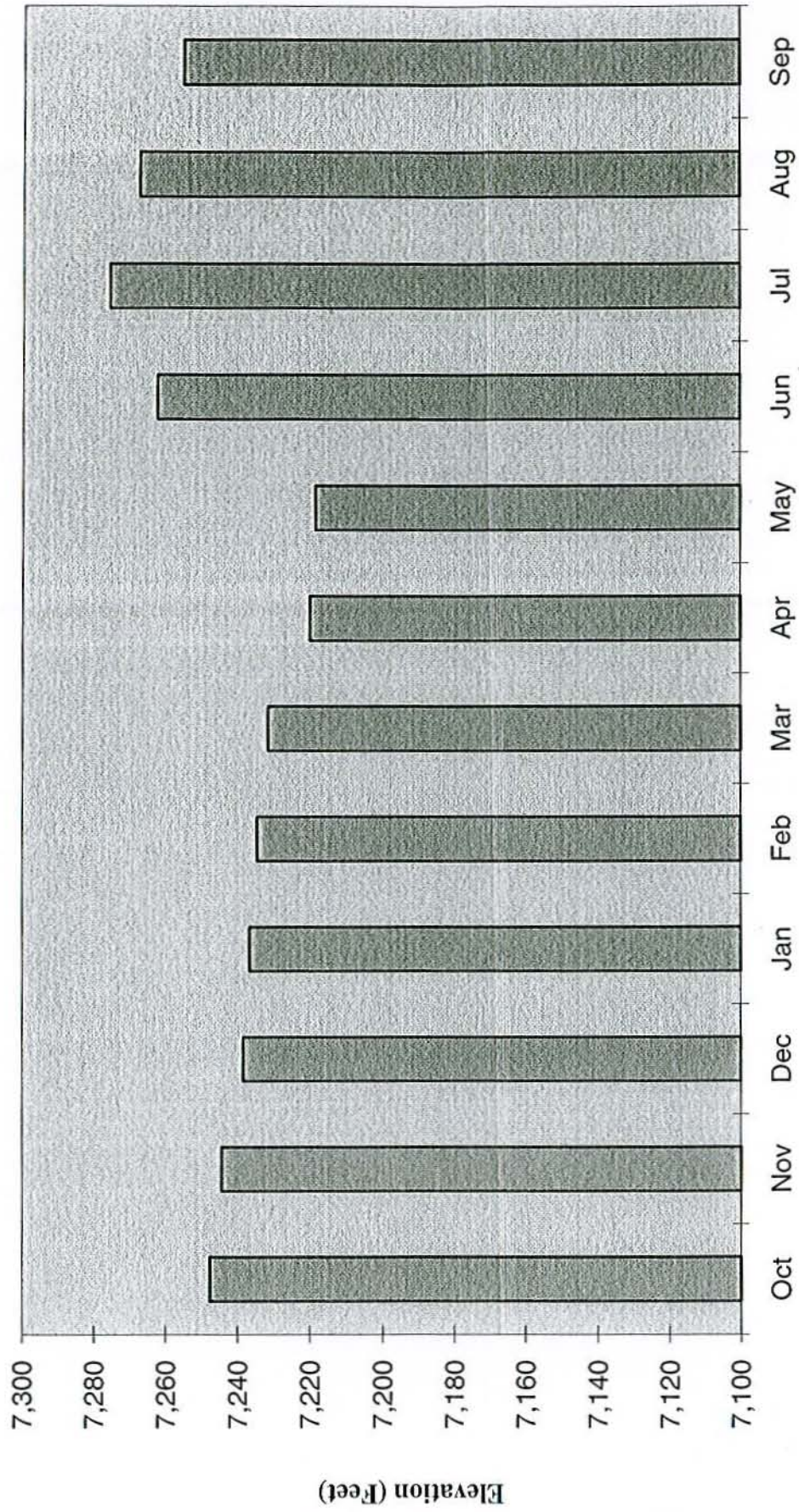
Note: Gross Reservoir Storage began on June 19, 1955.

### Gross Reservoir Mean Elevations for September (Water Years 1956 through 1991)



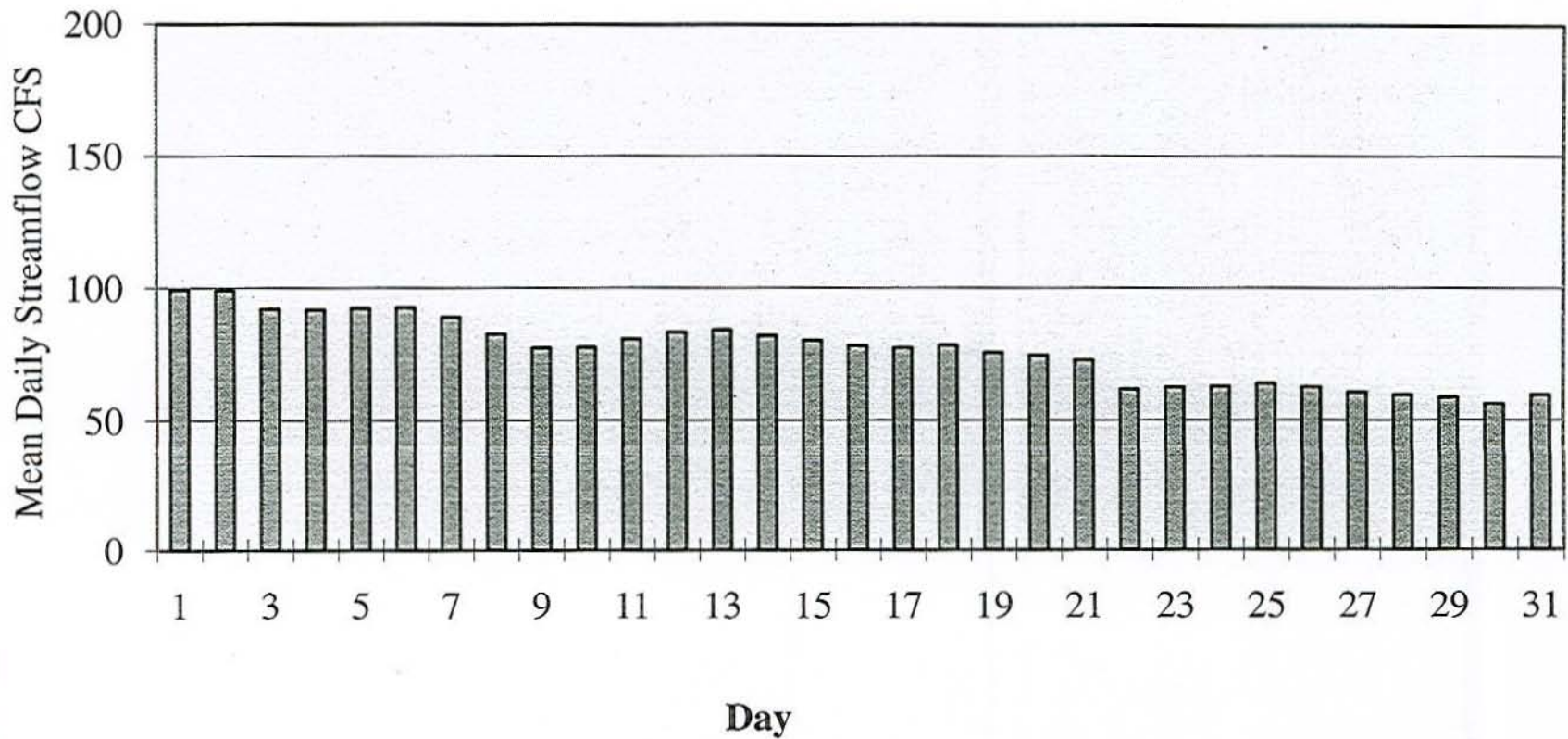
Note: Gross Reservoir Storage began on June 19, 1955.

### Average Monthly Gross Reservoir Water Level Elevation (Water Years 1956 through 1991)



Note: Gross Reservoir Storage began on June 19, 1955.

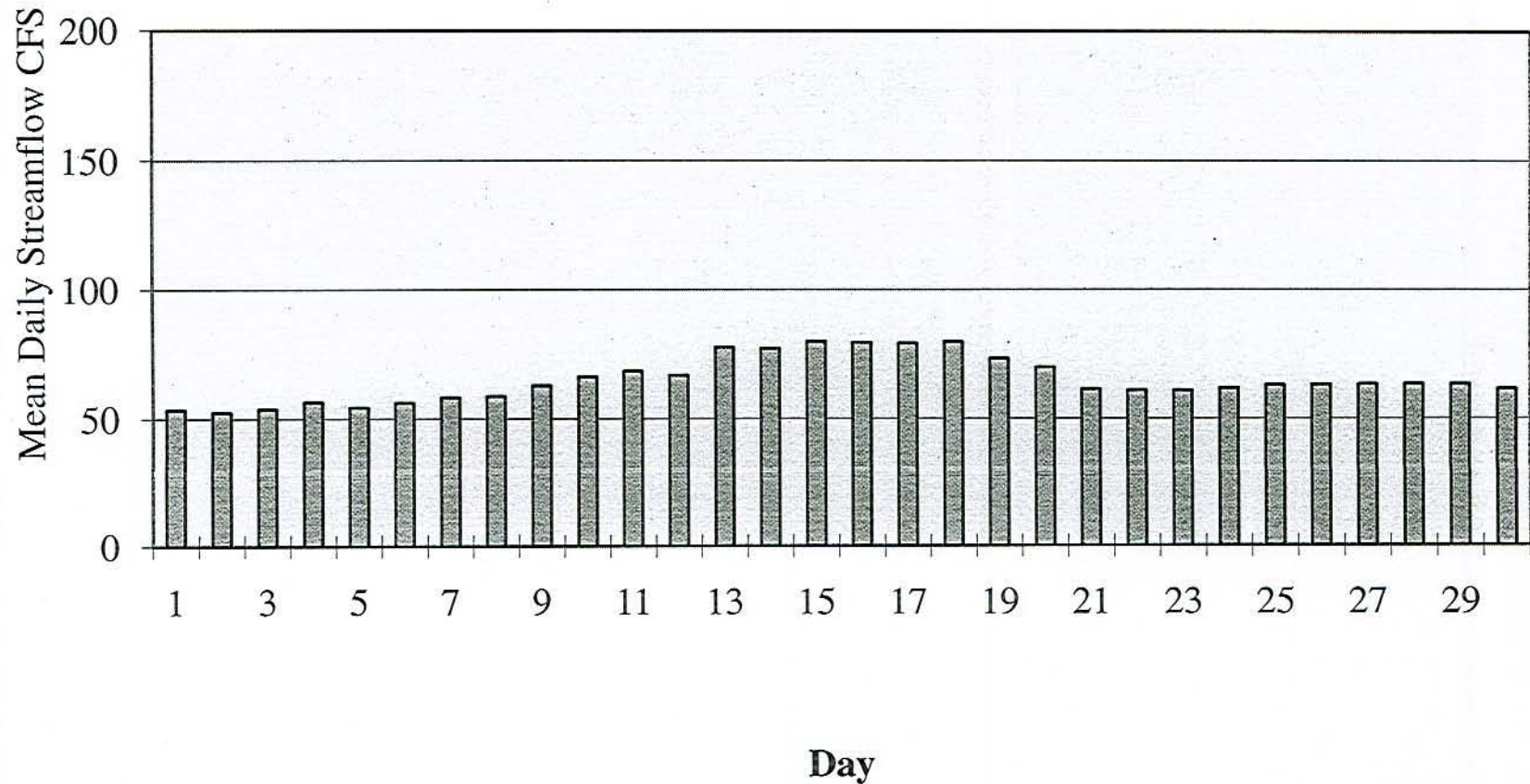
### Gross Reservoir Mean Daily Outflow For October (Water Years 1955 through 1991)



Note: Gross Reservoir Storage began on June 19, 1955.

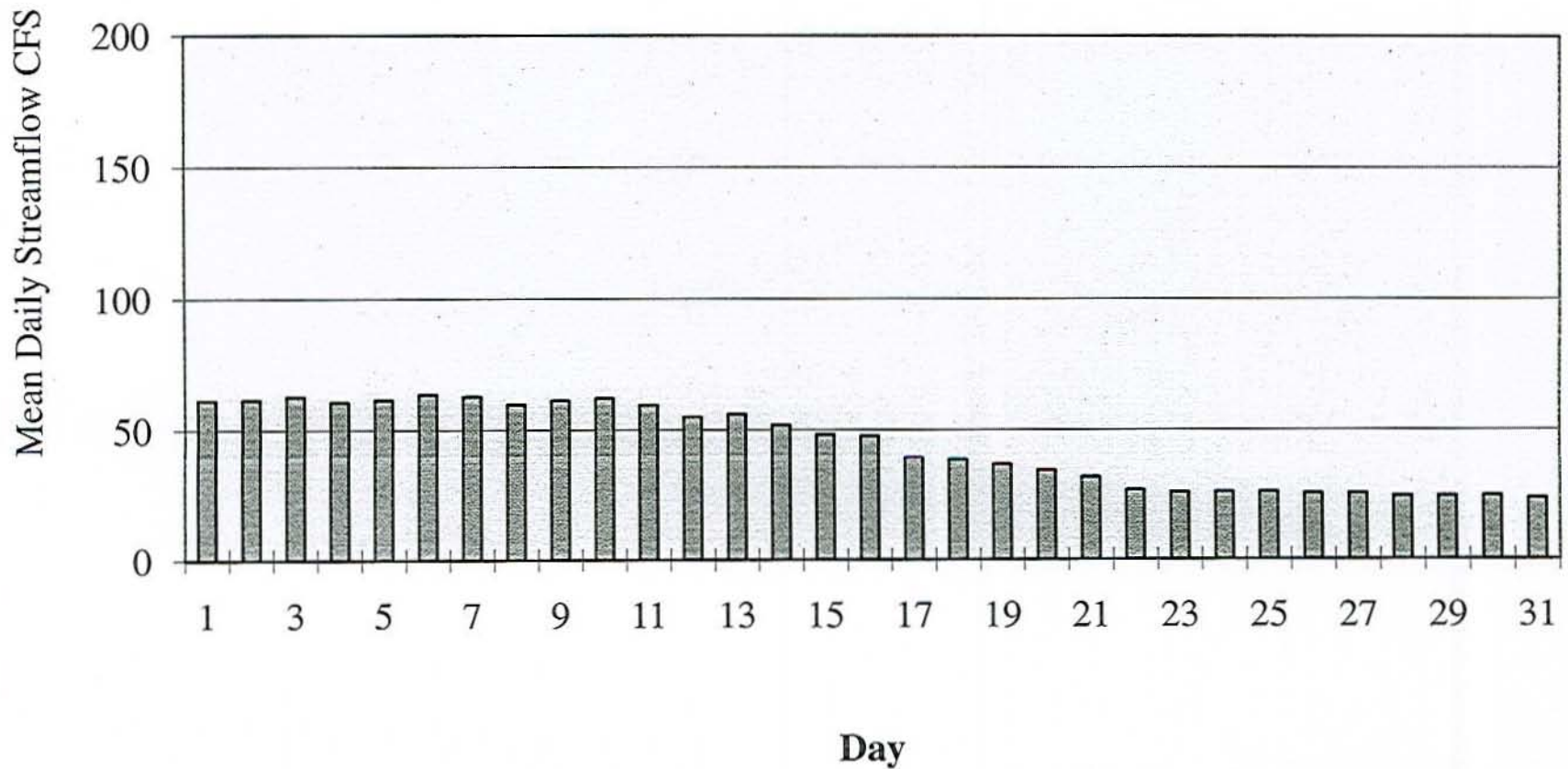


# Gross Reservoir Mean Daily Outflow For November (Water Years 1955 through 1991)



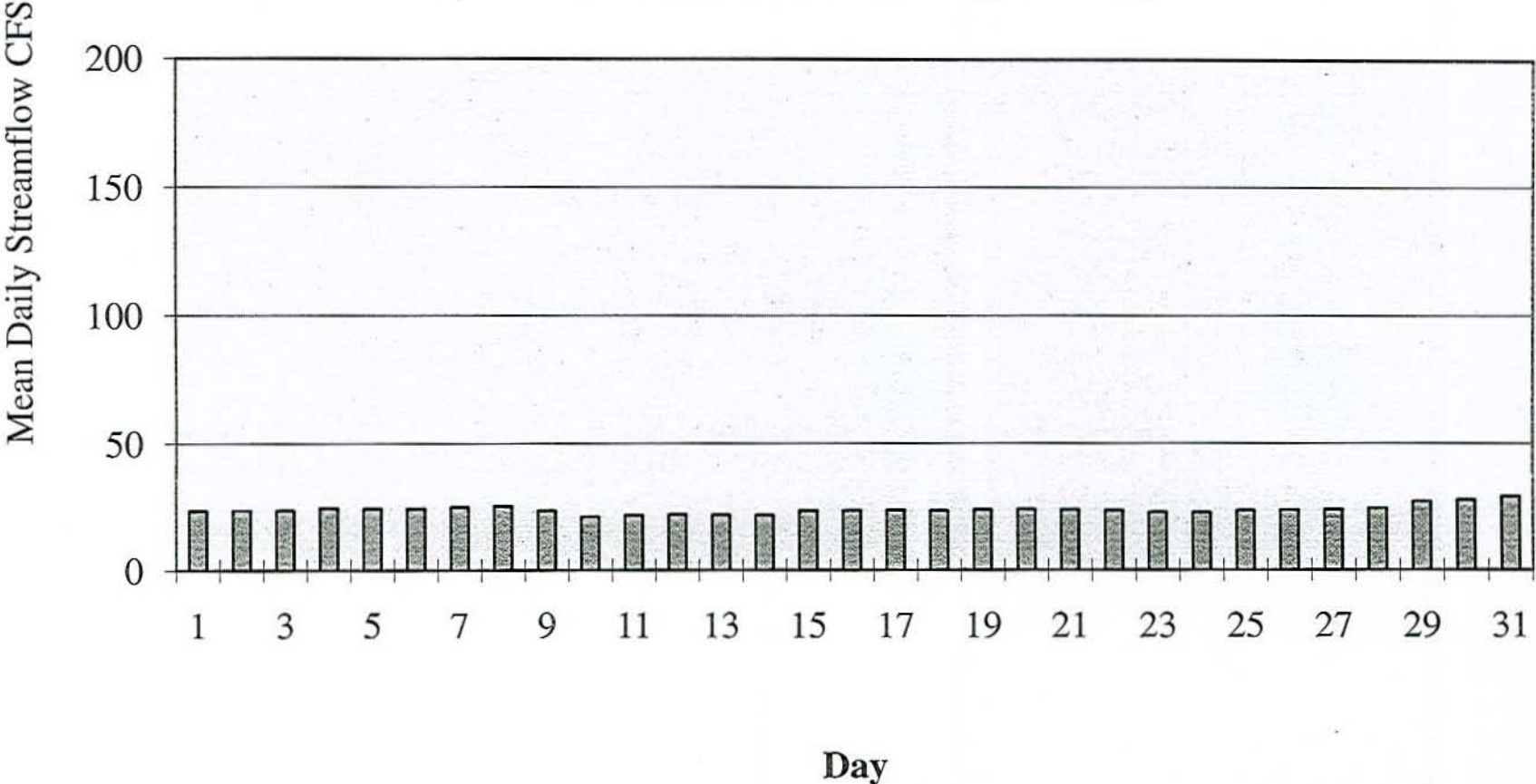
Note: Gross Reservoir Storage began on June 19, 1955.

### Gross Reservoir Mean Daily Outflow For December (Water Years 1955 through 1991)



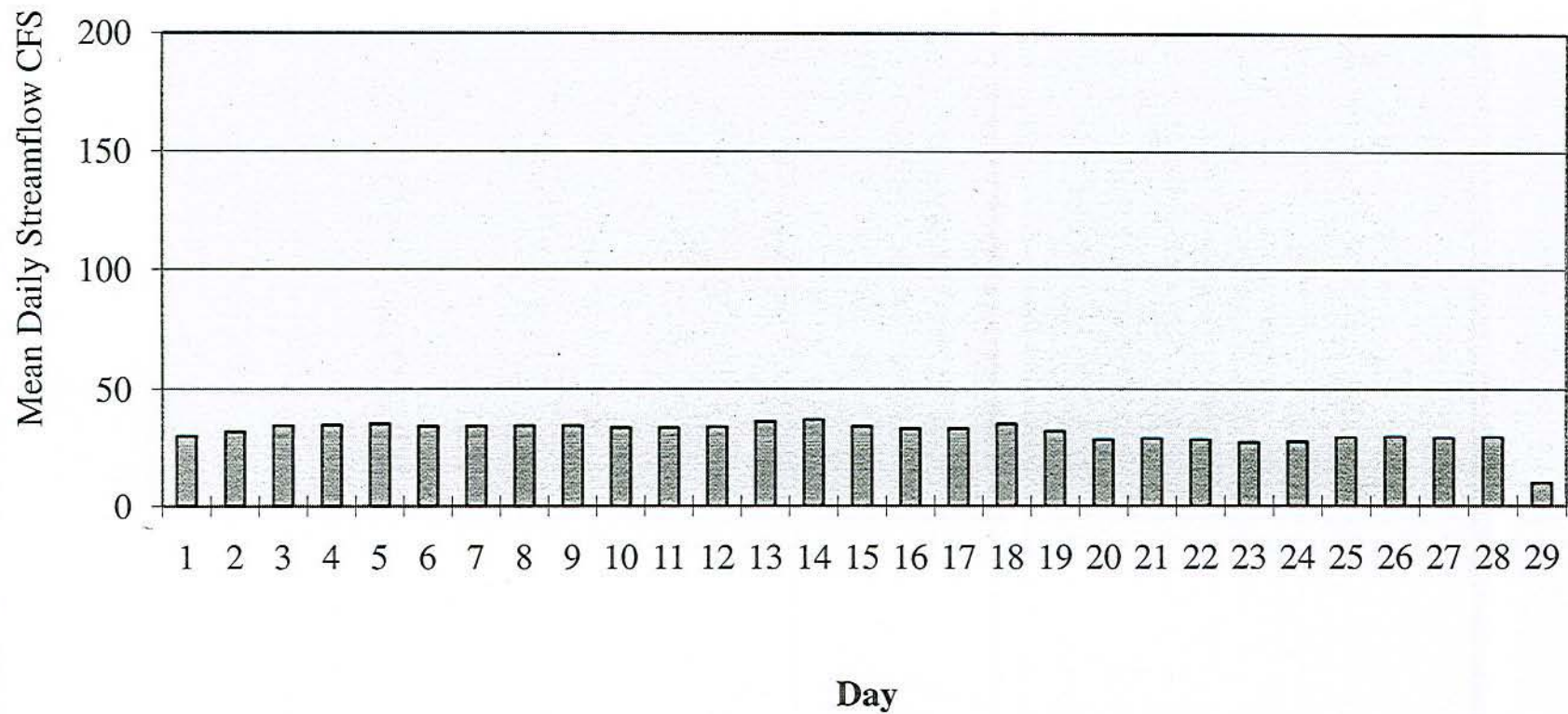
Note: Gross Reservoir Storage began on June 19, 1955.

### Gross Reservoir Mean Daily Outflow For January (Water Years 1955 through 1991)



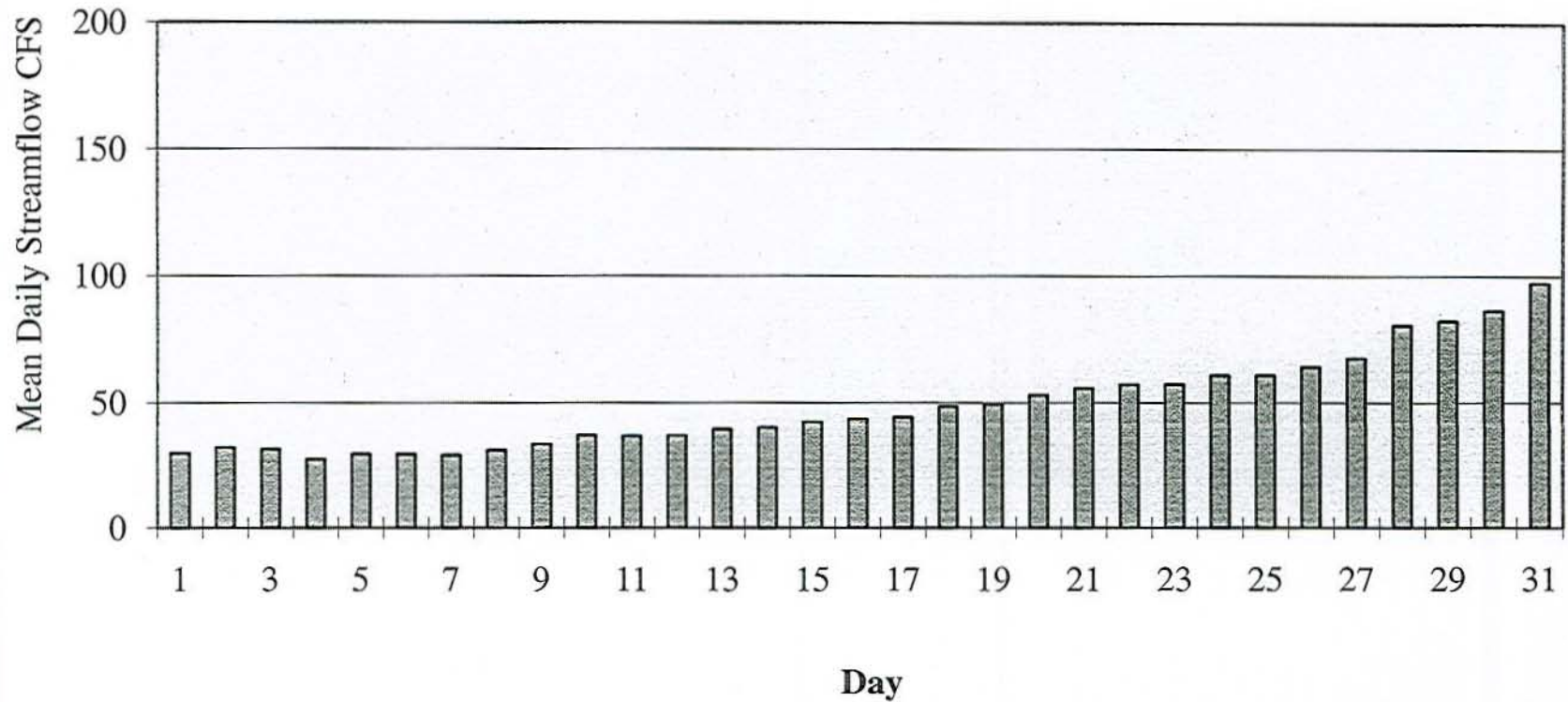
Note: Gross Reservoir Storage began on June 19,1955.

### Gross Reservoir Mean Daily Outflow for February (Water Years 1955 through 1991)



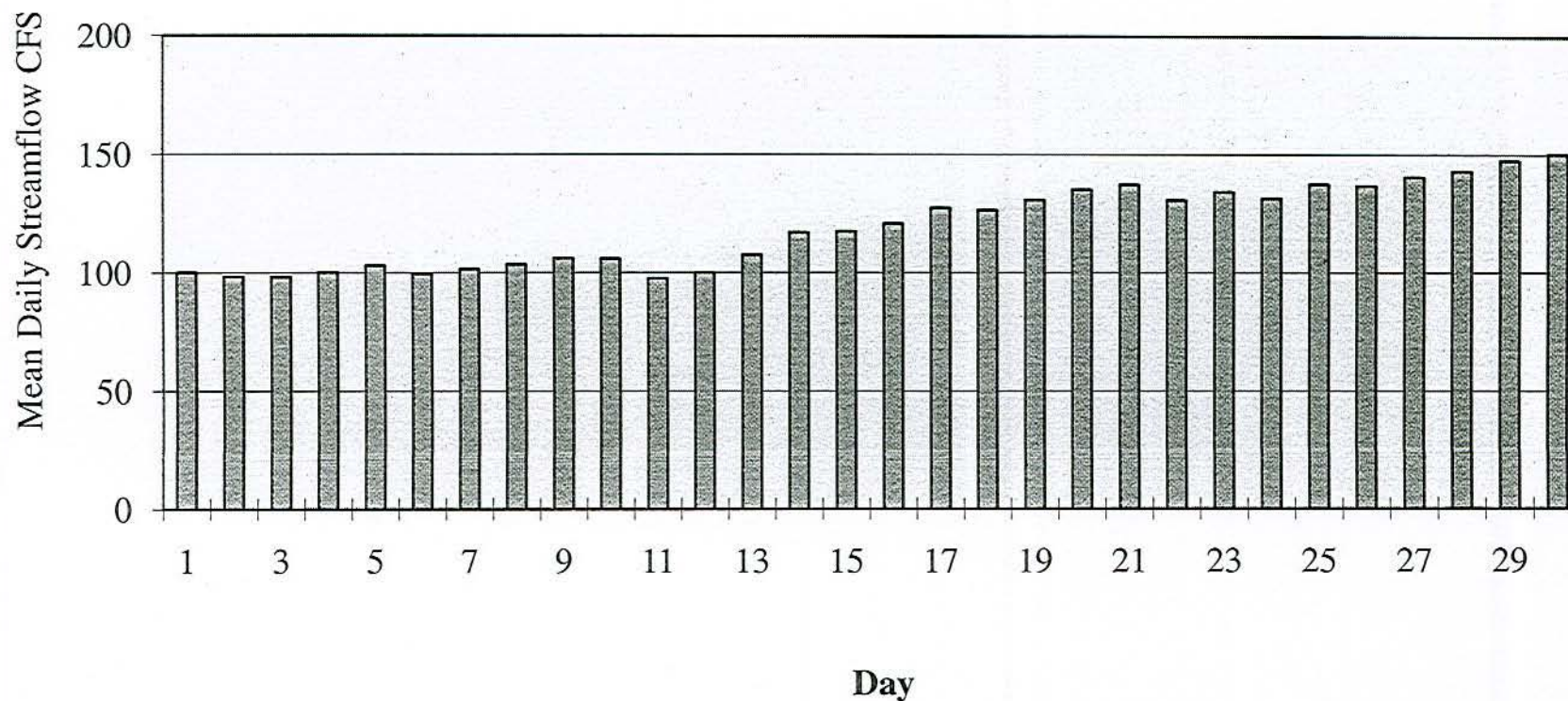
Note: Gross Reservoir Storage began on June 19, 1955.

### Gross Reservoir Mean Daily Outflow for March (Water Years 1955 through 1991)



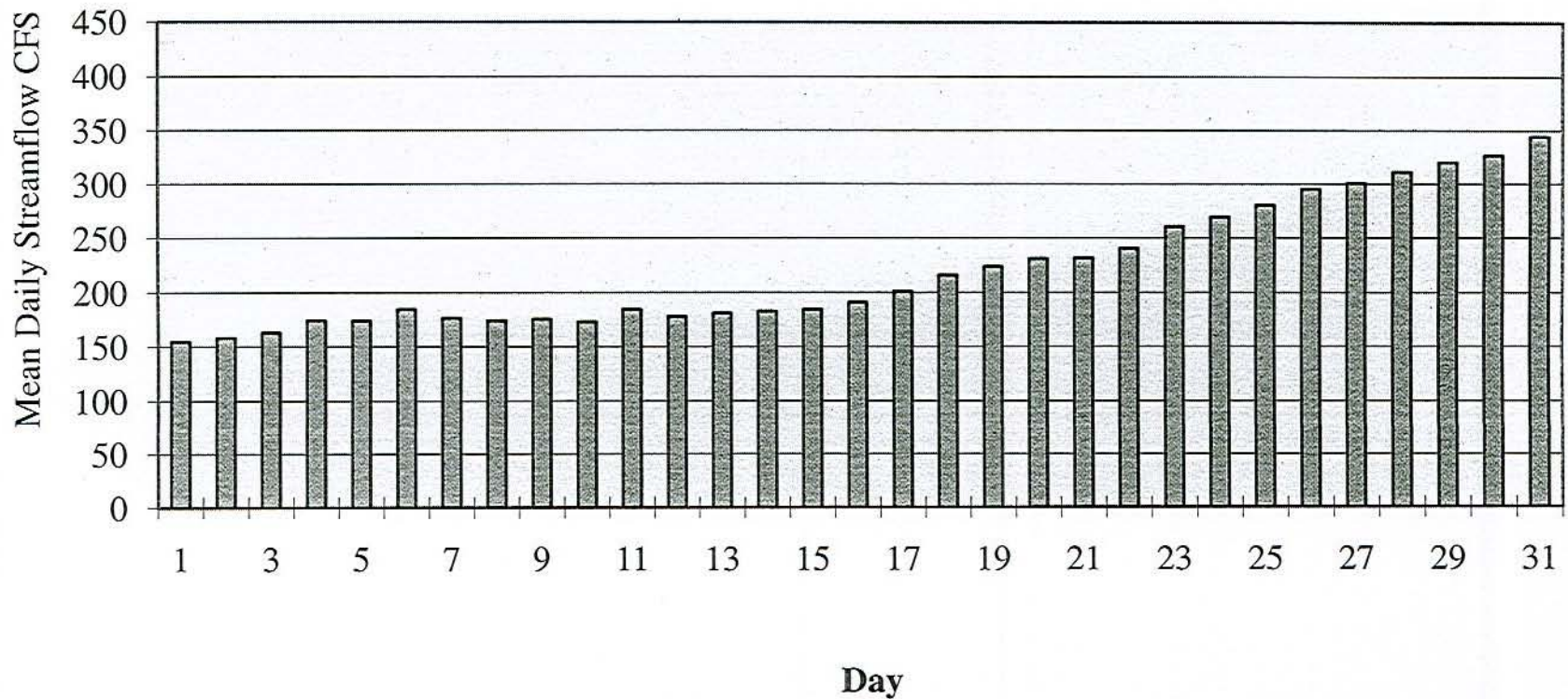
Note: Gross Reservoir Storage began on June 19, 1955.

### Gross Reservoir Mean Daily Outflow for April (Water Years 1955 through 1991)



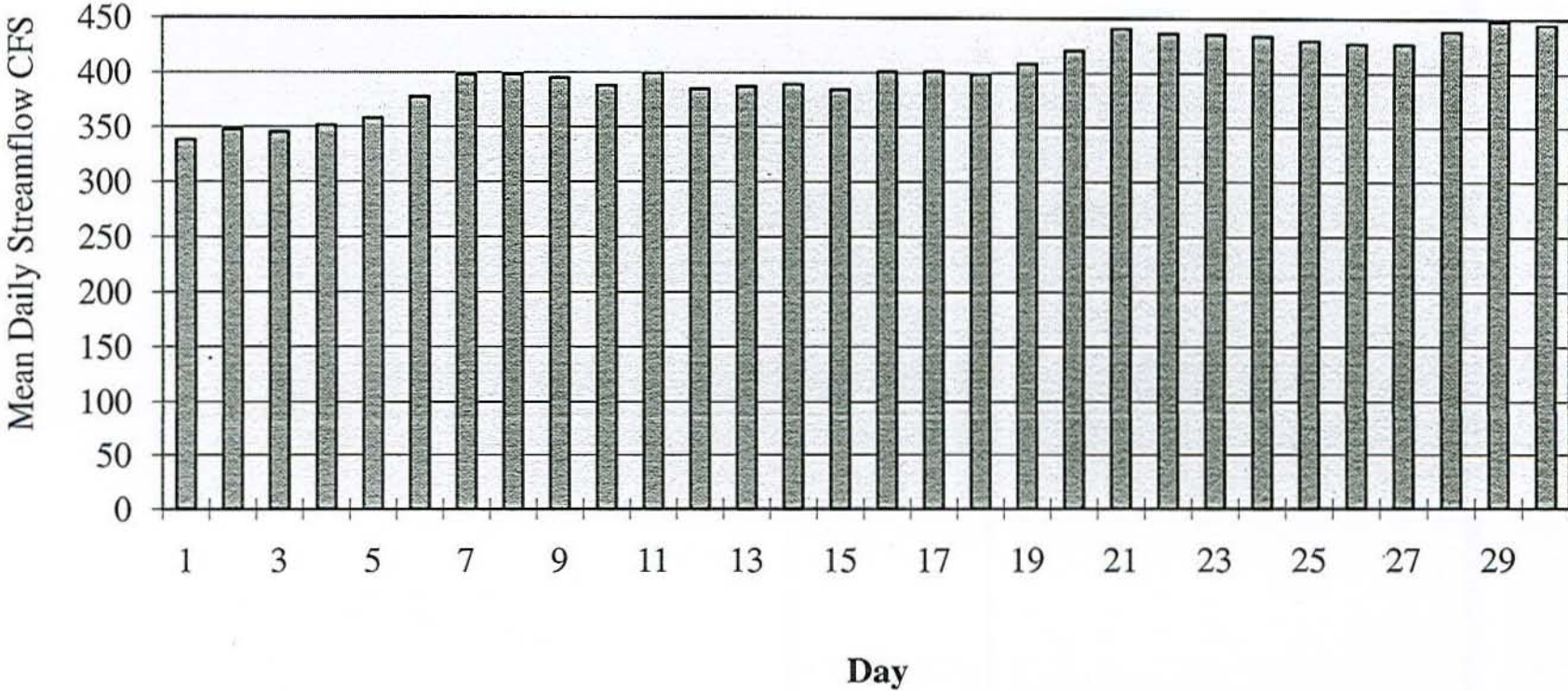
Note: Gross Reservoir Storage began on June 19, 1955.

### Gross Reservoir Mean Daily Outflow for May (Water Years 1955 through 1991)



Note: Gross Reservoir Storage began on June 19, 1955.

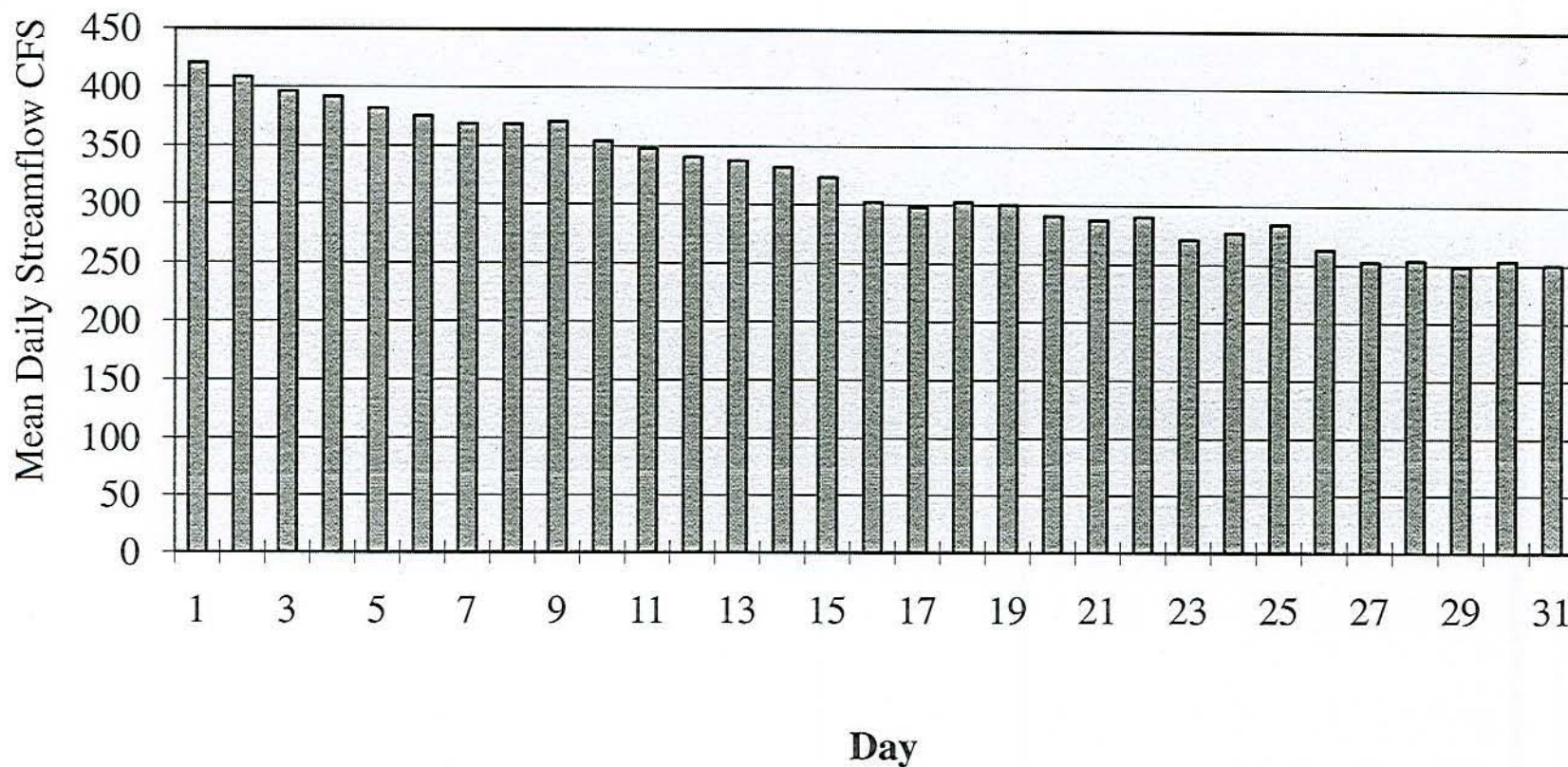
### Gross Reservoir Mean Daily Outflow for June (Water Years 1955 through 1991)



Note: Gross Reservoir Storage began on June 19, 1955.

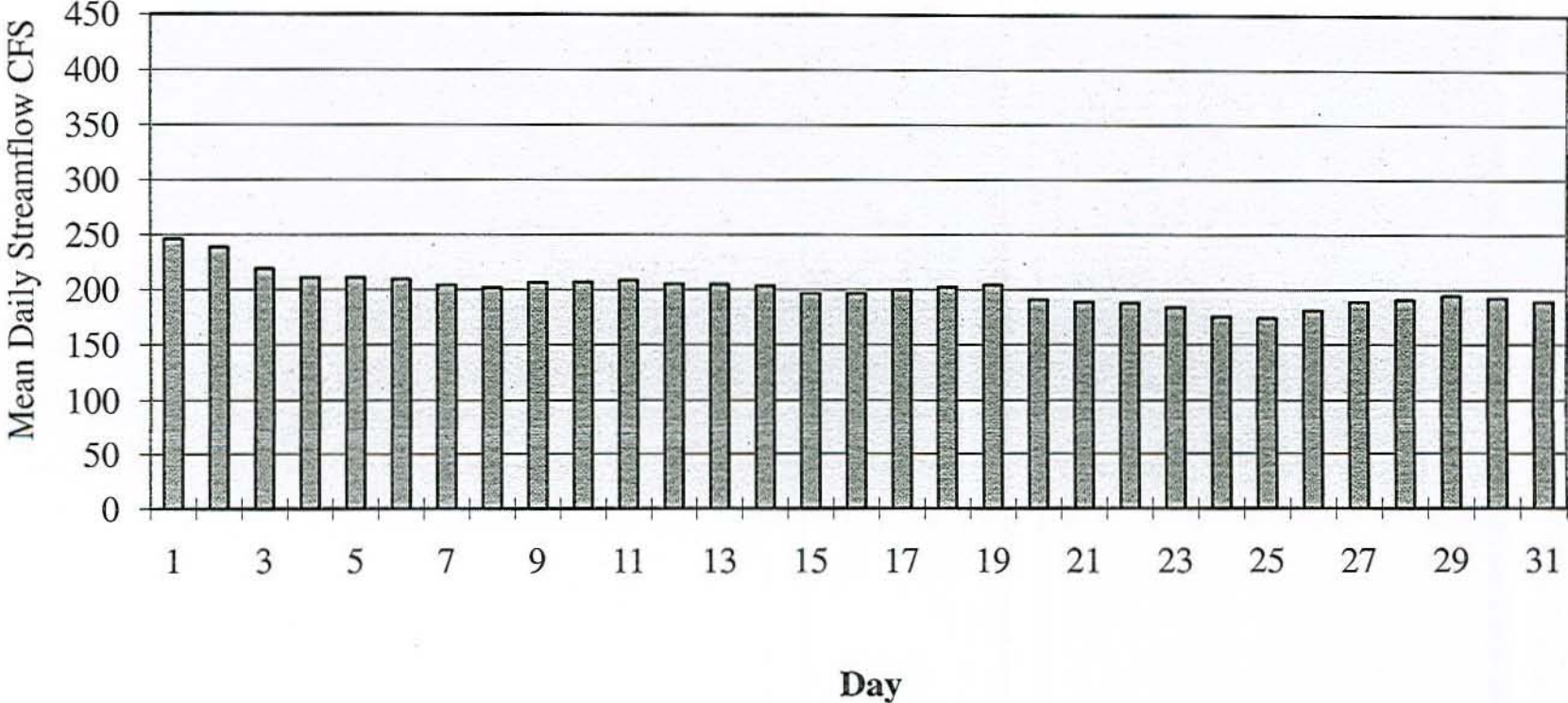


### Gross Reservoir Mean Daily Outflow for July (Water Years 1955 through 1991)



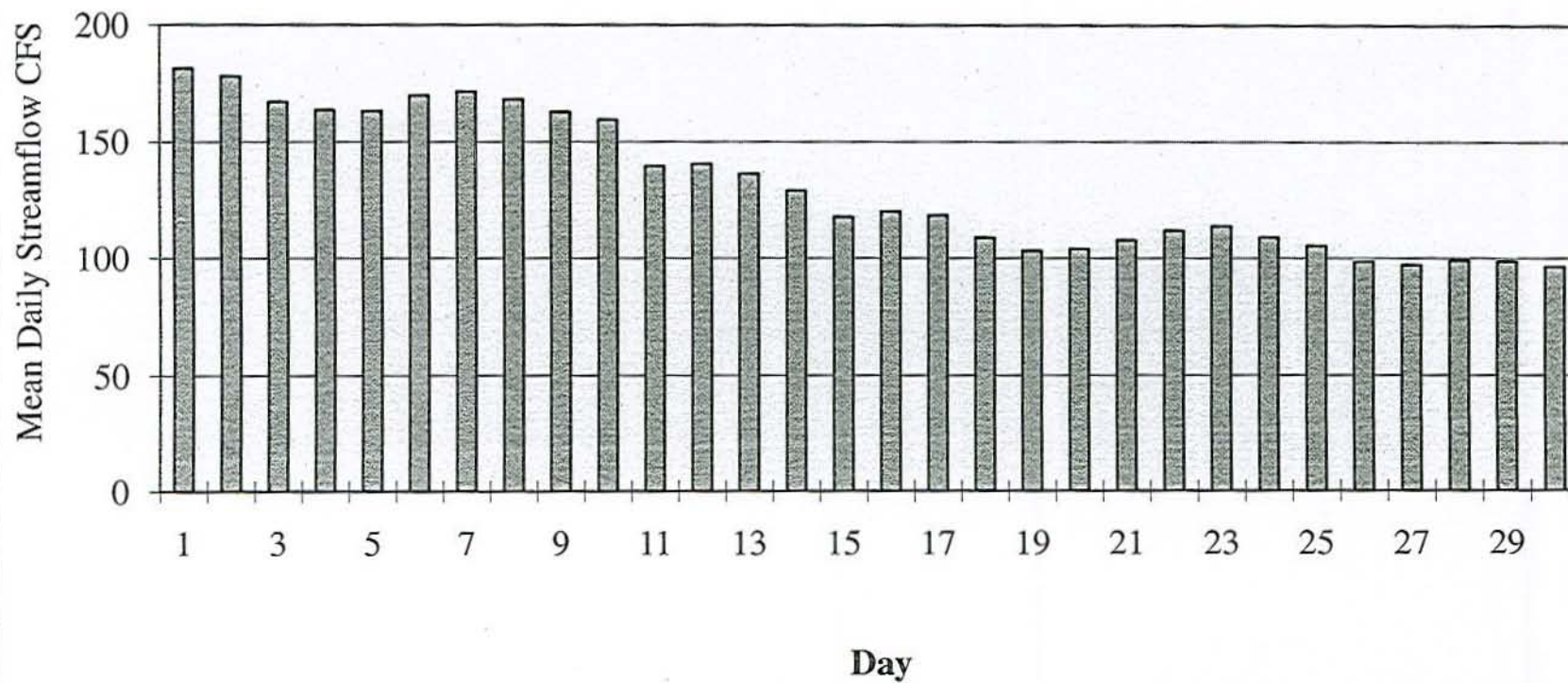
Note: Gross Reservoir Storage began on June 19, 1955.

### Gross Reservoir Mean Daily Outflow for August (Water Years 1955 through 1991)



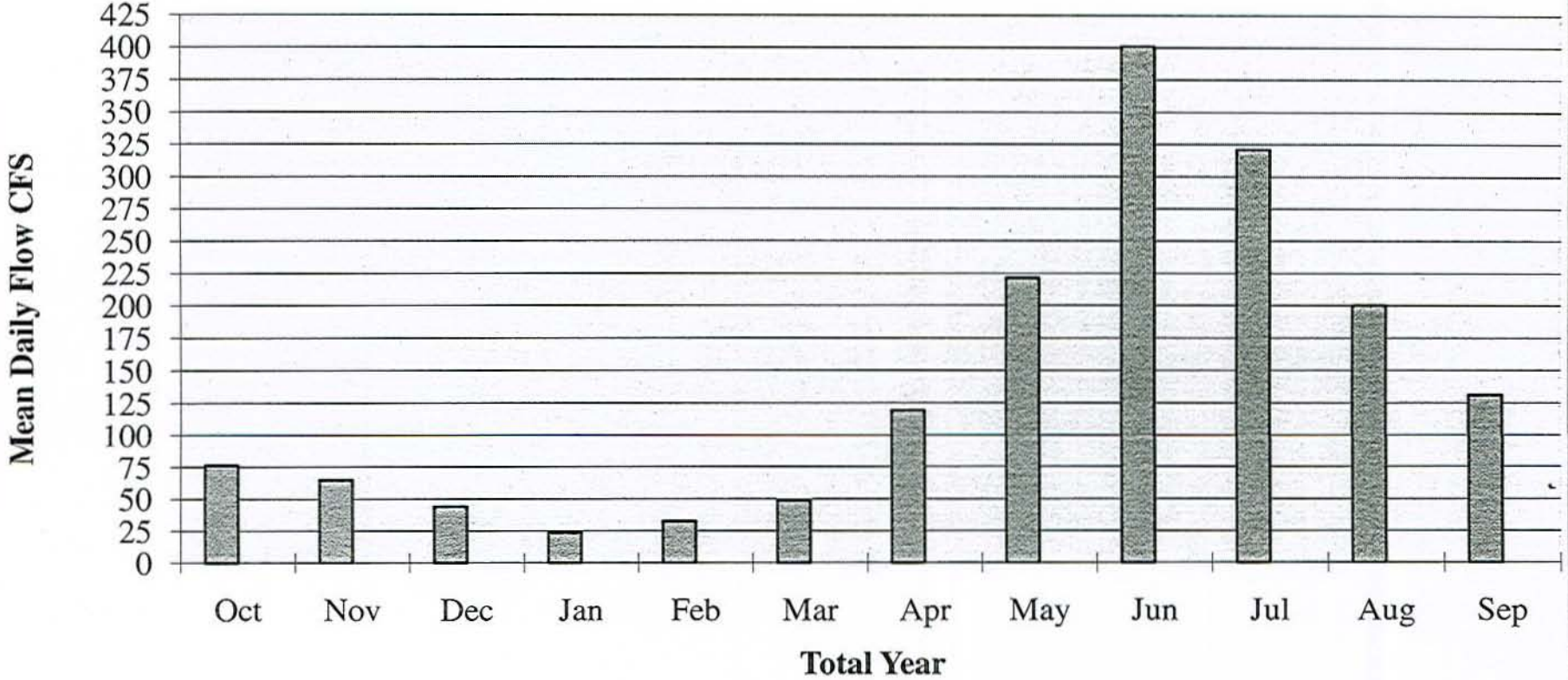
Note: Gross Reservoir Storage began on June 19, 1955.

### Gross Reservoir Mean Daily Outflow for September (Water Years 1955 through 1991)



Note: Gross Reservoir Storage began on June 19, 1955.

### Gross Reservoir Mean Daily Outflow (Water Years 1955 through 1991)



Note: Gross Reservoir Storage began on June 19, 1955.

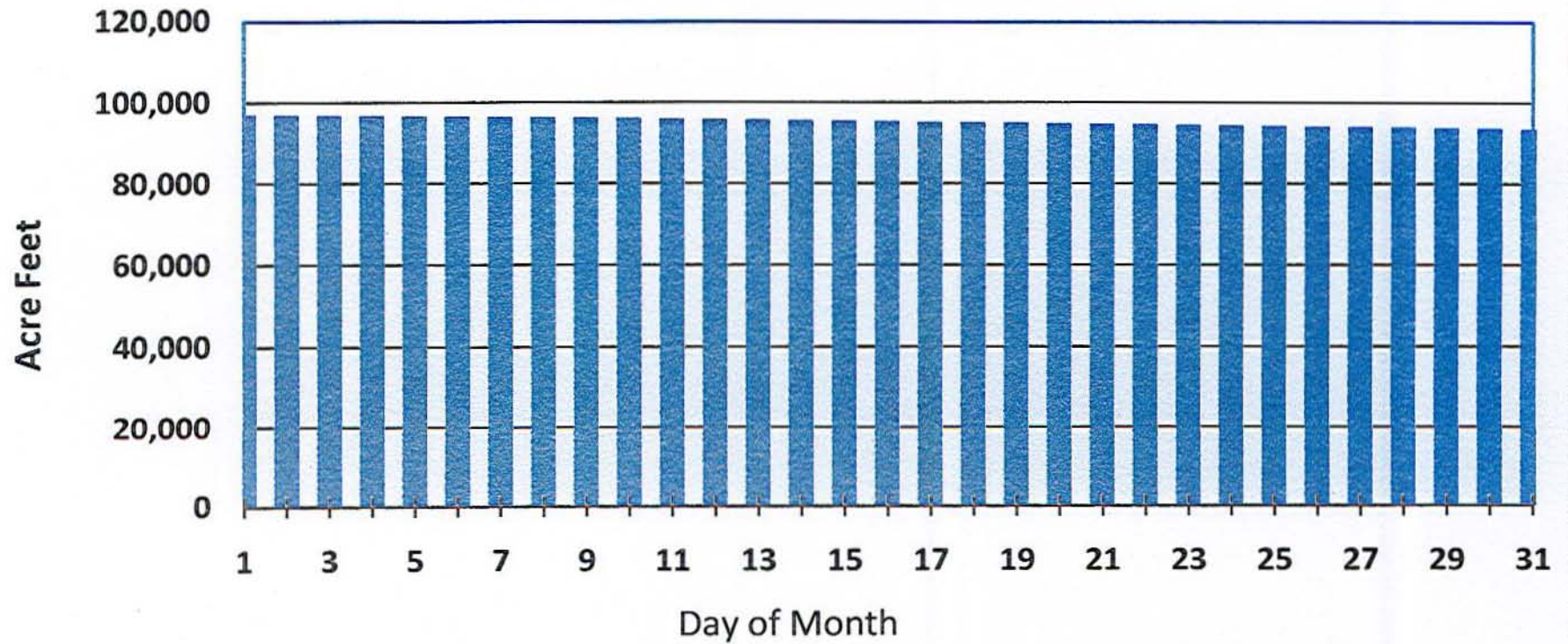
**GROSS RESERVOIR HYDROELECTRIC PROJECT NO. 2035-030**

**Hydrology – November 7, 2008**

Appendix B

# 72,000 Acre-Feet Enlargement of Gross Reservoir

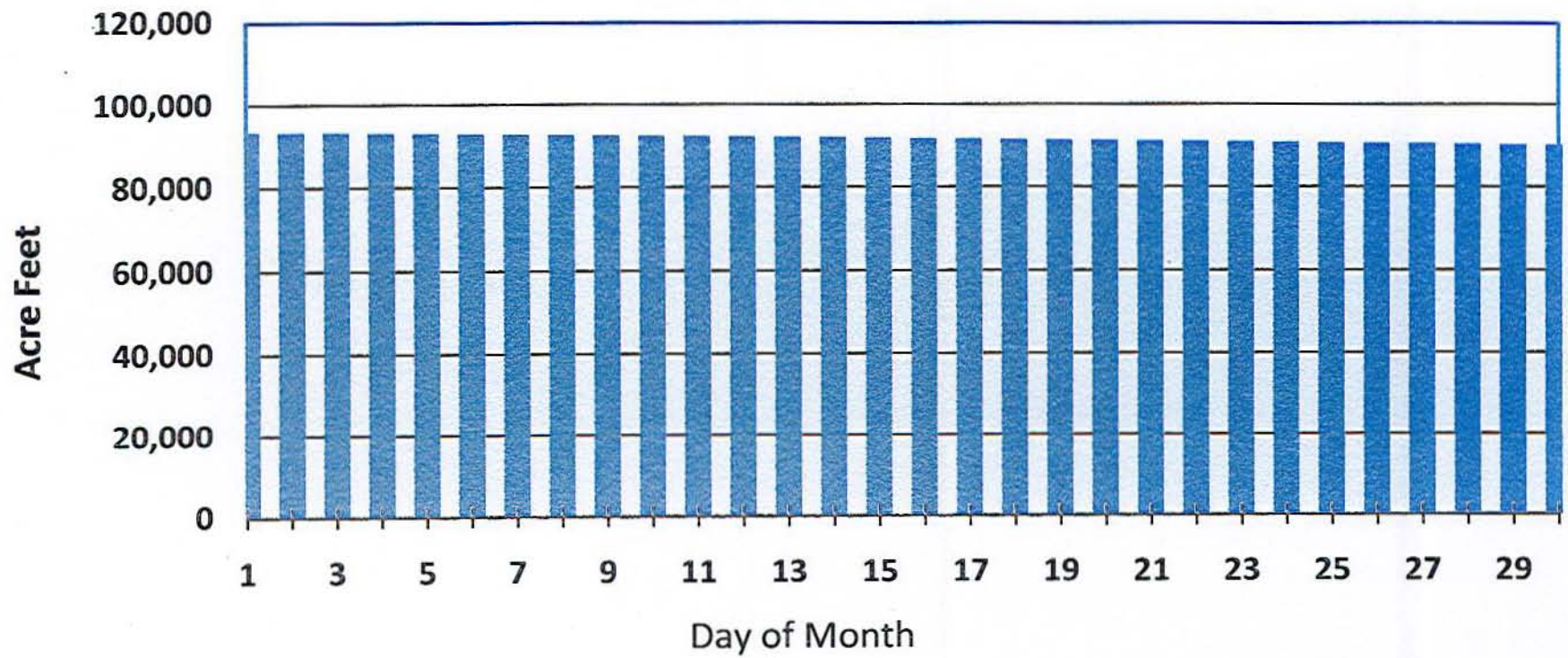
Gross Reservoir Mean Daily Storage for October  
(Water Years 1947 through 1991)



Appendix B, Figure 1

# 72,000 Acre-Feet Enlargement of Gross Reservoir

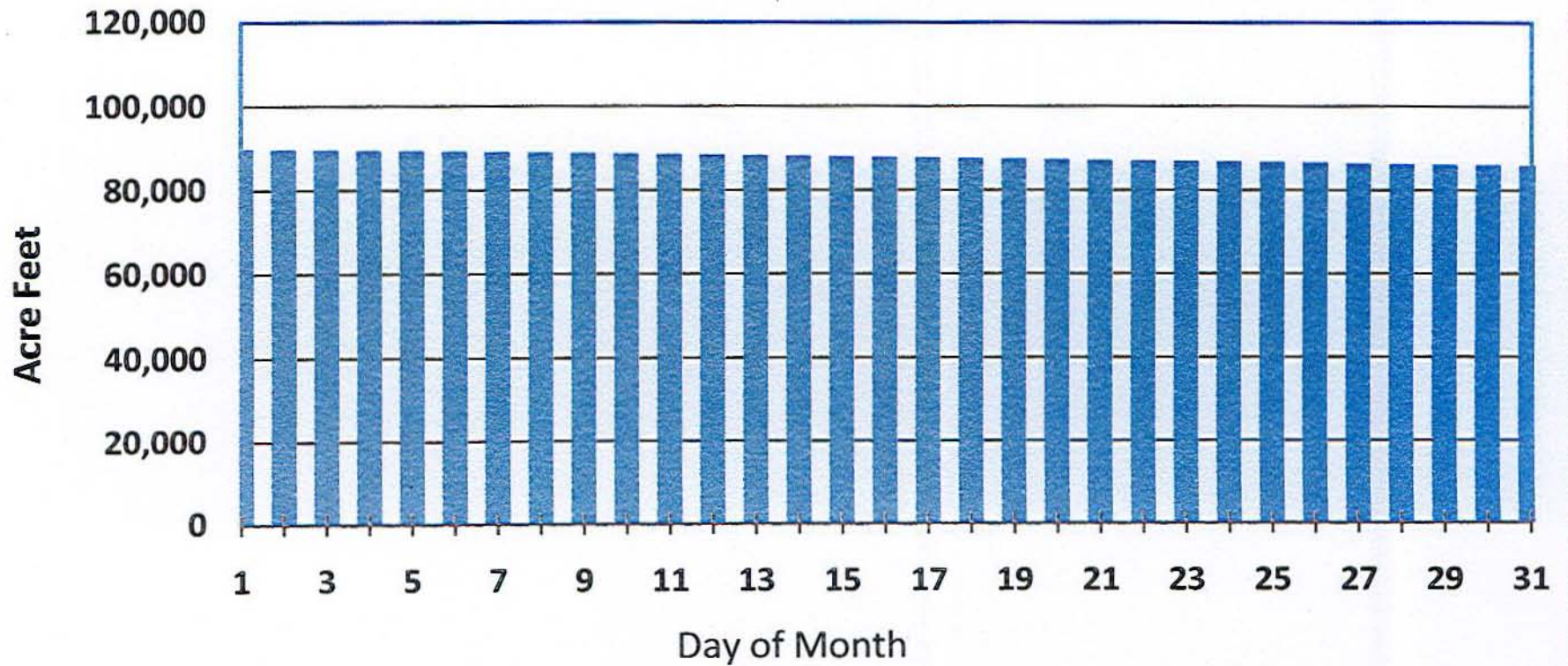
Gross Reservoir Mean Daily Storage for November  
(Water Years 1947 through 1991)



Appendix B, Figure 2

# 72,000 Acre-Feet Enlargement of Gross Reservoir

Gross Reservoir Mean Daily Storage for December  
(Water Years 1947 through 1991)

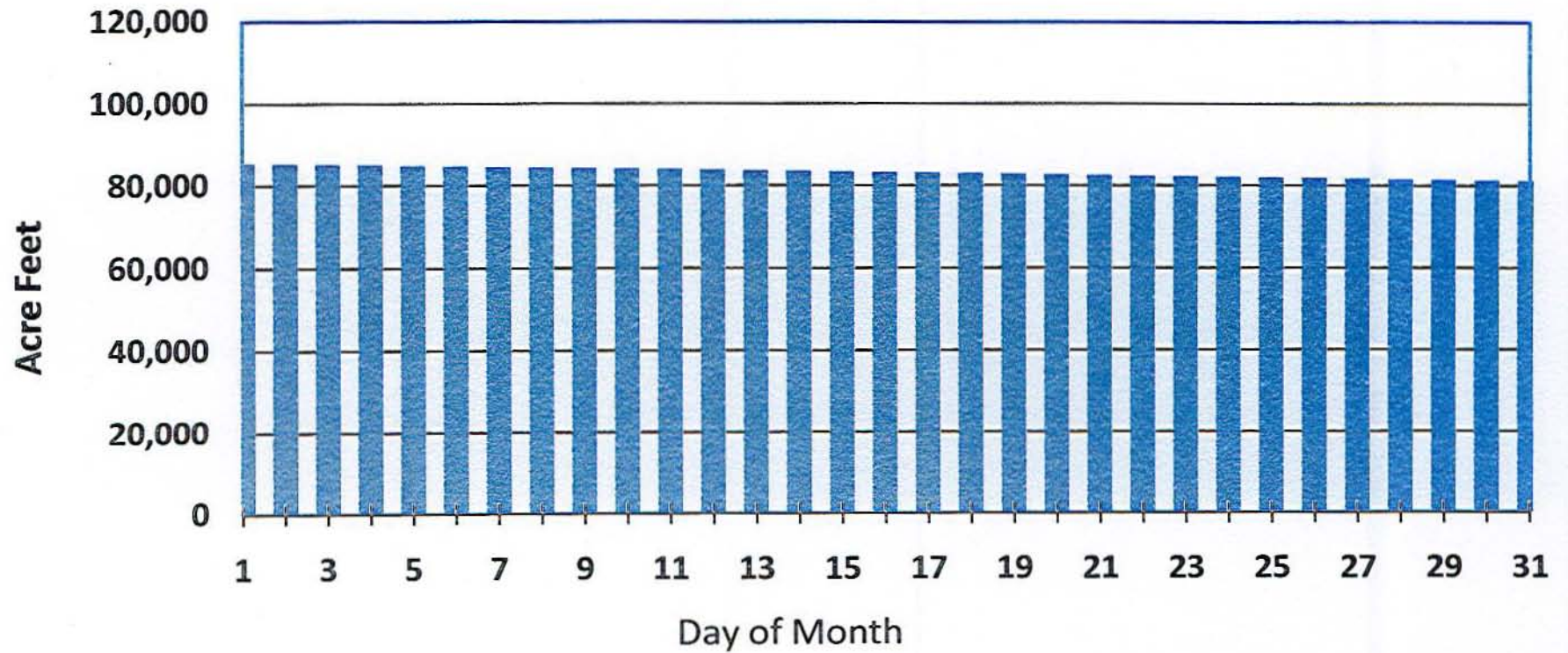


Appendix B, Figure 3



# 72,000 Acre-Feet Enlargement of Gross Reservoir

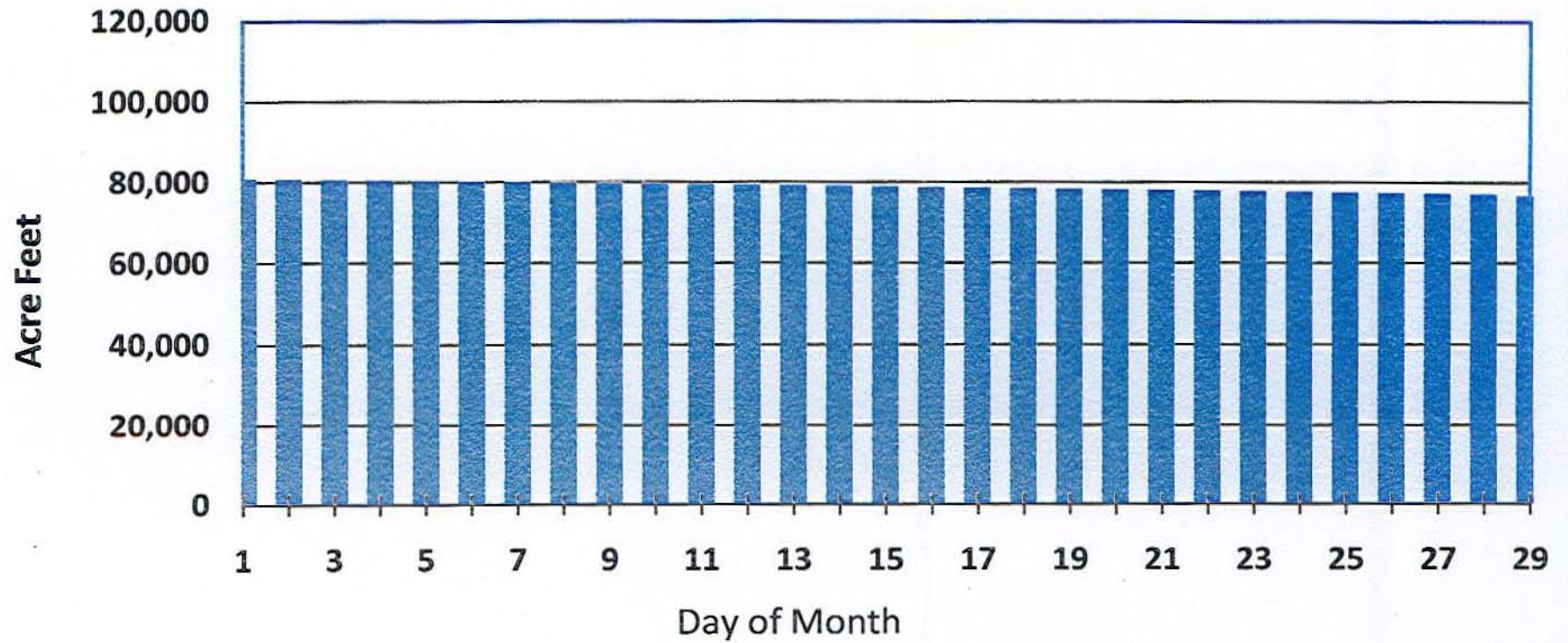
Gross Reservoir Mean Daily Storage for January  
(Water Years 1947 through 1991)



Appendix B, Figure 4

# 72,000 Acre-Feet Enlargement of Gross Reservoir

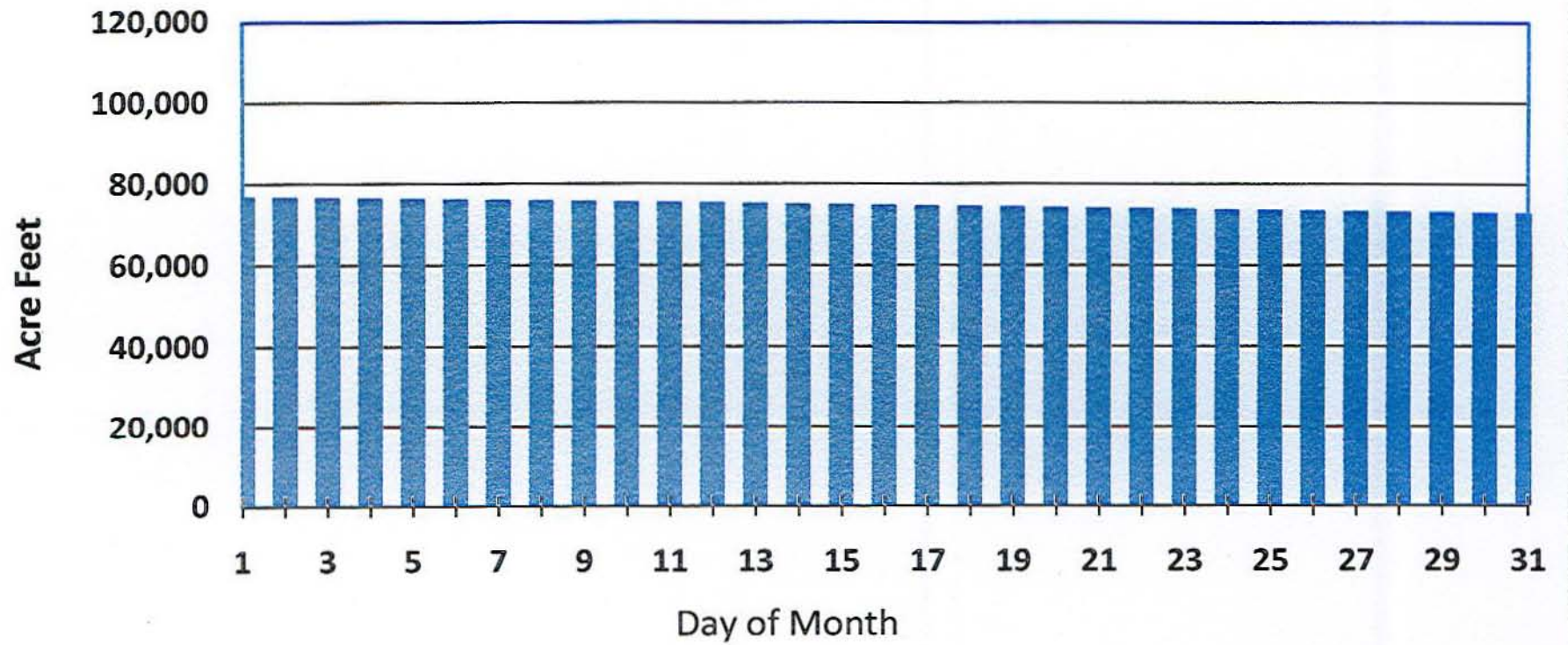
Gross Reservoir Mean Daily Storage for January  
(Water Years 1947 through 1991)



Appendix B, Figure 5

# 72,000 Acre-Feet Enlargement of Gross Reservoir

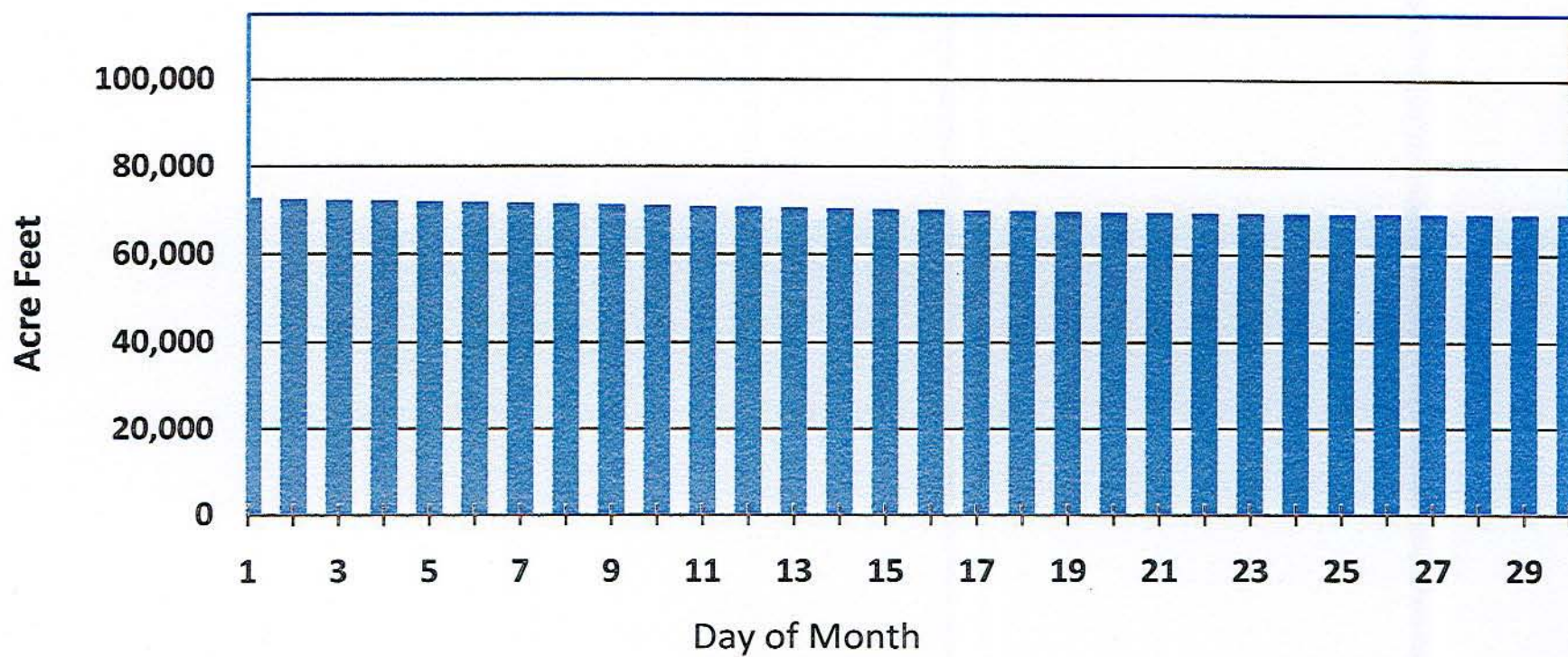
Gross Reservoir Mean Daily Storage for March  
(Water Years 1947 through 1991)



Appendix B, Figure 6

## 72,000 Acre-Feet Enlargement of Gross Reservoir

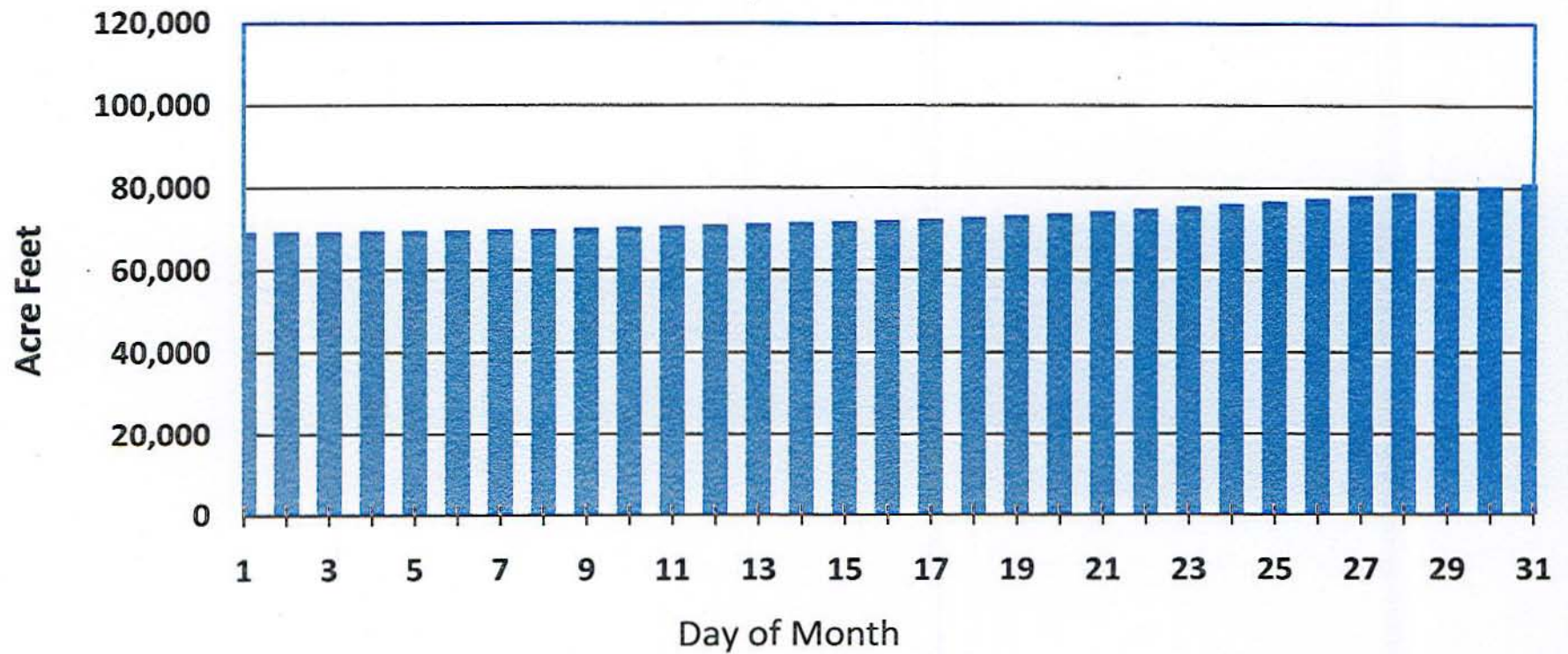
Gross Reservoir Mean Daily Storage for April  
(Water Years 1947 through 1991)



Appendix B, Figure 7

# 72,000 Acre-Feet Enlargement of Gross Reservoir

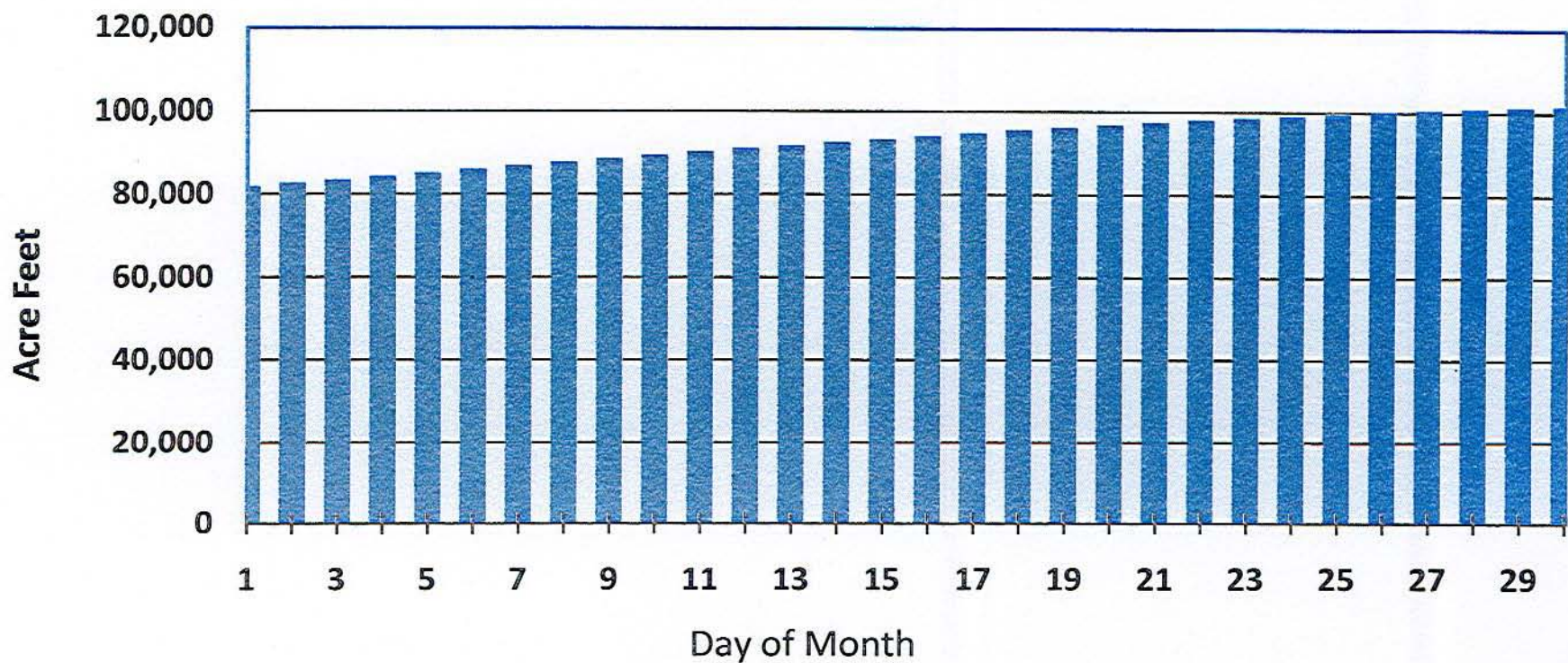
Gross Reservoir Mean Daily Storage for May  
(Water Years 1947 through 1991)



Appendix B, Figure 8

# 72,000 Acre-Feet Enlargement of Gross Reservoir

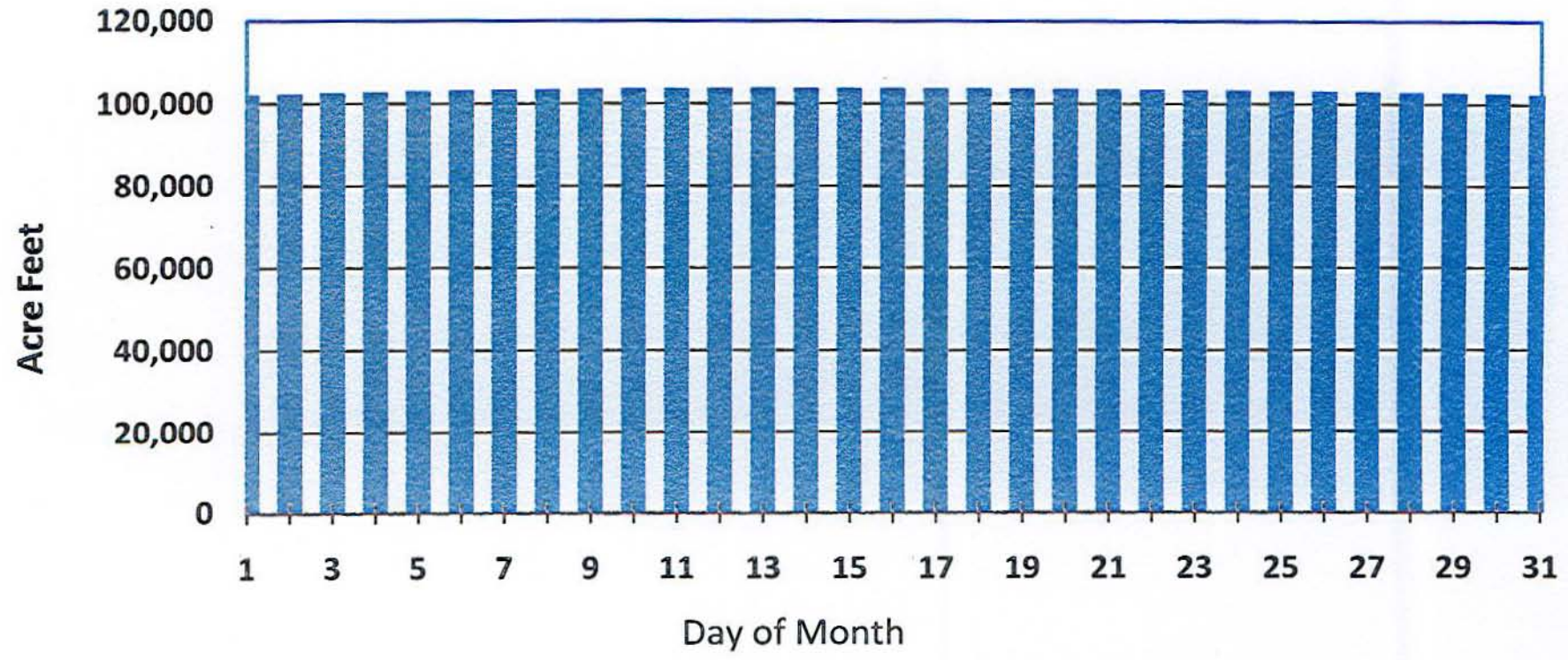
Gross Reservoir Mean Daily Storage for June  
(Water Years 1947 through 1991)



Appendix B, Figure 9

# 72,000 Acre-Feet Enlargement of Gross Reservoir

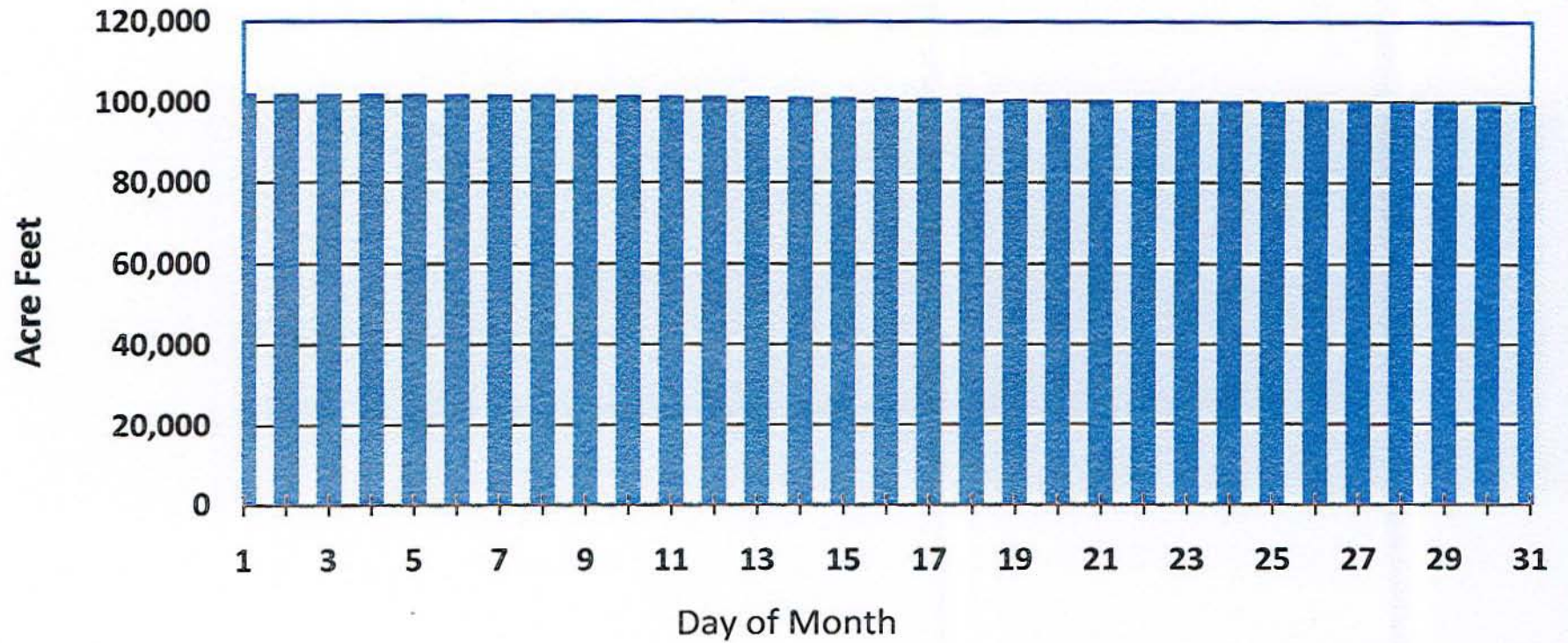
Gross Reservoir Mean Daily Storage for July  
(Water Years 1947 through 1991)



Appendix B, Figure 10

# 72,000 Acre-Feet Enlargement of Gross Reservoir

Gross Reservoir Mean Daily Storage for August  
(Water Years 1947 through 1991)

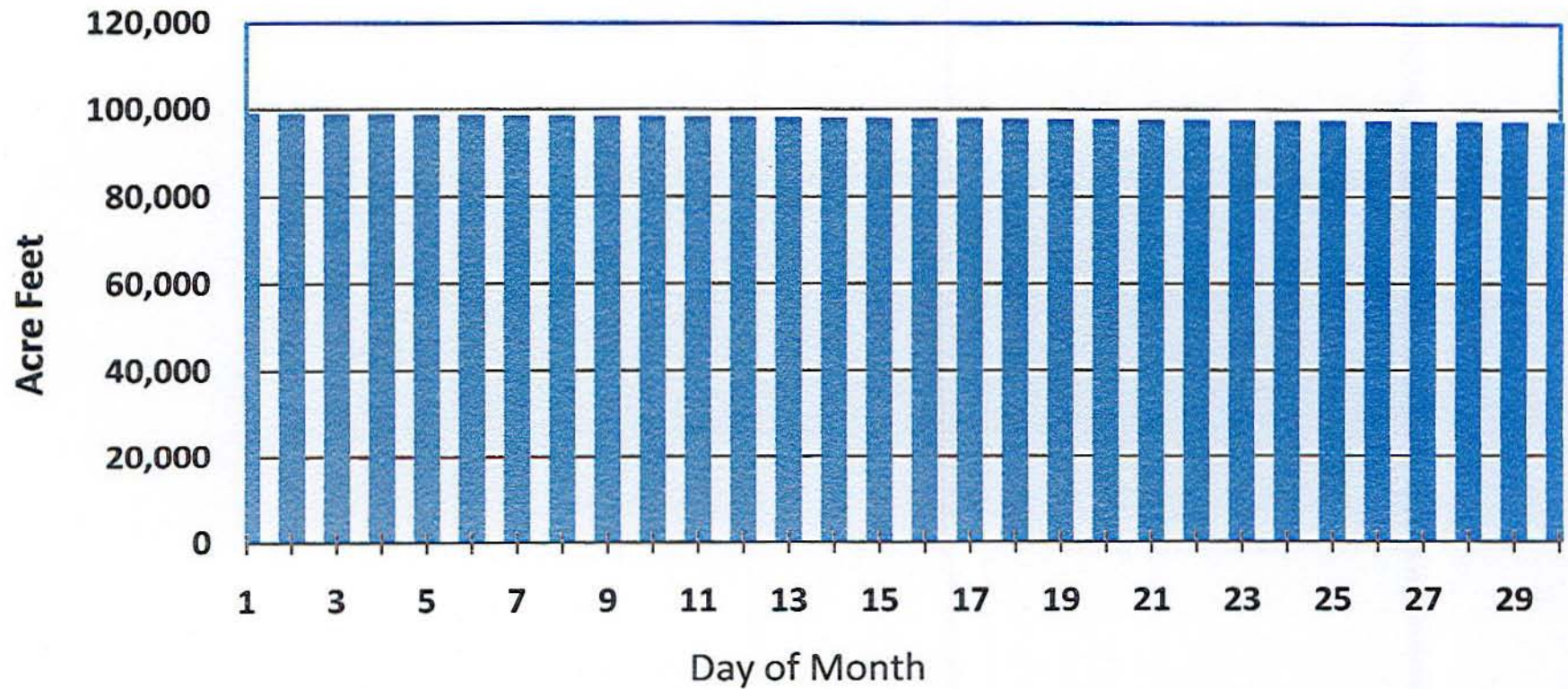


Appendix B, Figure 11



# 72,000 Acre-Feet Enlargement of Gross Reservoir

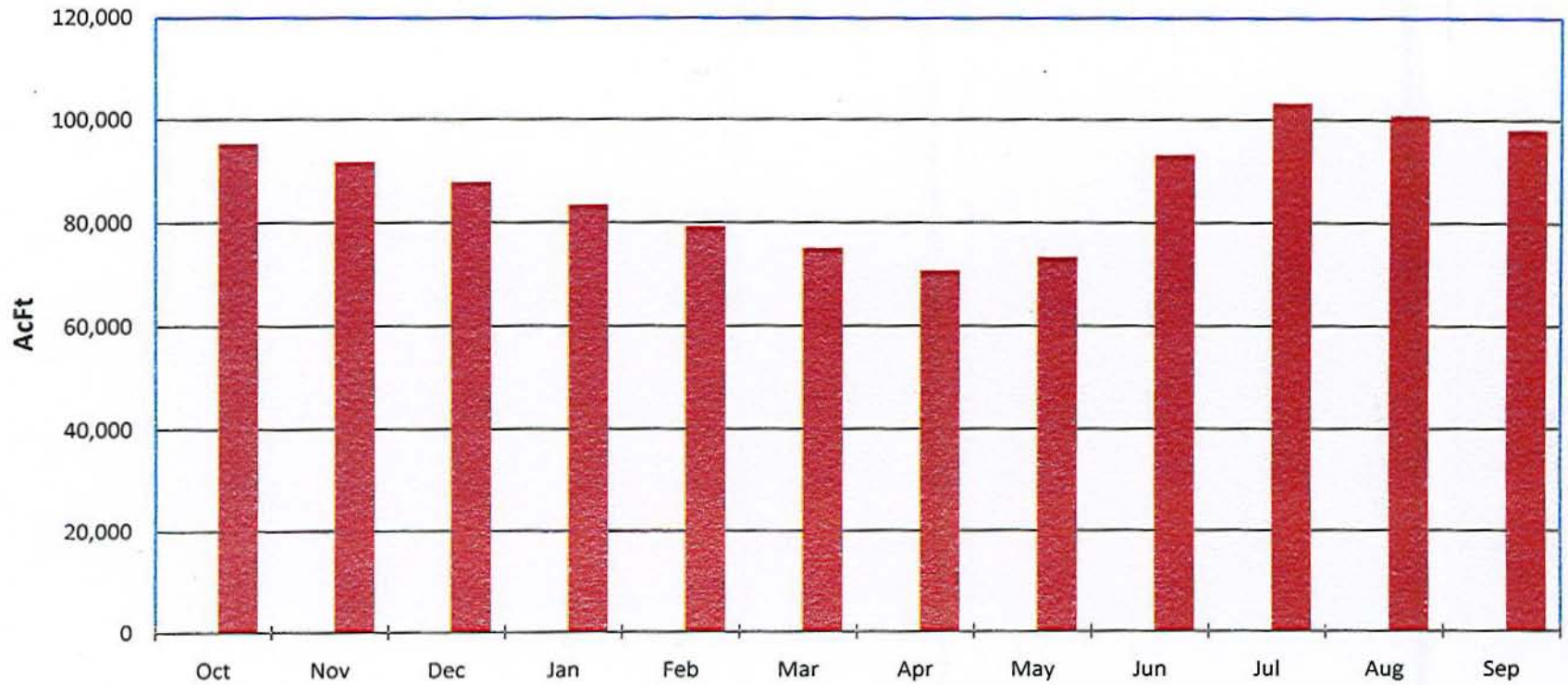
Gross Reservoir Mean Daily Storage for September  
(Water Years 1947 through 1991)



Appendix B, Figure 12

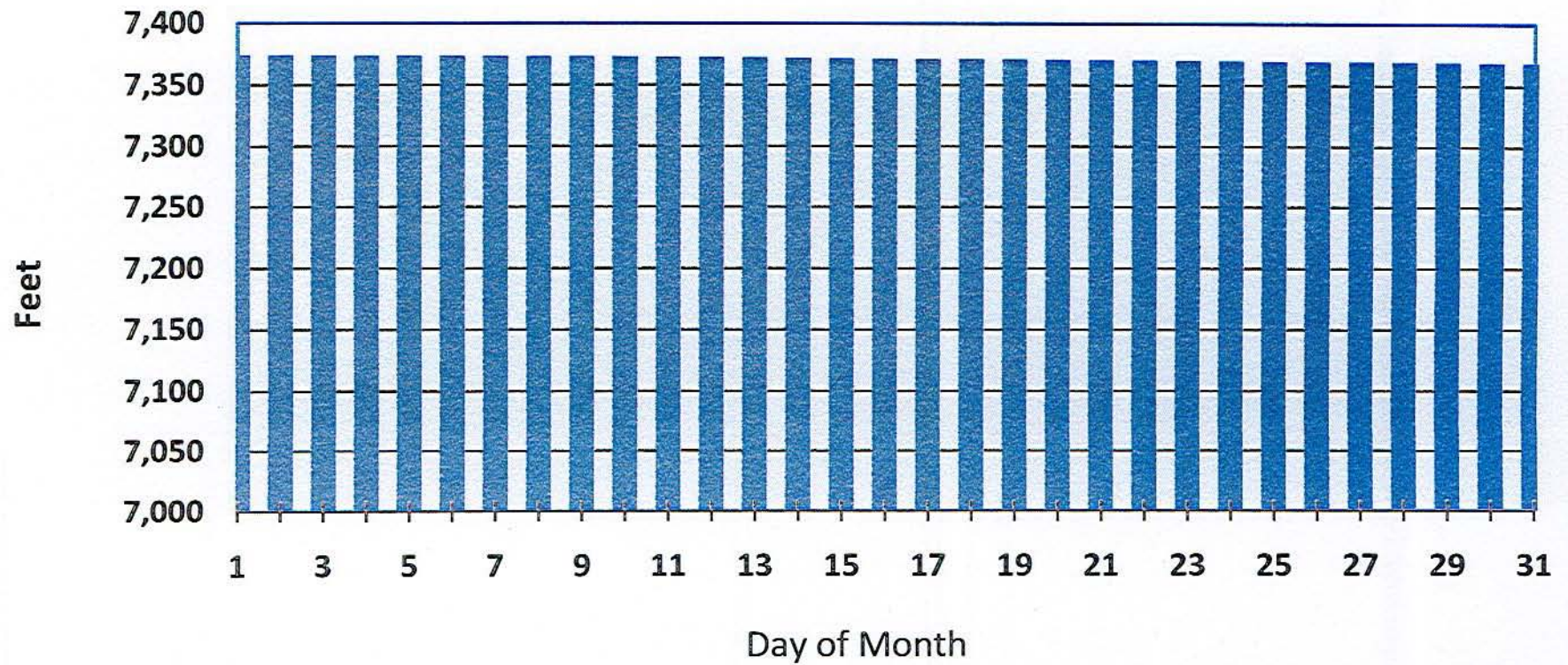
## 72,000 Acre-Feet Enlargement of Gross Reservoir

Mean Monthly Gross Reservoir Contents  
(Water Years 1947 Through 1991)



## 72,000 Acre-Feet Enlargement of Gross Reservoir

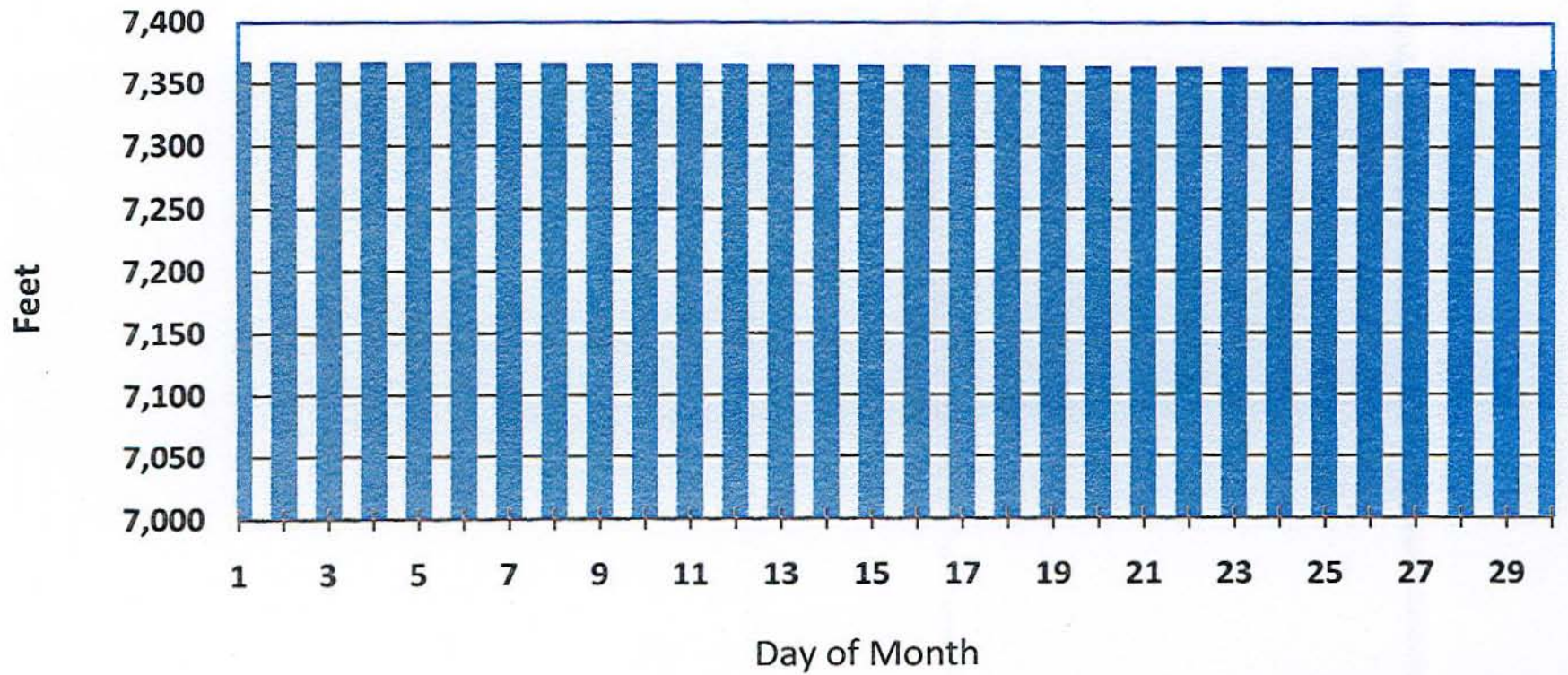
Gross Reservoir Mean Daily Elevation for October  
(Water Years 1947 through 1991)



Appendix B, Figure 14

# 72,000 Acre-Feet Enlargement of Gross Reservoir

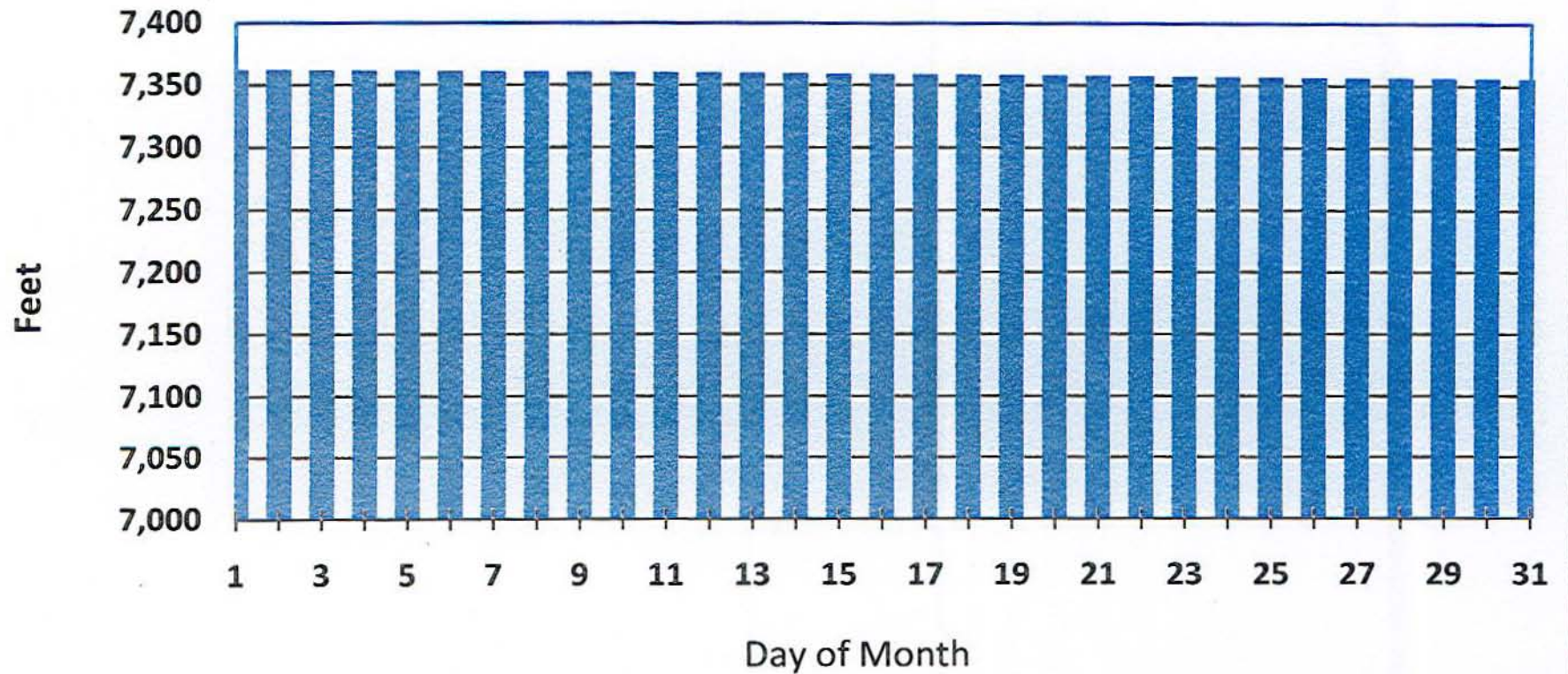
Gross Reservoir Mean Daily Elevation for November  
(Water Years 1947 through 1991)



Appendix B, Figure 15

# 72,000 Acre-Feet Enlargement of Gross Reservoir

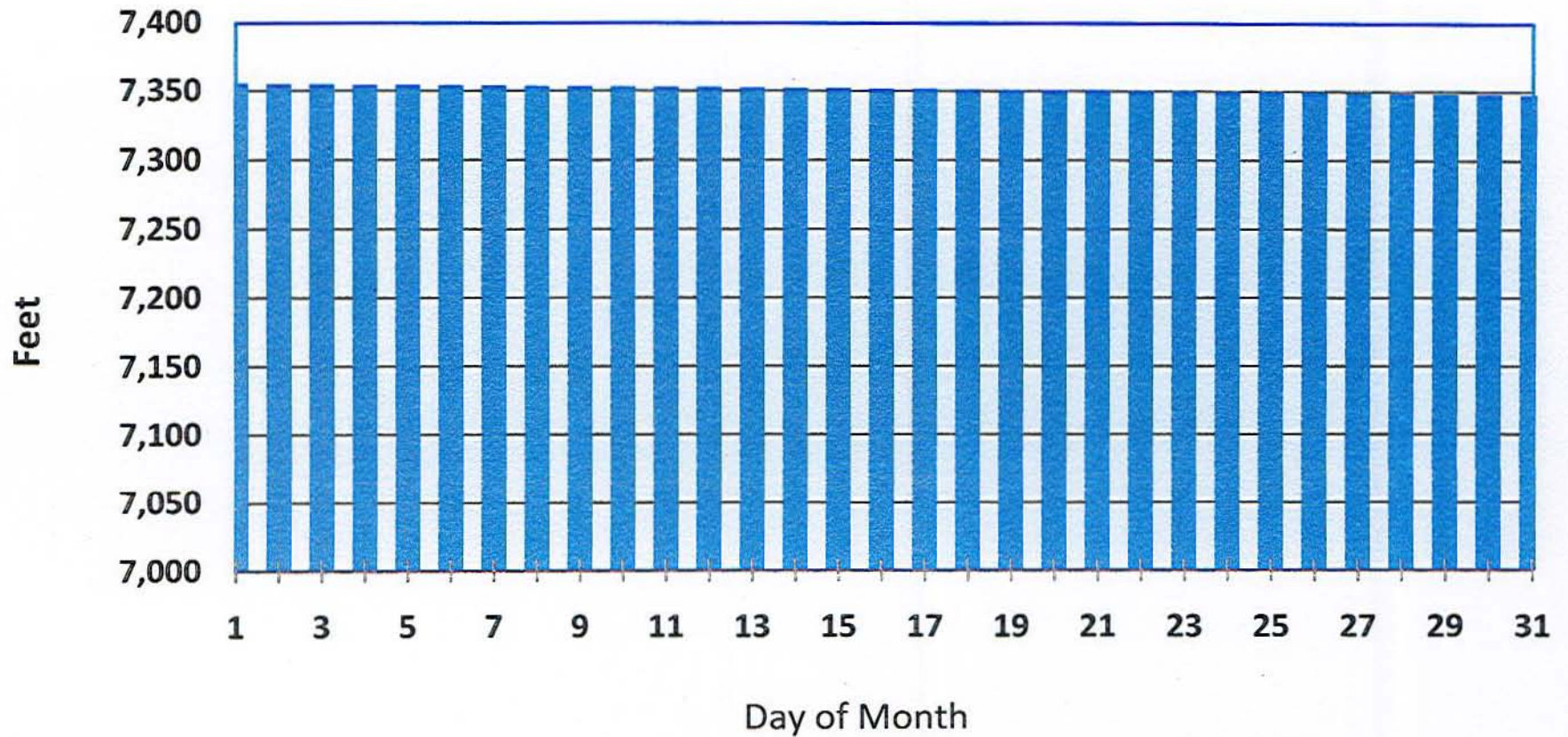
Gross Reservoir Mean Daily Elevation for December  
(Water Years 1947 through 1991)



Appendix B, Figure 16

# 72,000 Acre-Feet Enlargement of Gross Reservoir

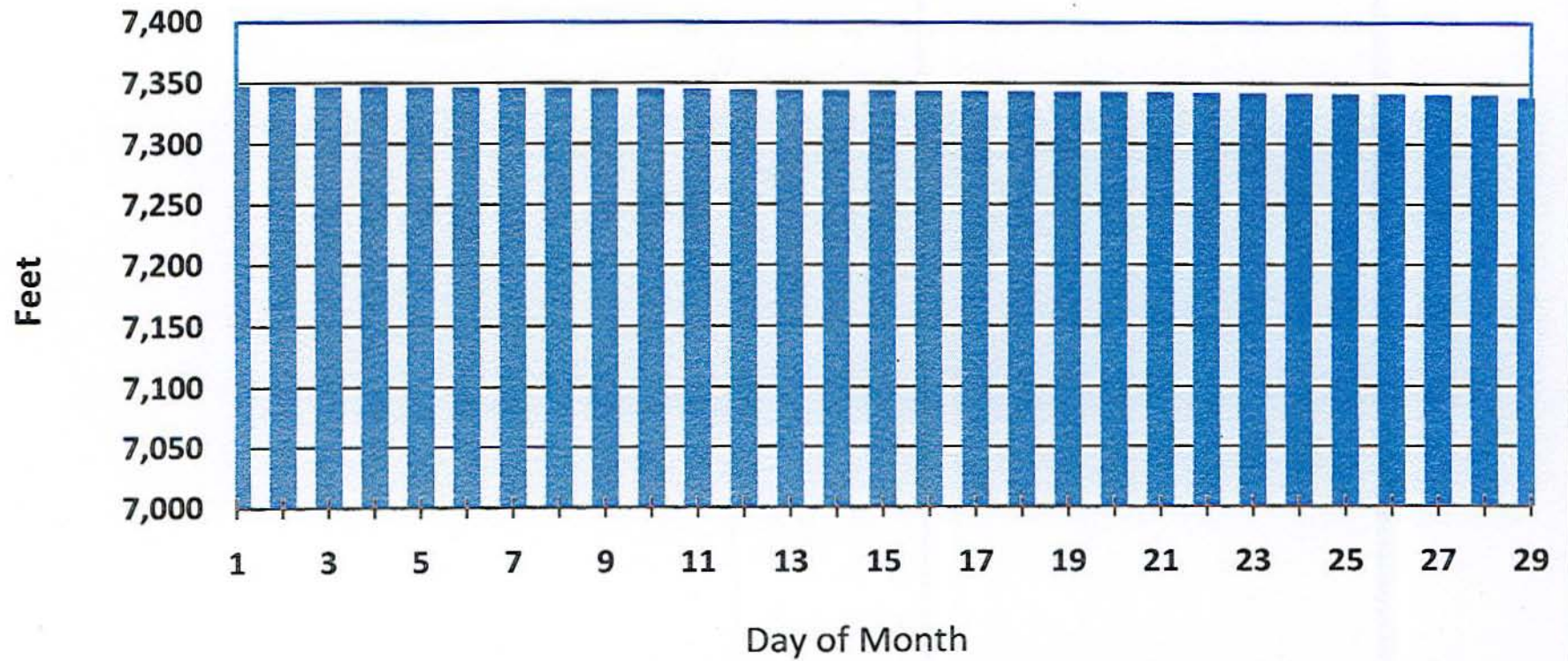
Gross Reservoir Mean Daily Elevation for January  
(Water Years 1947 through 1991)



Appendix B, Figure 14

# 72,000 Acre-Feet Enlargement of Gross Reservoir

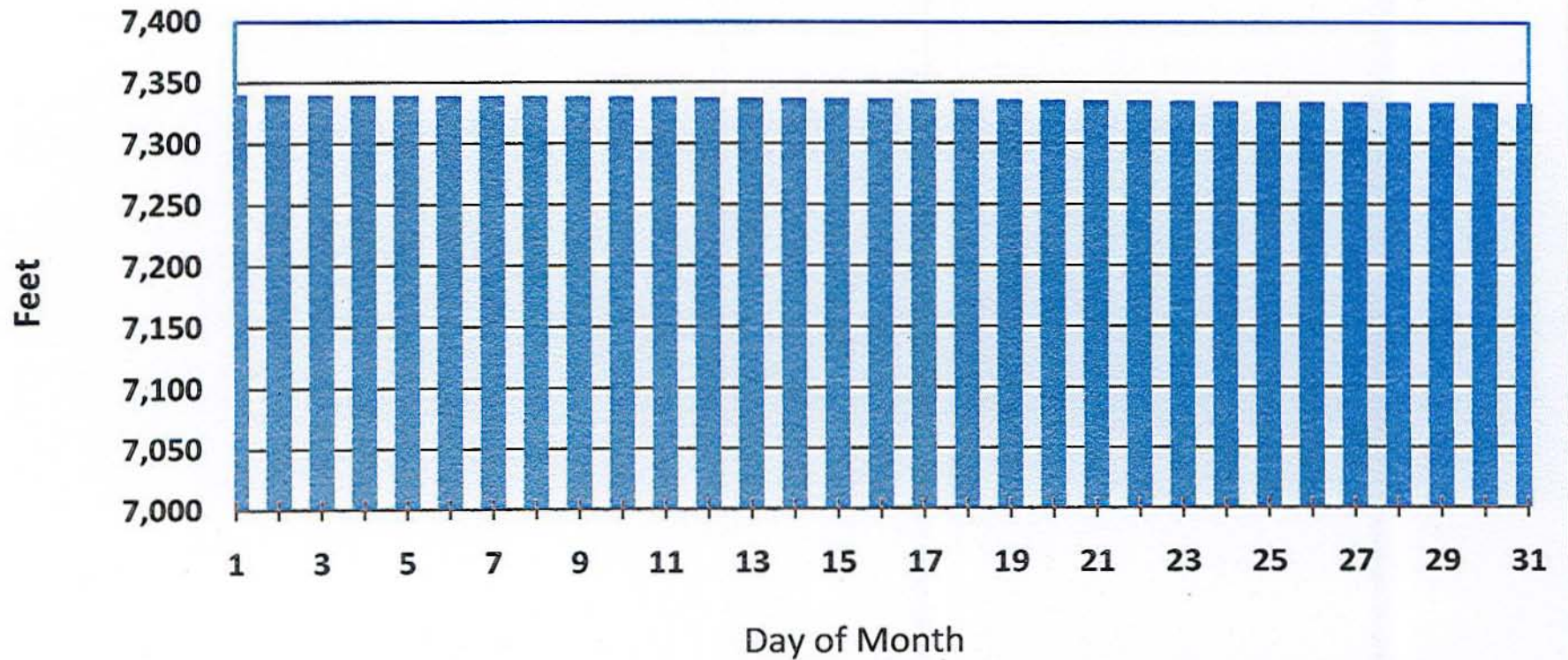
Gross Reservoir Mean Daily Elevation for February  
(Water Years 1947 through 1991)



Appendix B, Figure 18

# 72,000 Acre-Feet Enlargement of Gross Reservoir

Gross Reservoir Mean Daily Elevation for March  
(Water Years 1947 through 1991)

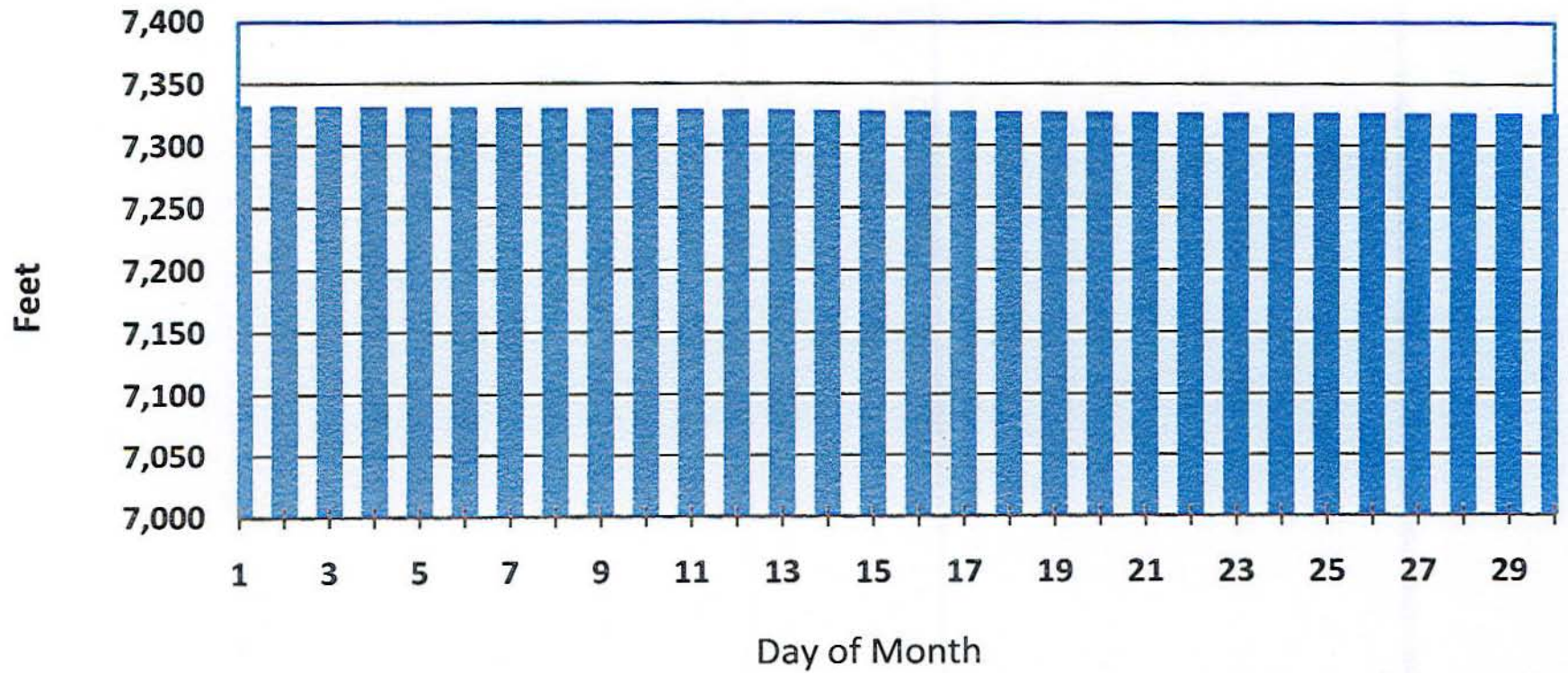


Appendix B, Figure 19



# 72,000 Acre-Feet Enlargement of Gross Reservoir

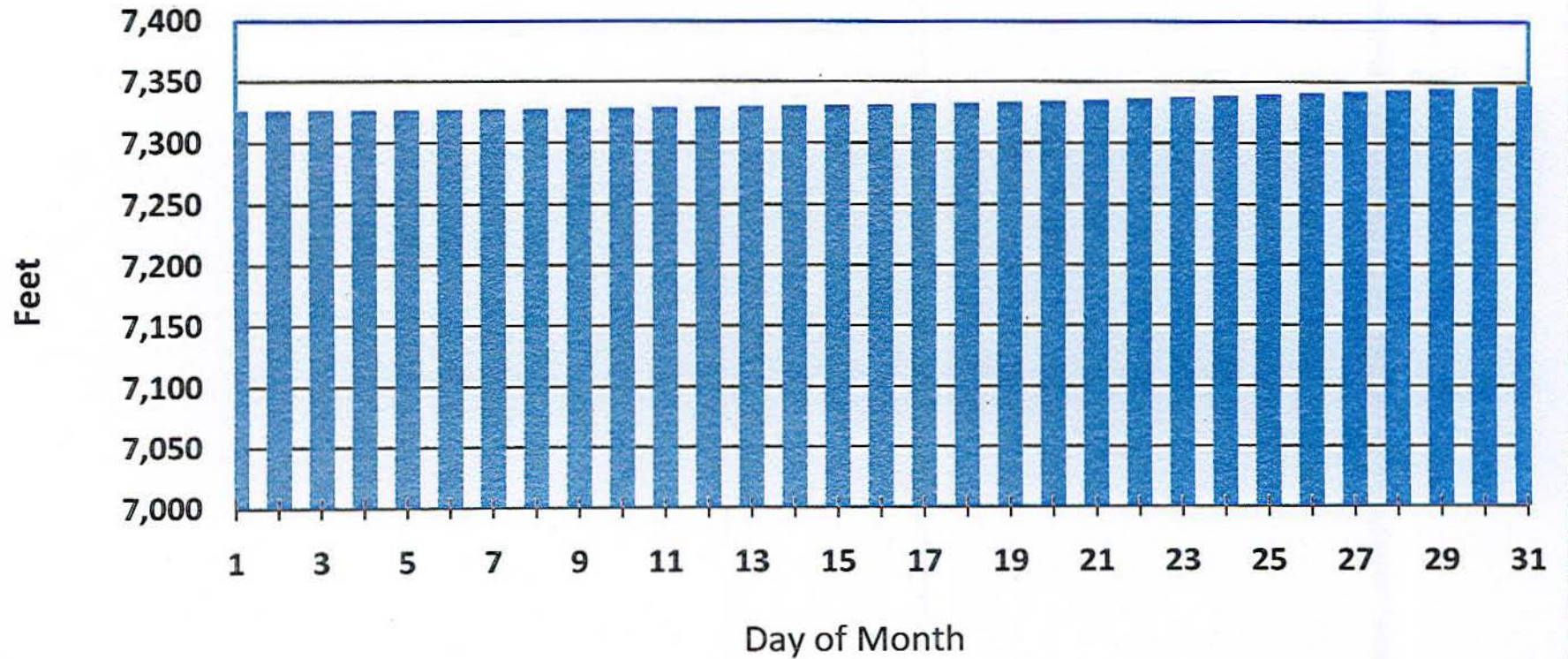
Gross Reservoir Mean Daily Elevation for April  
(Water Years 1947 through 1991)



Appendix B, Figure 20

# 72,000 Acre-Feet Enlargement of Gross Reservoir

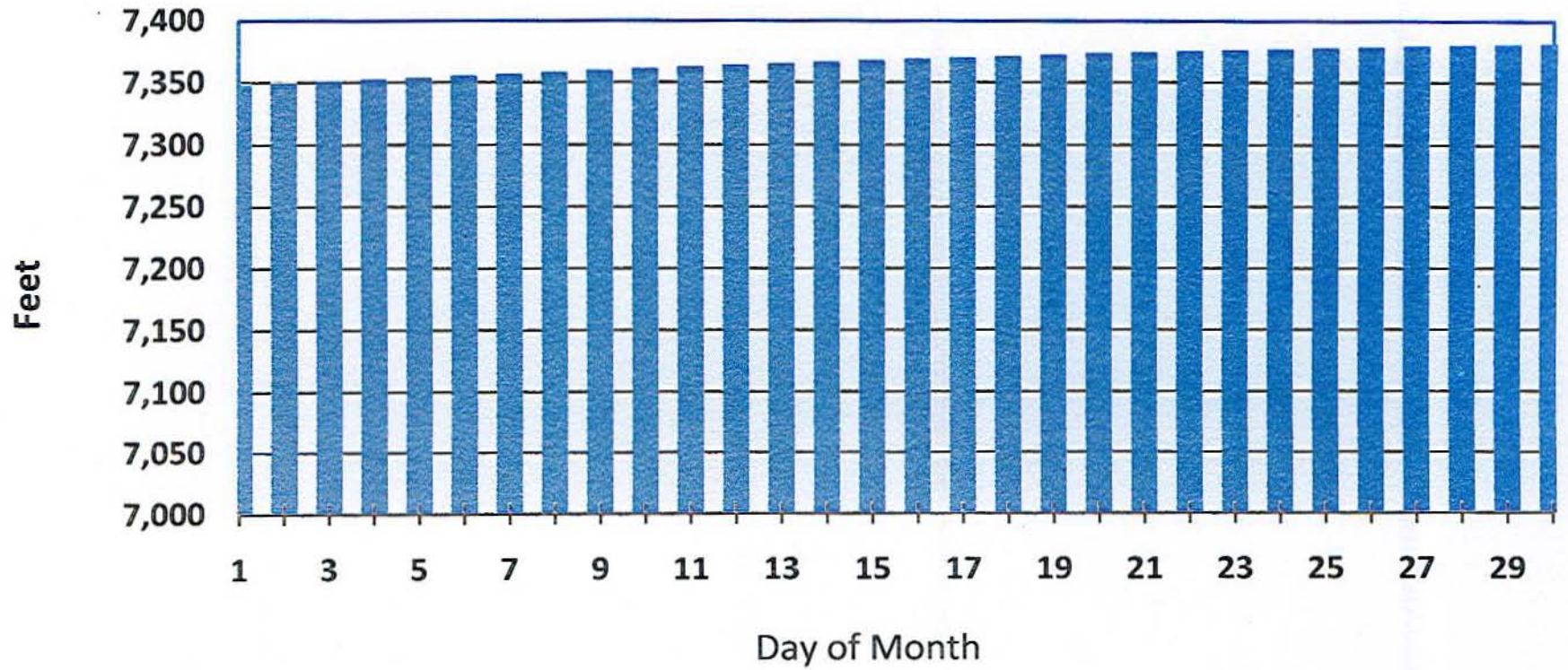
Gross Reservoir Mean Daily Elevation for May  
(Water Years 1947 through 1991)



Appendix B, Figure 21

# 72,000 Acre-Feet Enlargement of Gross Reservoir

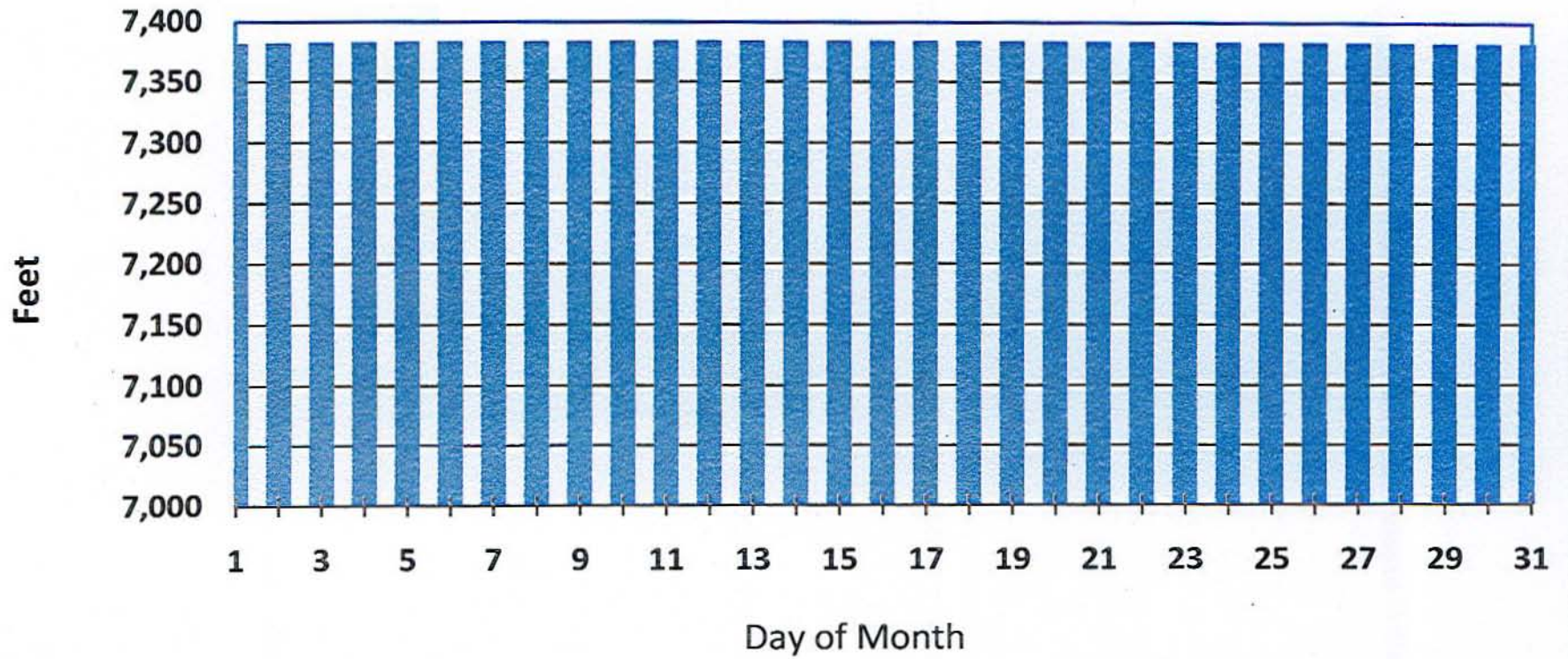
Gross Reservoir Mean Daily Elevation for June  
(Water Years 1947 through 1991)



Appendix B, Figure 22

# 72,000 Acre-Feet Enlargement of Gross Reservoir

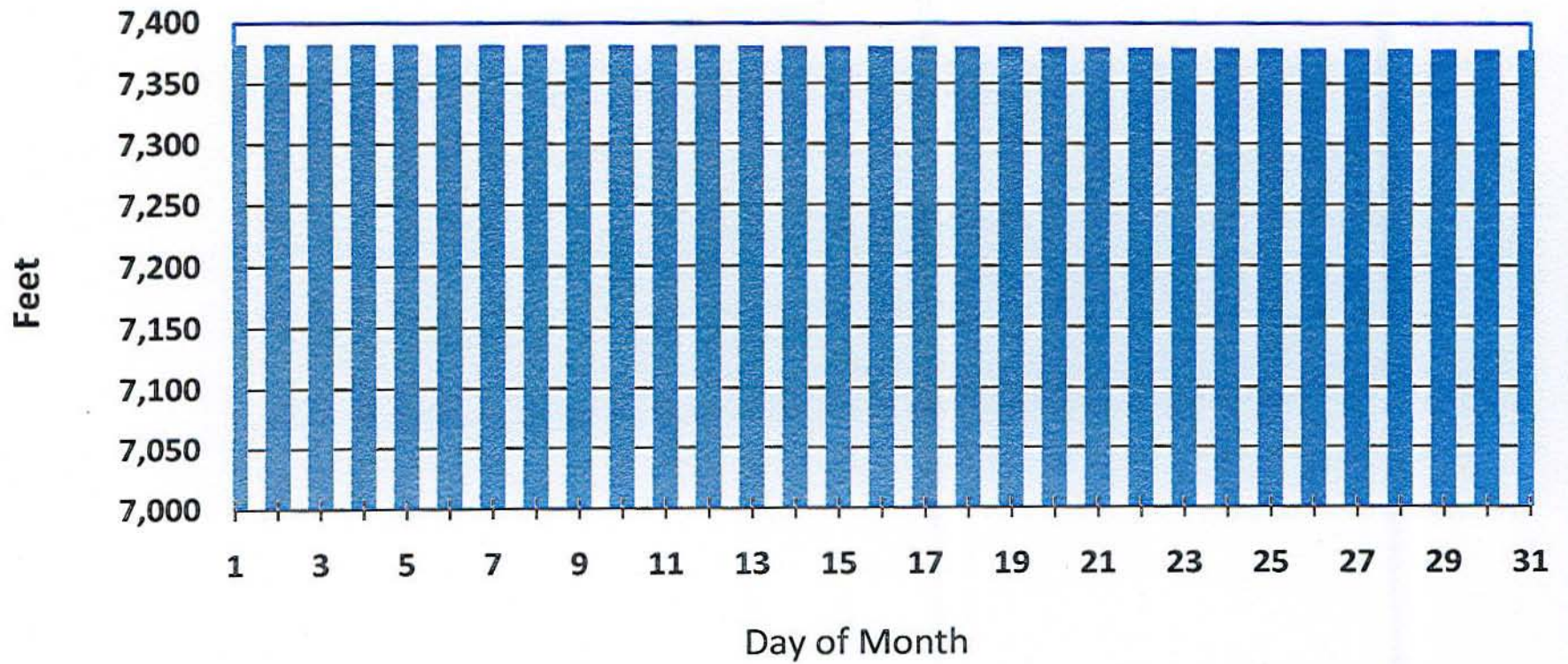
Gross Reservoir Mean Daily Elevation for July  
(Water Years 1947 through 1991)



Appendix B, Figure 23

# 72,000 Acre-Feet Enlargement of Gross Reservoir

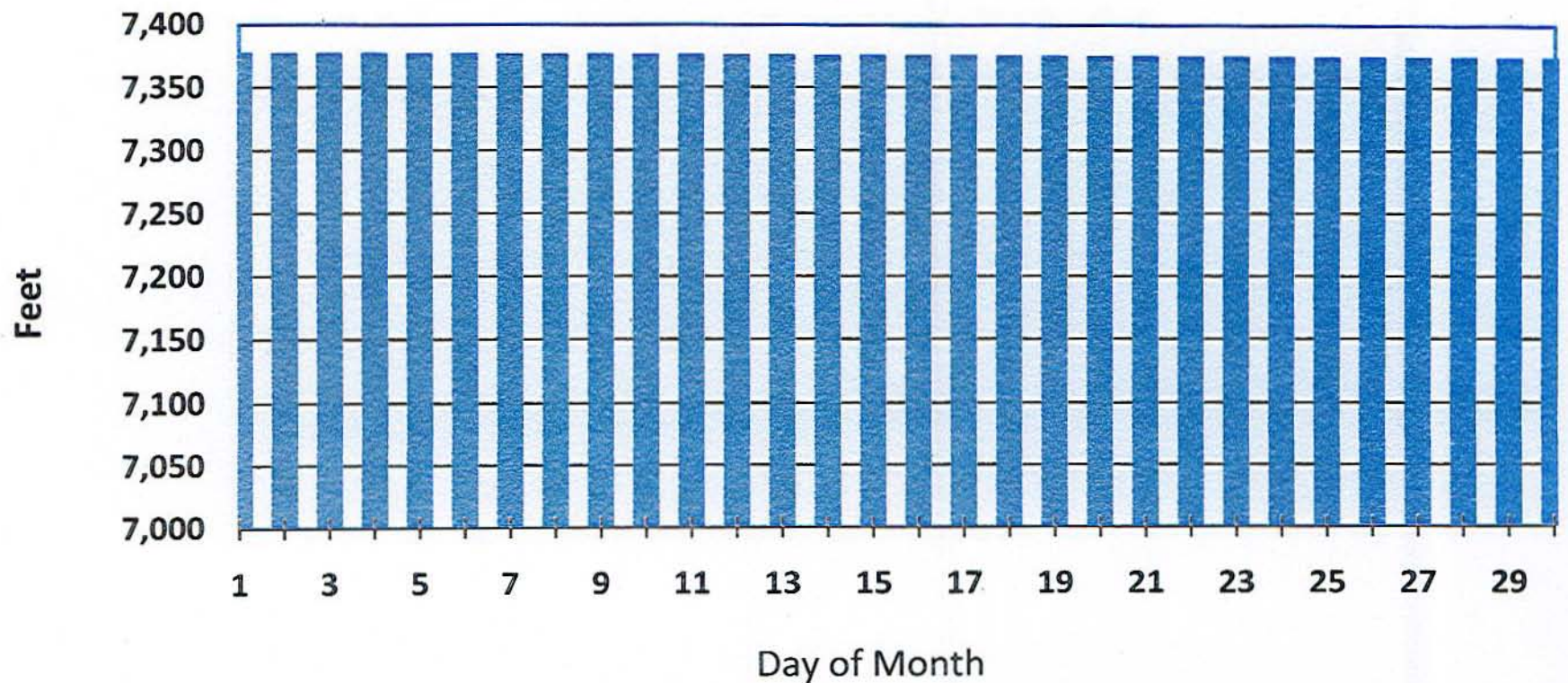
Gross Reservoir Mean Daily Elevation for August  
(Water Years 1947 through 1991)



Appendix B, Figure 24

# 72,000 Acre-Feet Enlargement of Gross Reservoir

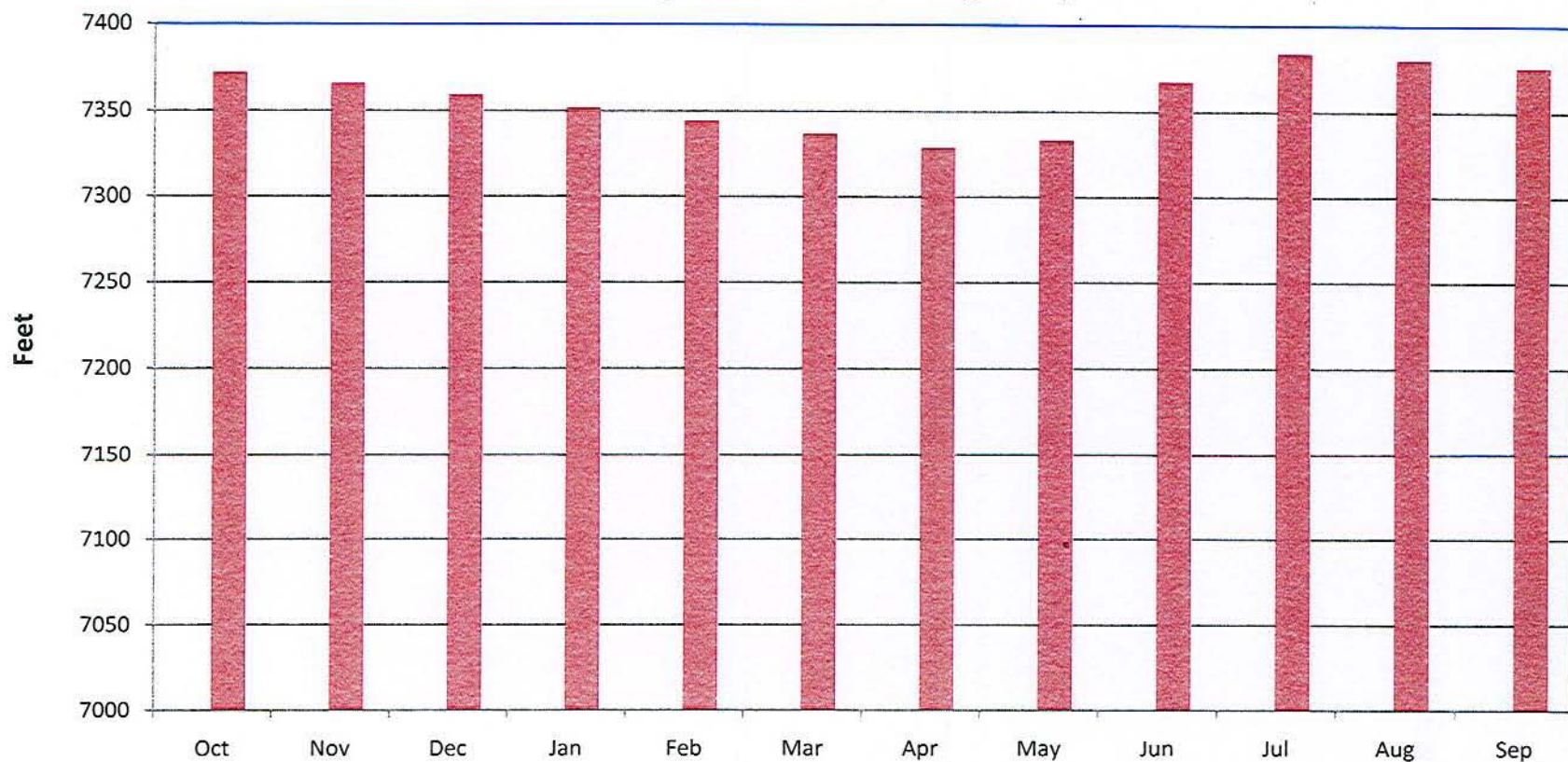
Gross Reservoir Mean Daily Elevation for September  
(Water Years 1947 through 1991)



Appendix B, Figure 25

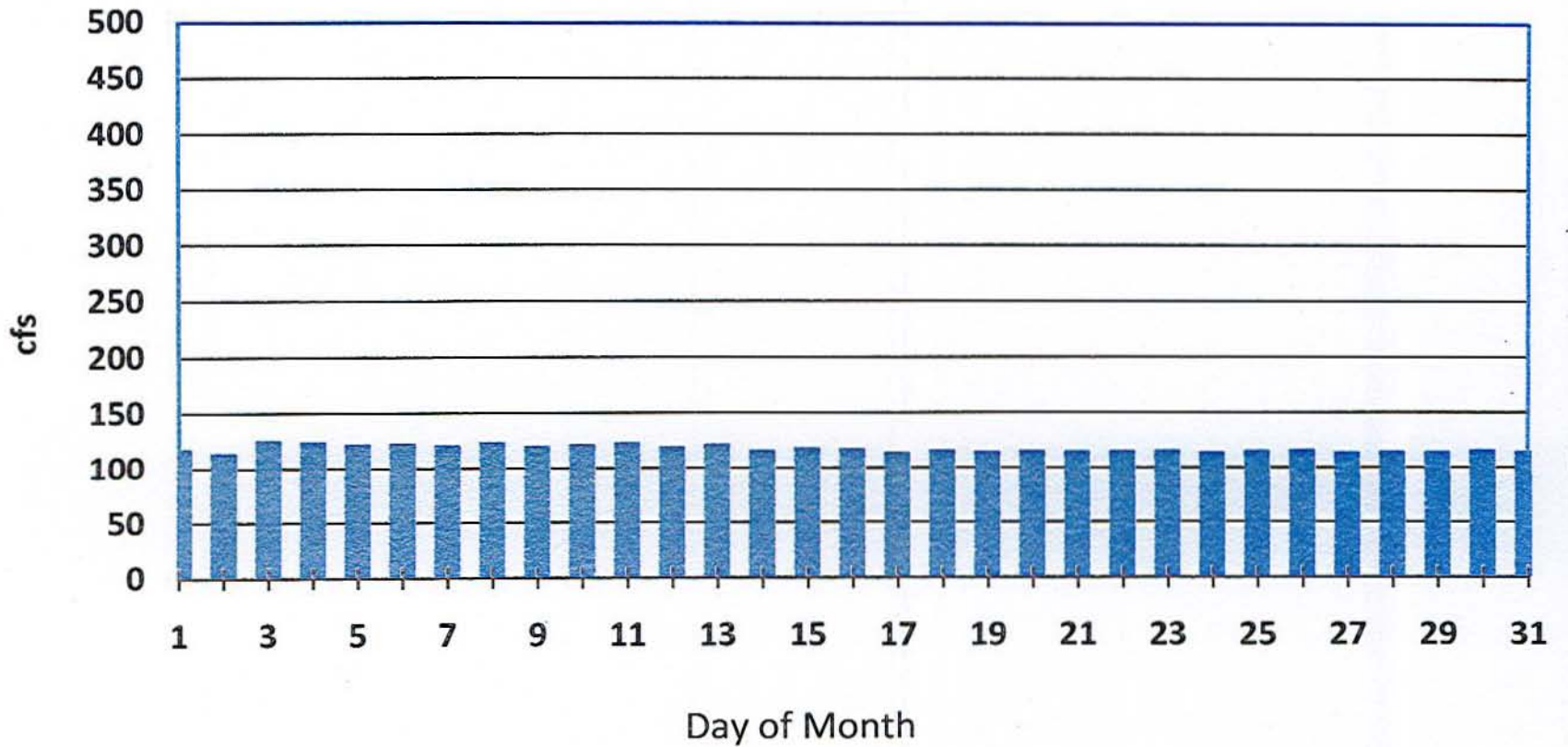
## 72,000 Acre-Feet enlargement of Gross Reservoir

Mean Monthly Gross Reservoir Elevation  
(Water Years 1947 Through 1991)



# 72,000 Acre-Feet Enlargement of Gross Reservoir

Gross Reservoir Mean Daily Outflow for October  
(Water Years 1947 through 1991)

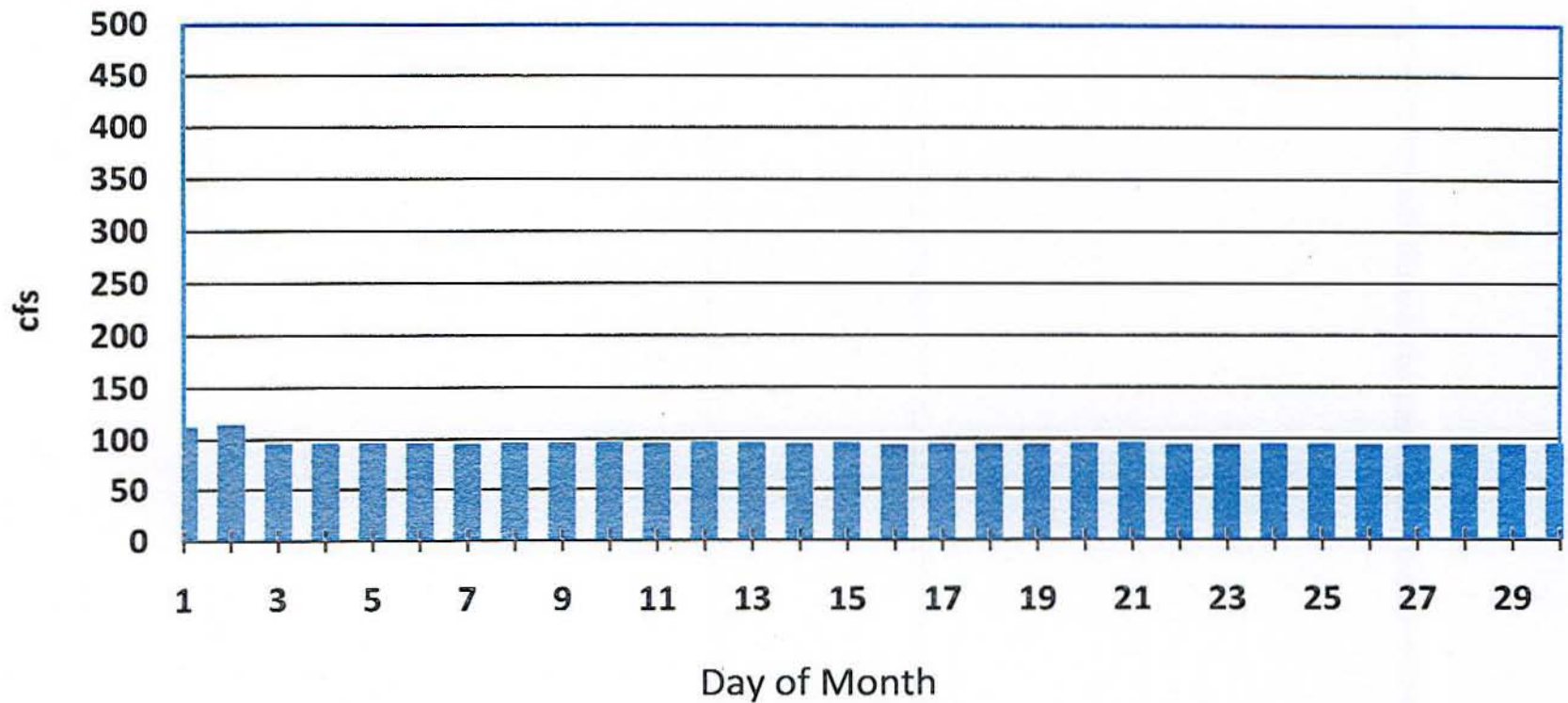


Appendix B, Figure 27



## 72,000 Acre-Feet Enlargement of Gross Reservoir

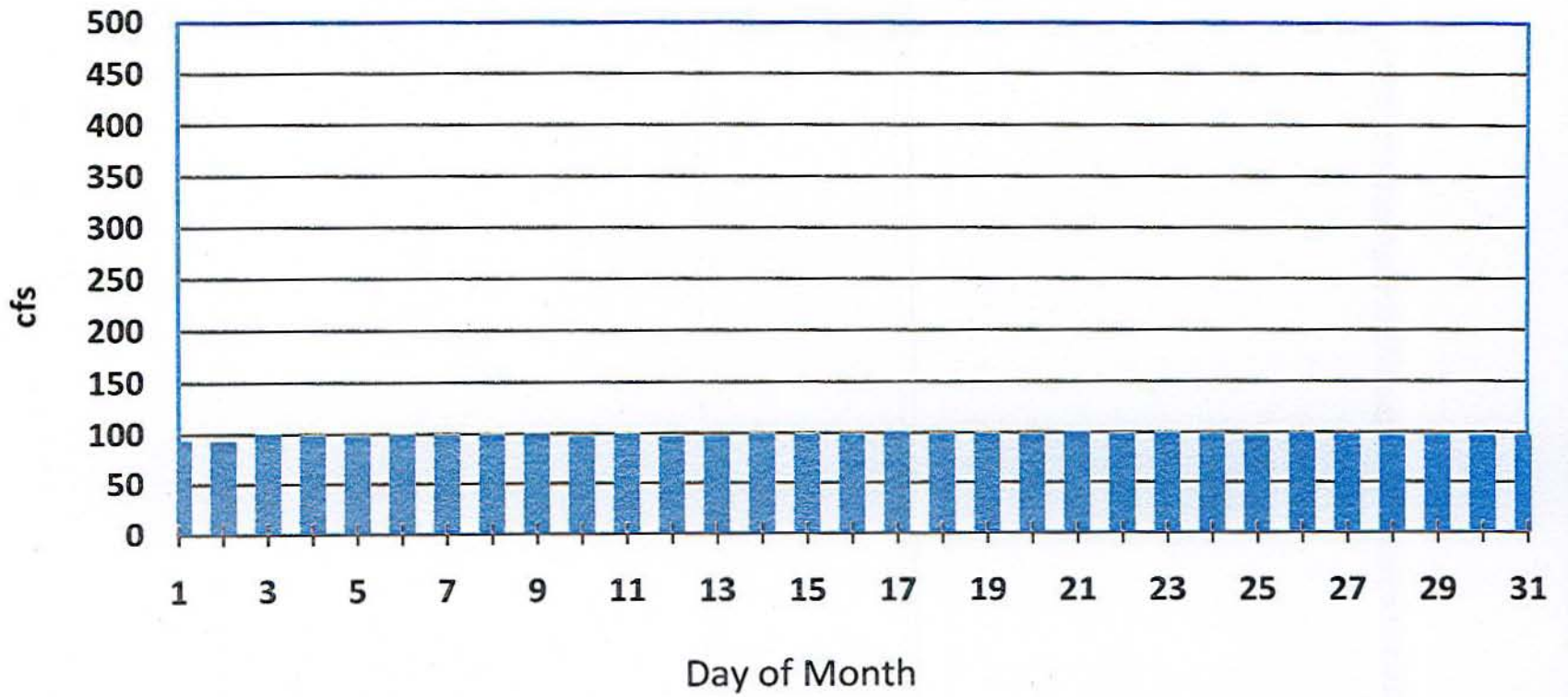
Gross Reservoir Mean Daily Outflow for November  
(Water Years 1947 through 1991)



Appendix B, Figure 28

# 72,000 Acre-Feet Enlargement of Gross Reservoir

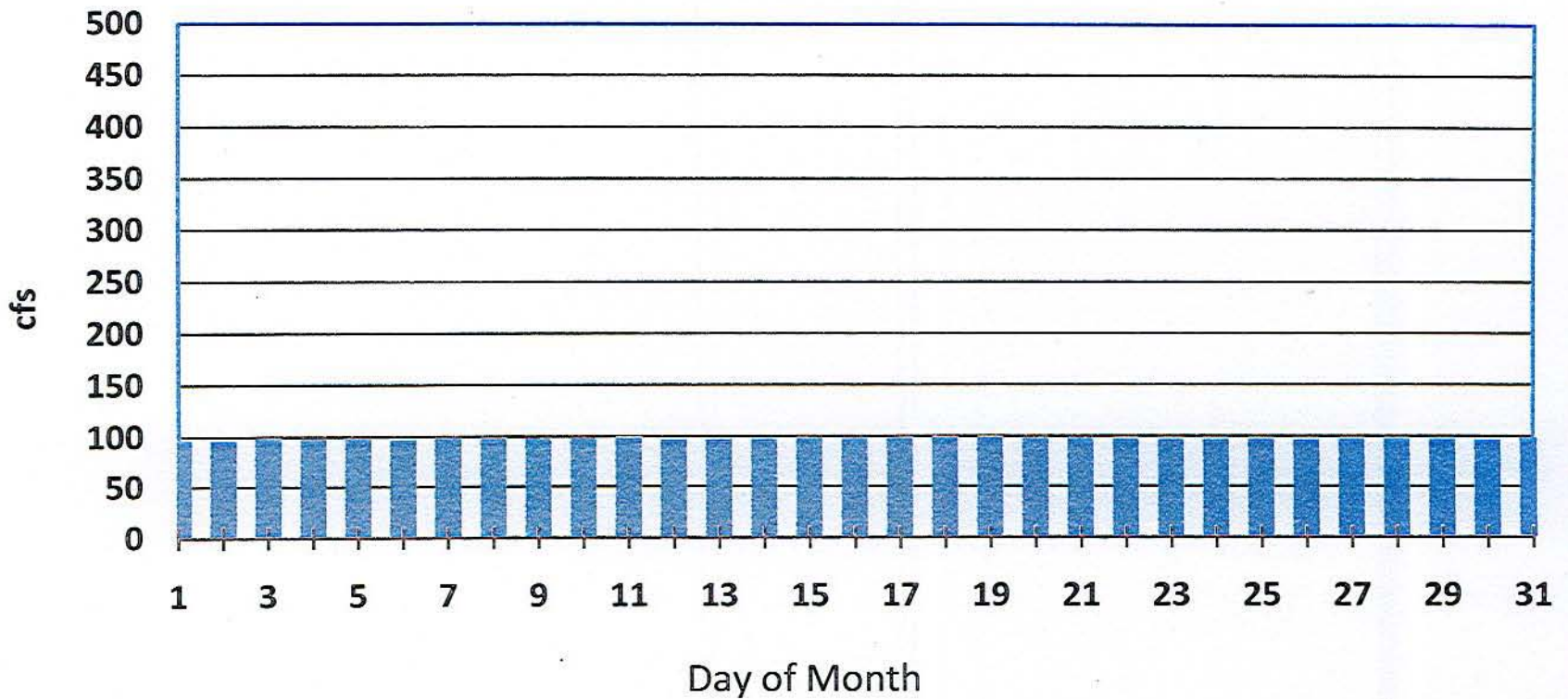
Gross Reservoir Mean Daily Outflow for December  
(Water Years 1947 through 1991)



Appendix B, Figure 29

# 72,000 Acre-Foot Enlargement of Gross Reservoir

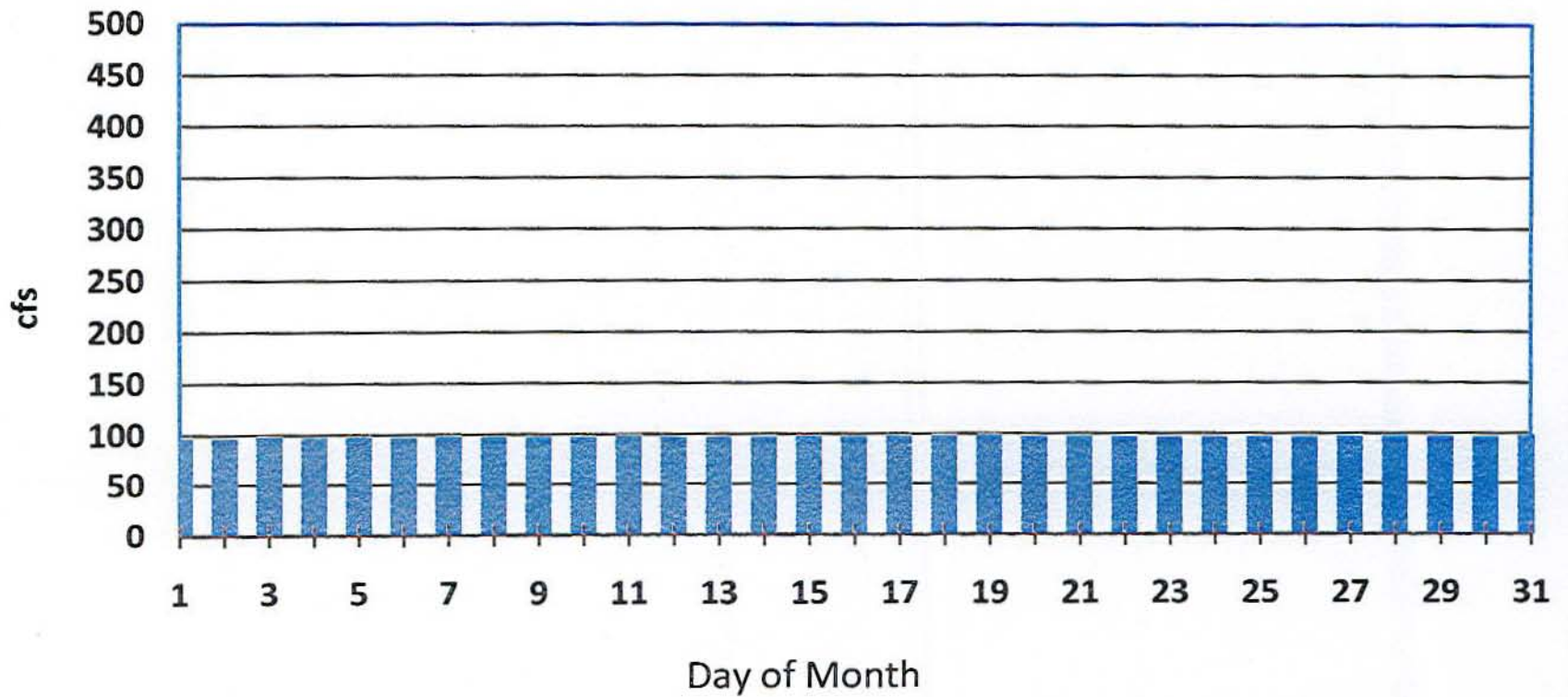
Gross Reservoir Mean Daily Outflow for January  
(Water Years 1947 through 1991)



Appendix B, Figure 30

# 72,000 Acre-Foot Enlargement of Gross Reservoir

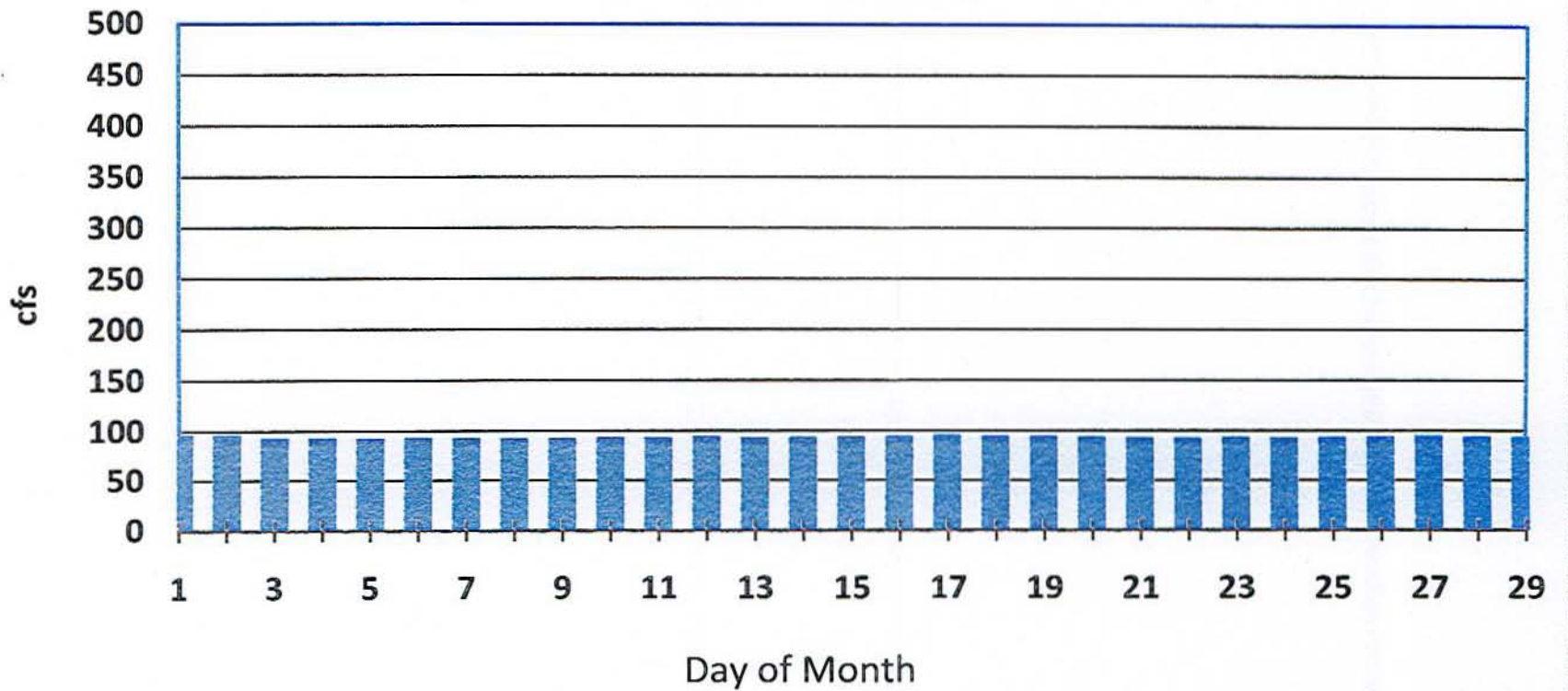
Gross Reservoir Mean Daily Outflow for January  
(Water Years 1947 through 1991)



Appendix B, Figure 30

# 72,000 Acre-Foot Enlargement of Gross Reservoir

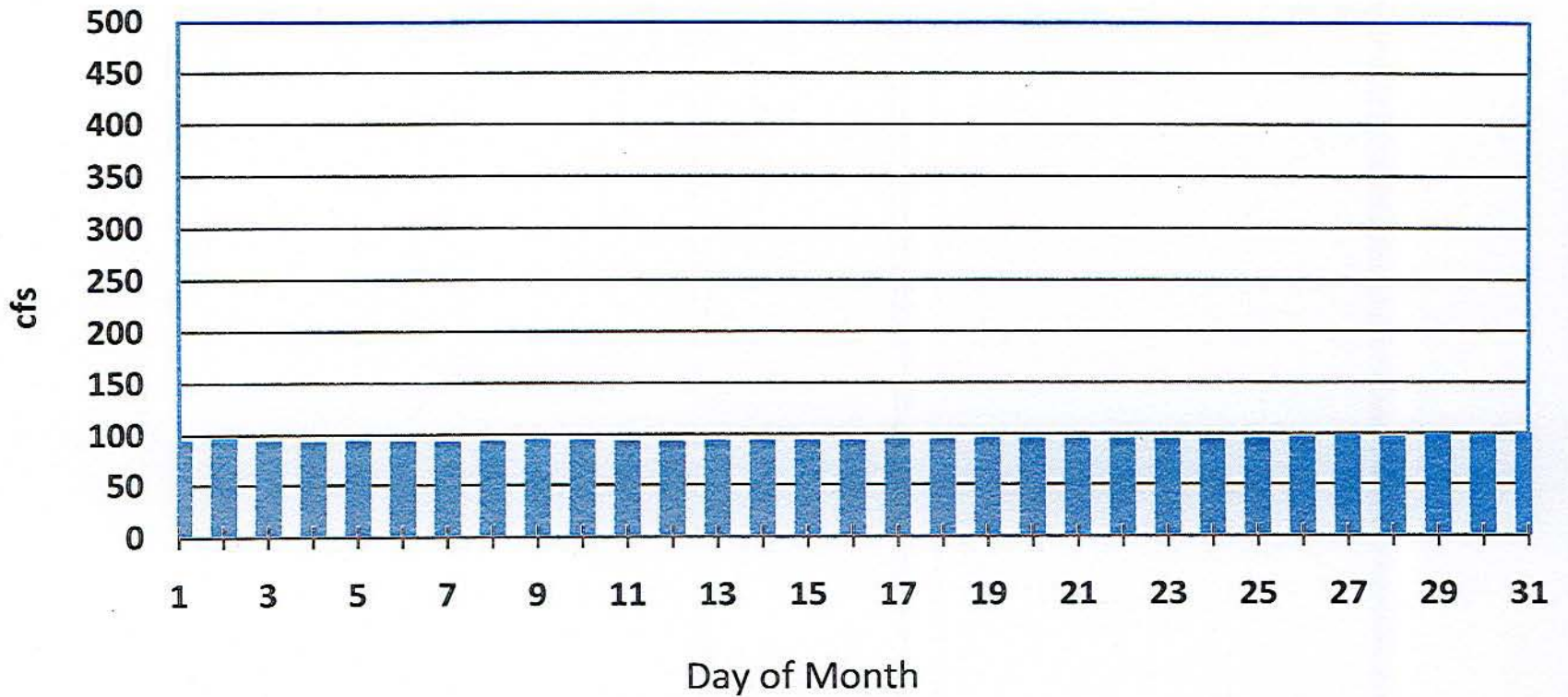
Gross Reservoir Mean Daily Outflow for February  
(Water Years 1947 through 1991)



Appendix B, Figure 31

# 72,000 Acre-Foot Enlargement of Gross Reservoir

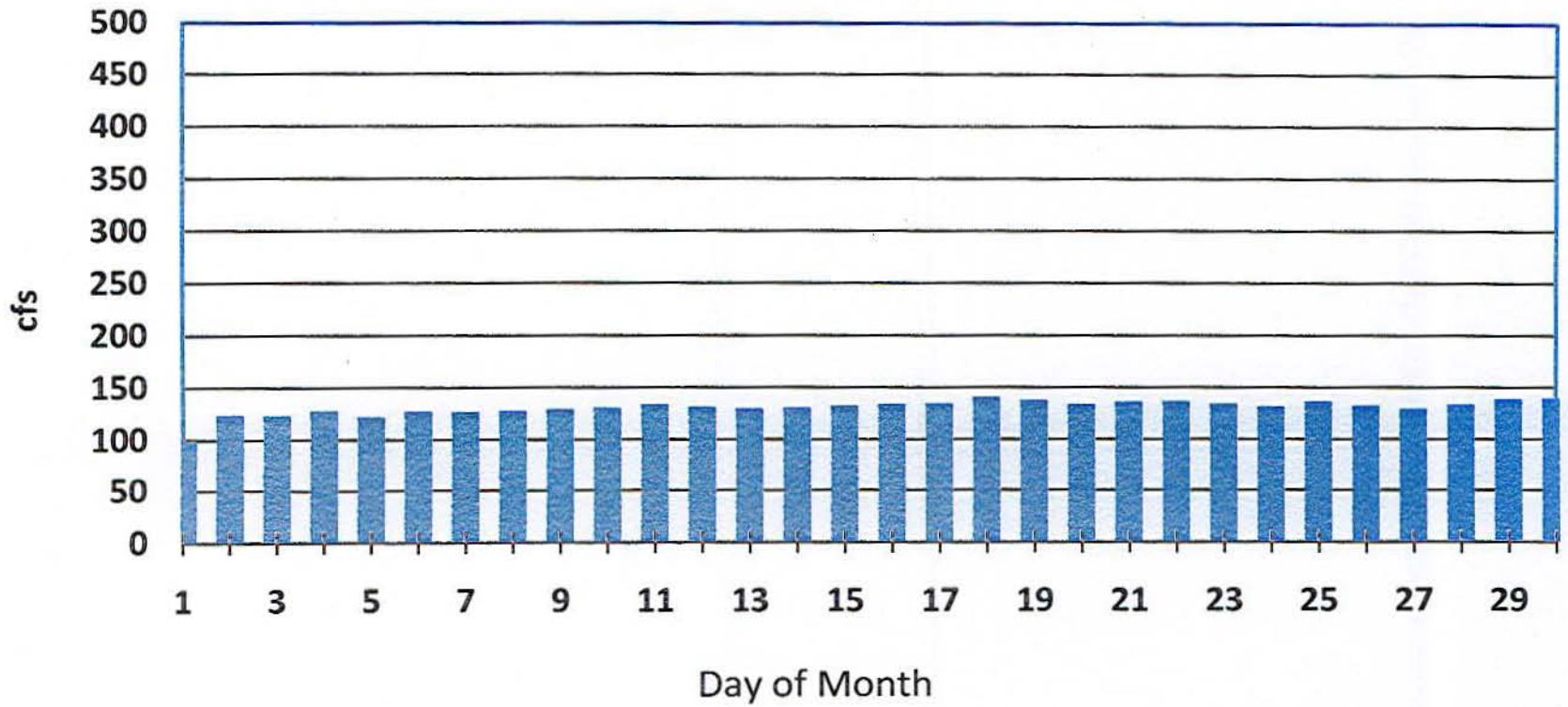
Gross Reservoir Mean Daily Outflow for March  
(Water Years 1947 through 1991)



Appendix B, Figure 32

# 72,000 Acre-Feet Enlargement of Gross Reservoir

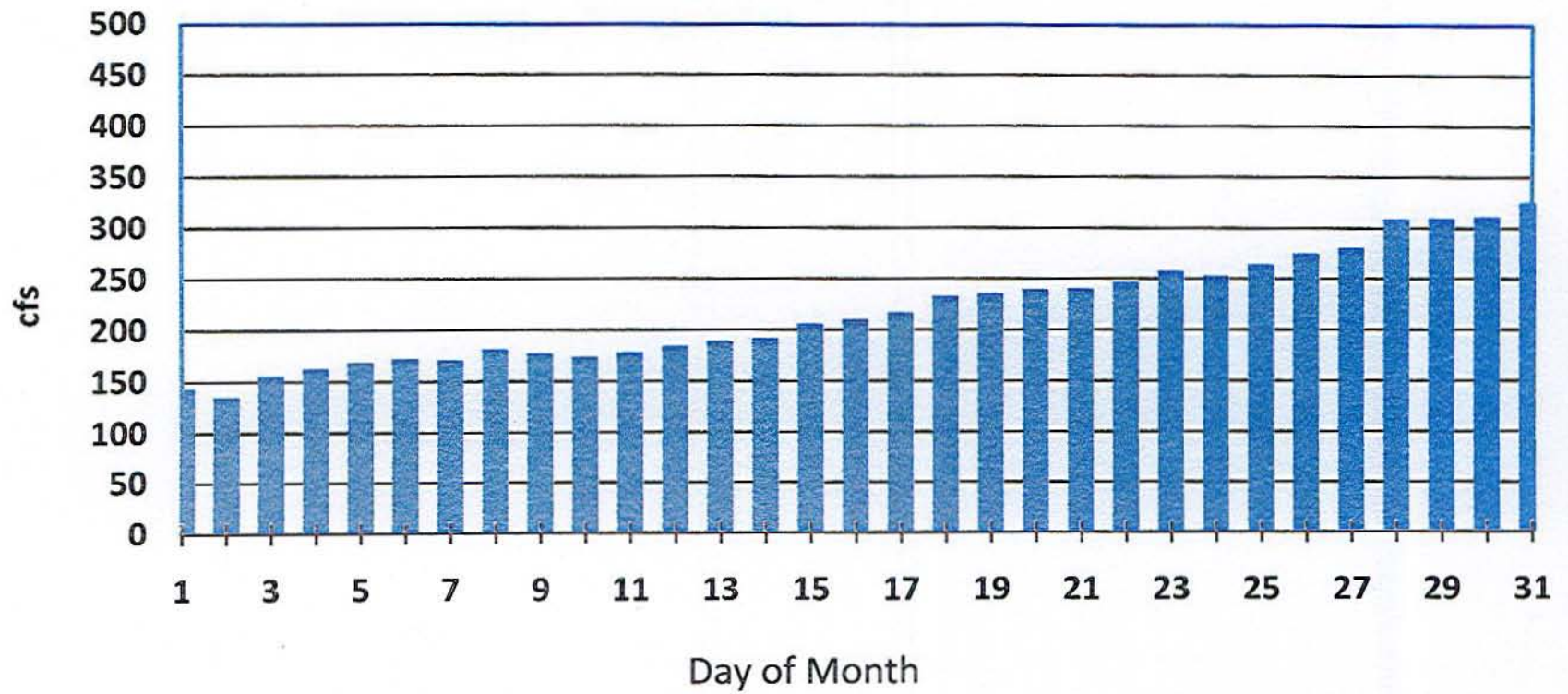
Gross Reservoir Mean Daily Outflow for April  
(Water Years 1947 through 1991)



Appendix B, Figure 33

# 72,000 Acre-Feet Enlargement of Gross Reservoir

Gross Reservoir Mean Daily Outflow for May  
(Water Years 1947 through 1991)

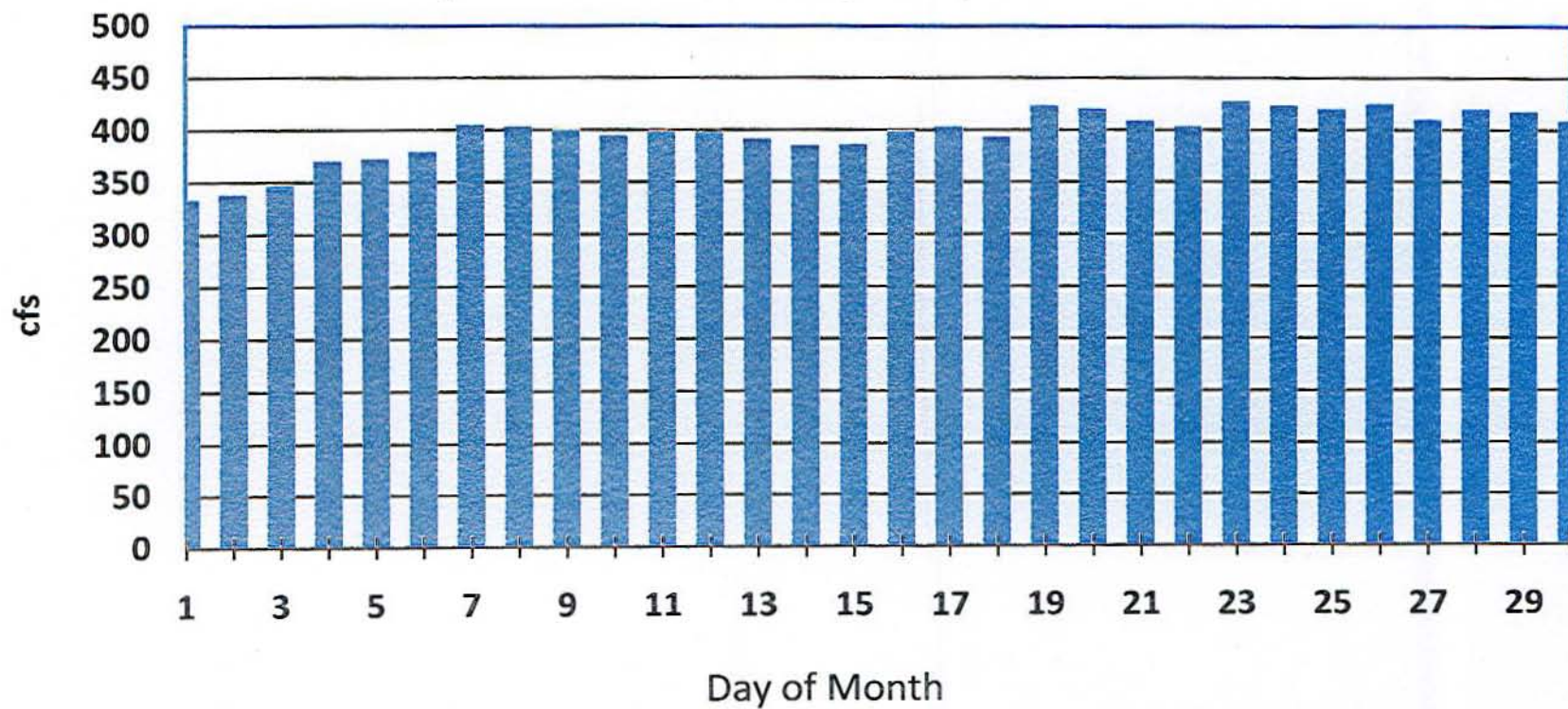


Appendix B, Figure 34



## 72,000 Acre-Foot Enlargement of Gross Reservoir

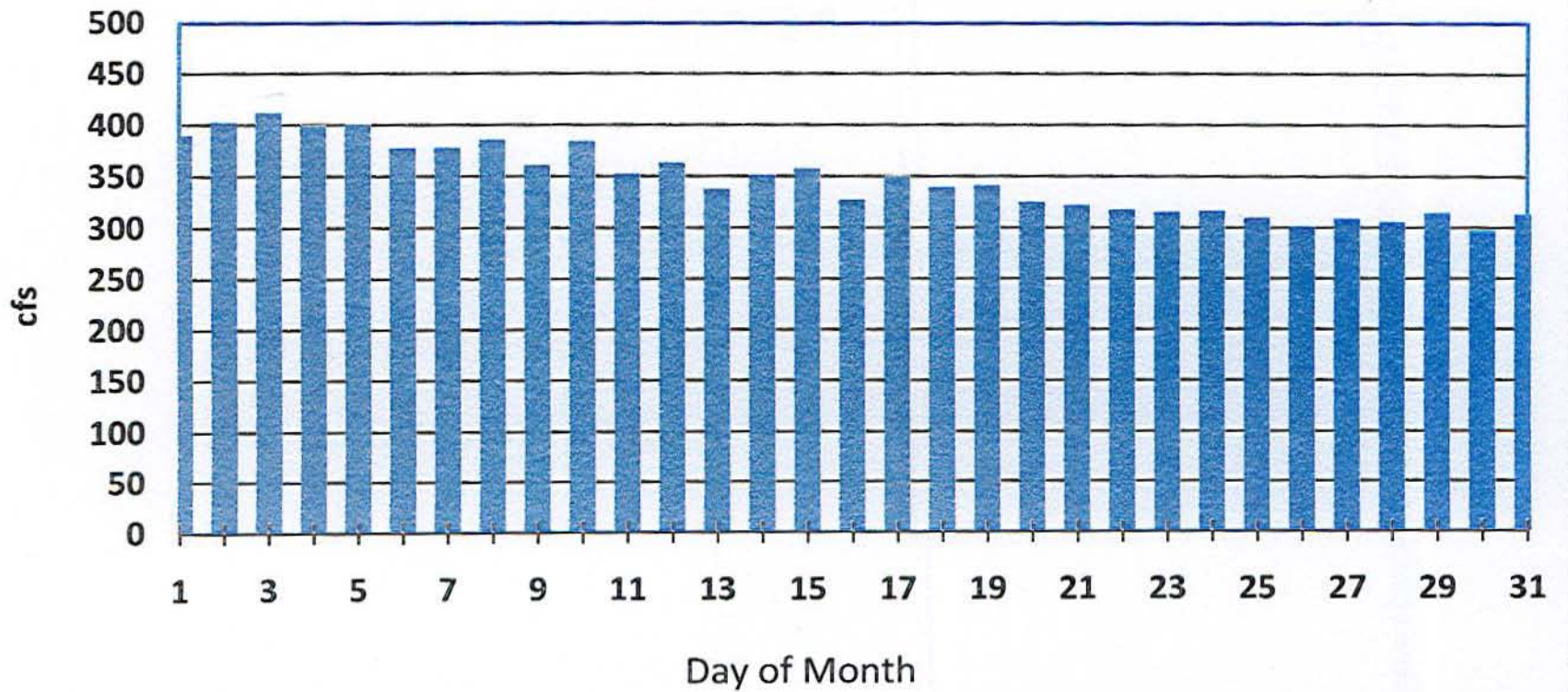
Gross Reservoir Mean Daily Outflow for June  
(Water Years 1947 through 1991)



Appendix B, Figure 35

# 72,000 Acre-Foot Enlargement of Gross Reservoir

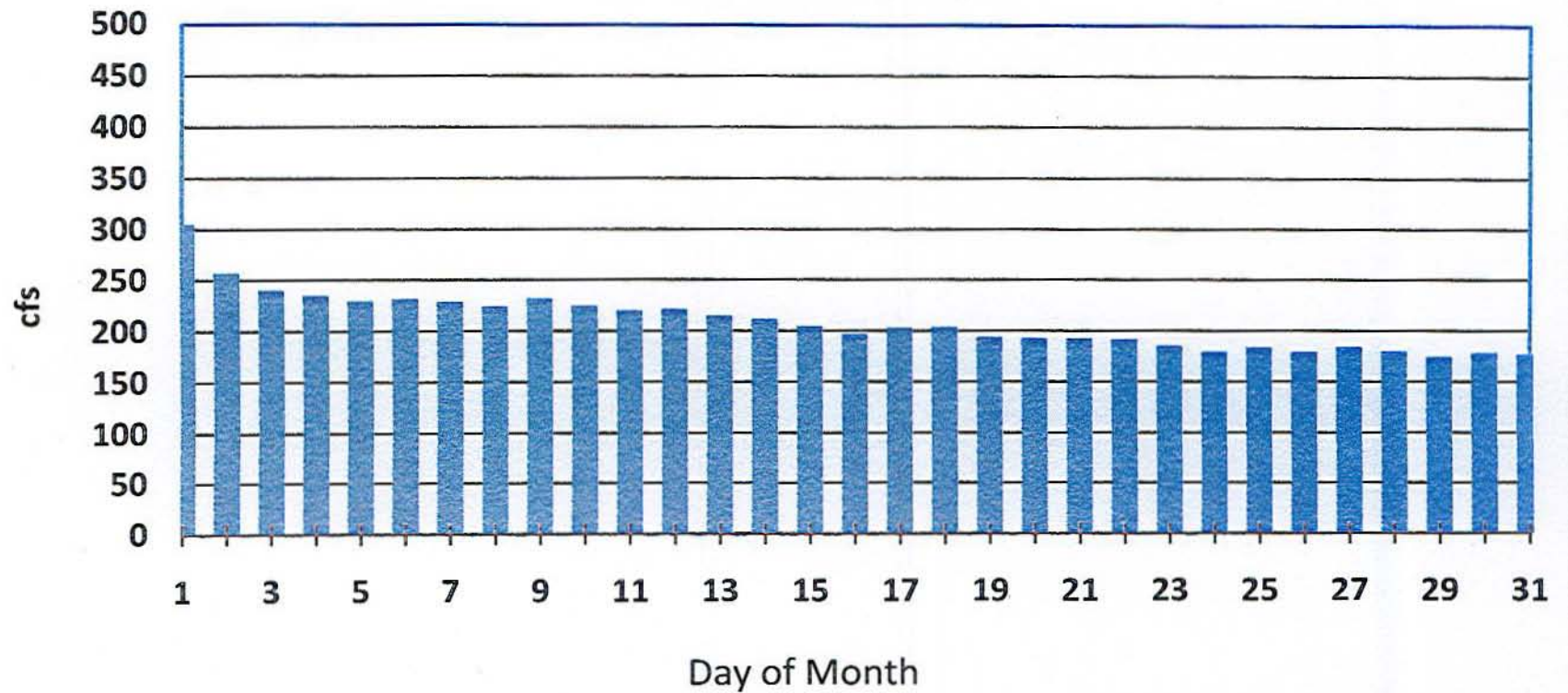
Gross Reservoir Mean Daily Outflow for July  
(Water Years 1947 through 1991)



Appendix B, Figure 36

# 72,000 Acre-Feet Enlargement of Gross Reservoir

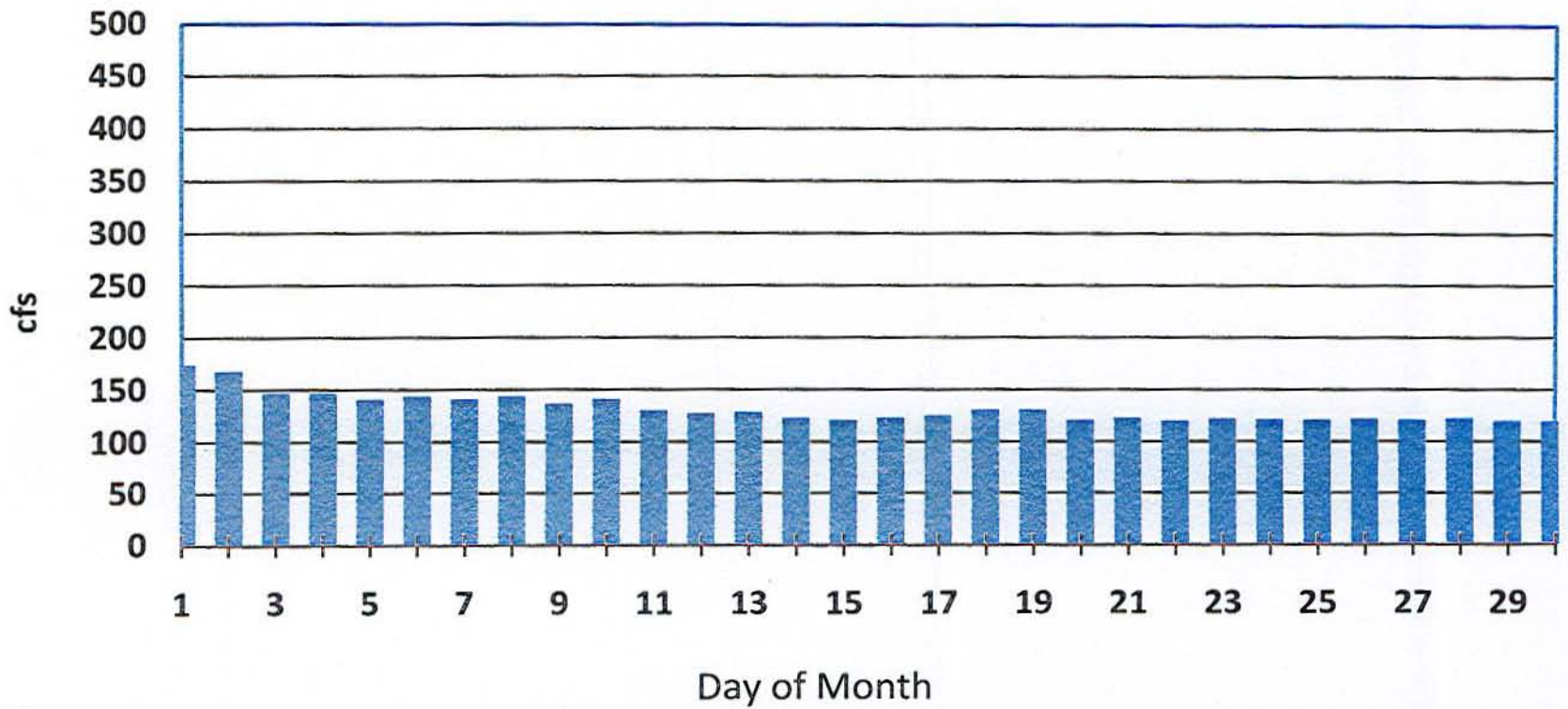
Gross Reservoir Mean Daily Outflow for August  
(Water Years 1947 through 1991)



Appendix B, Figure 37

# 72,000 Acre-Foot Enlargement of Gross Reservoir

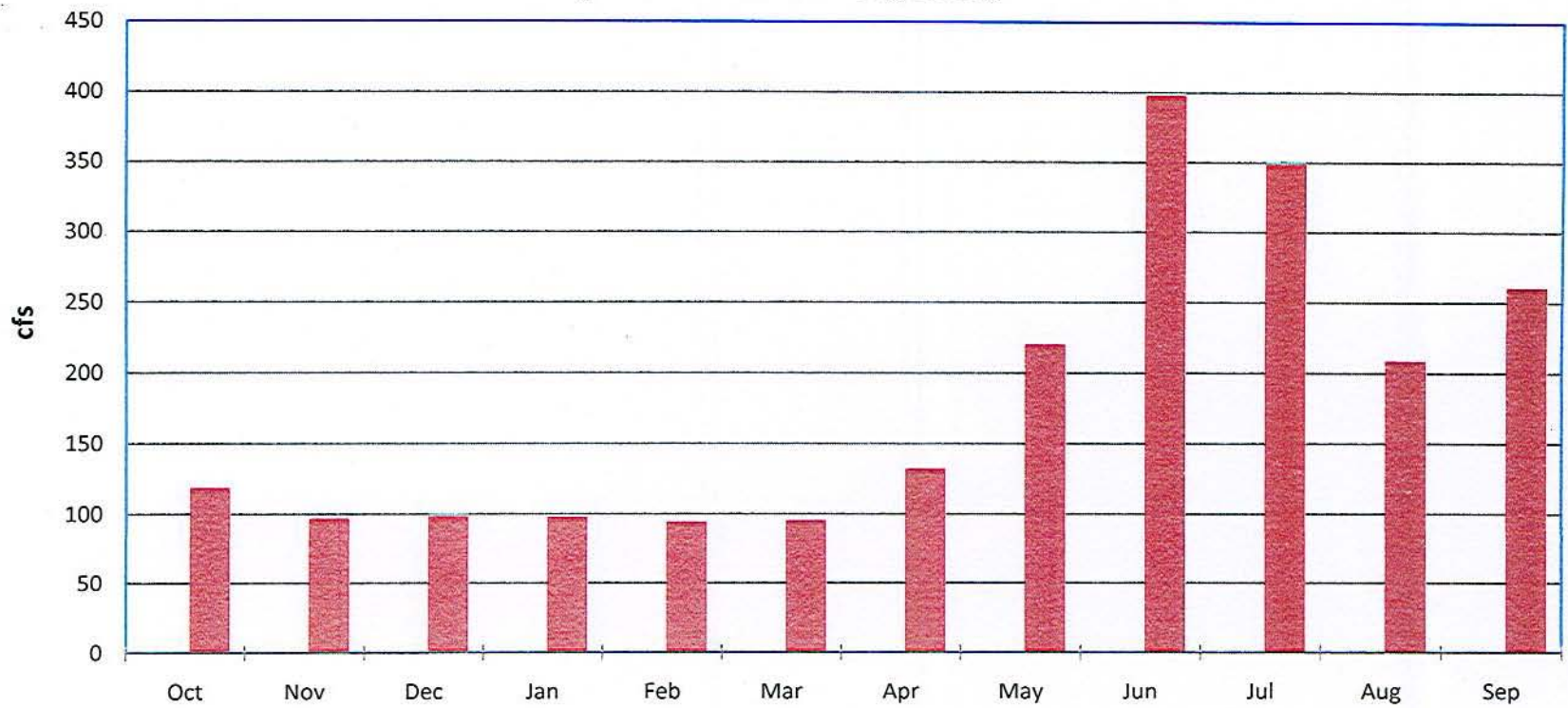
Gross Reservoir Mean Daily Outflow for September  
(Water Years 1947 through 1991)



Appendix B, Figure 38

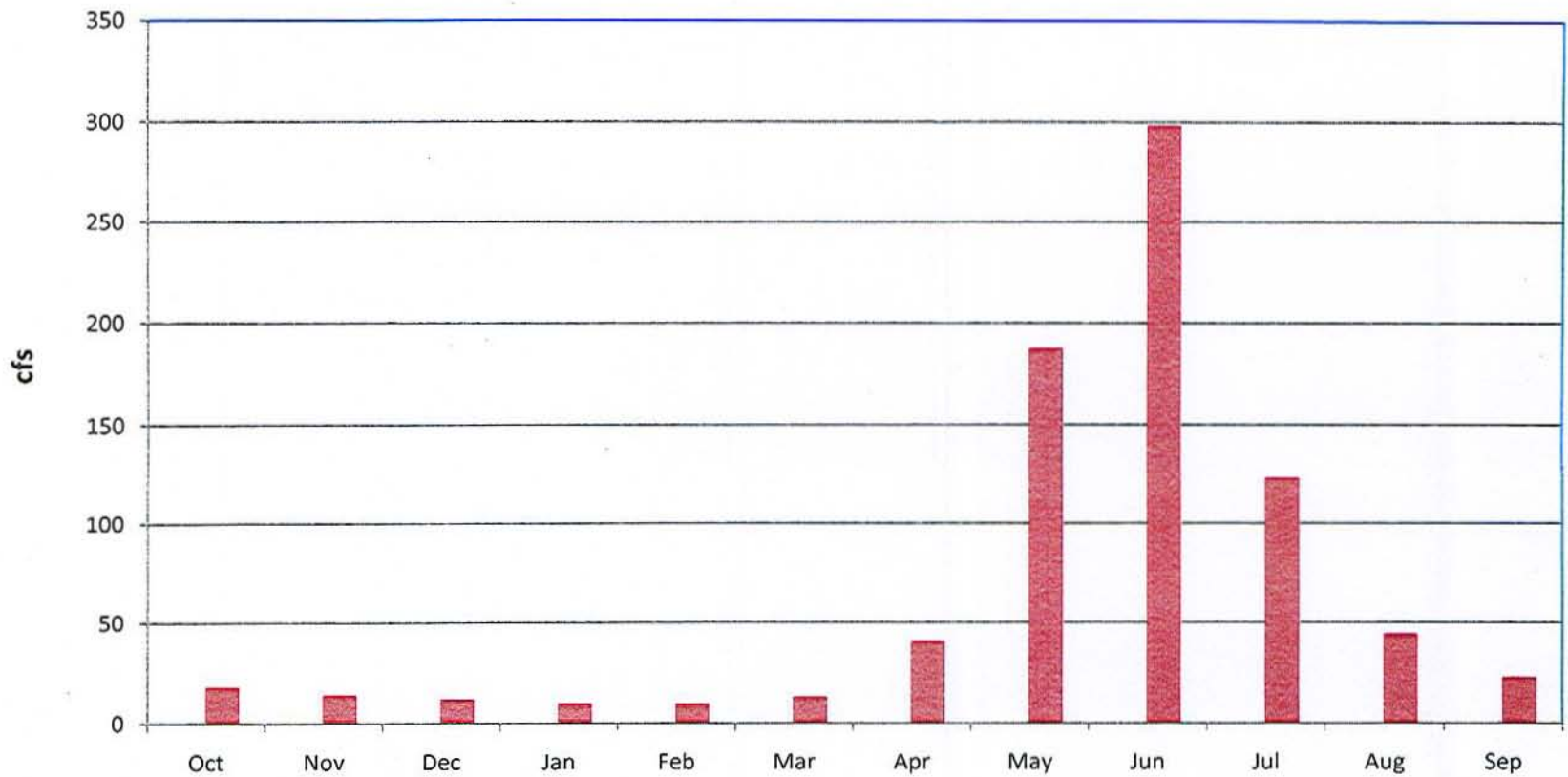
## 72,000 Acre-Foot Enlargement of Gross Reservoir

Mean Monthly Gross Reservoir Outflow  
(Water Years 1947 Through 1991)

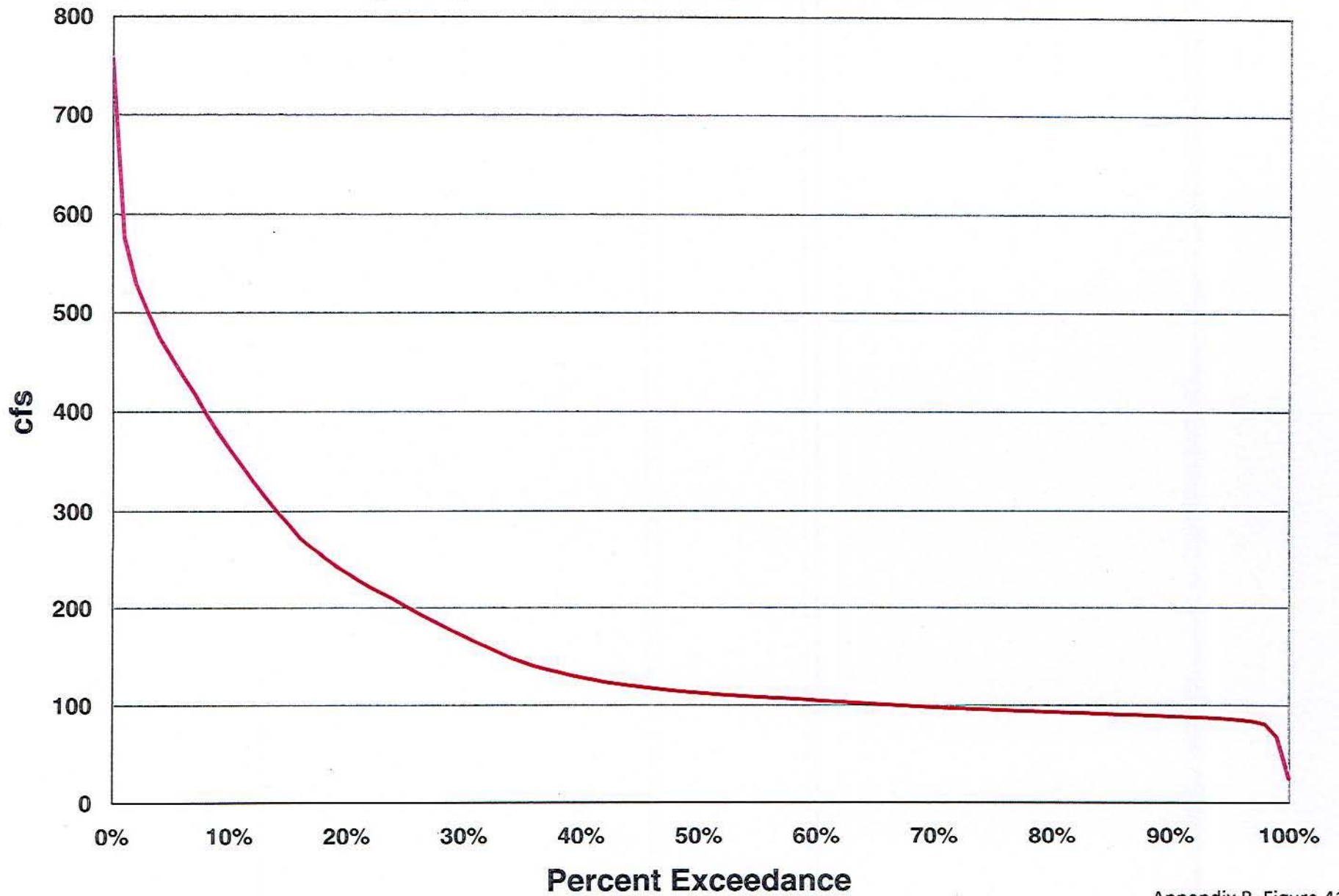


### 72,000 Acre-Foot enlargement of Gross Reservoir

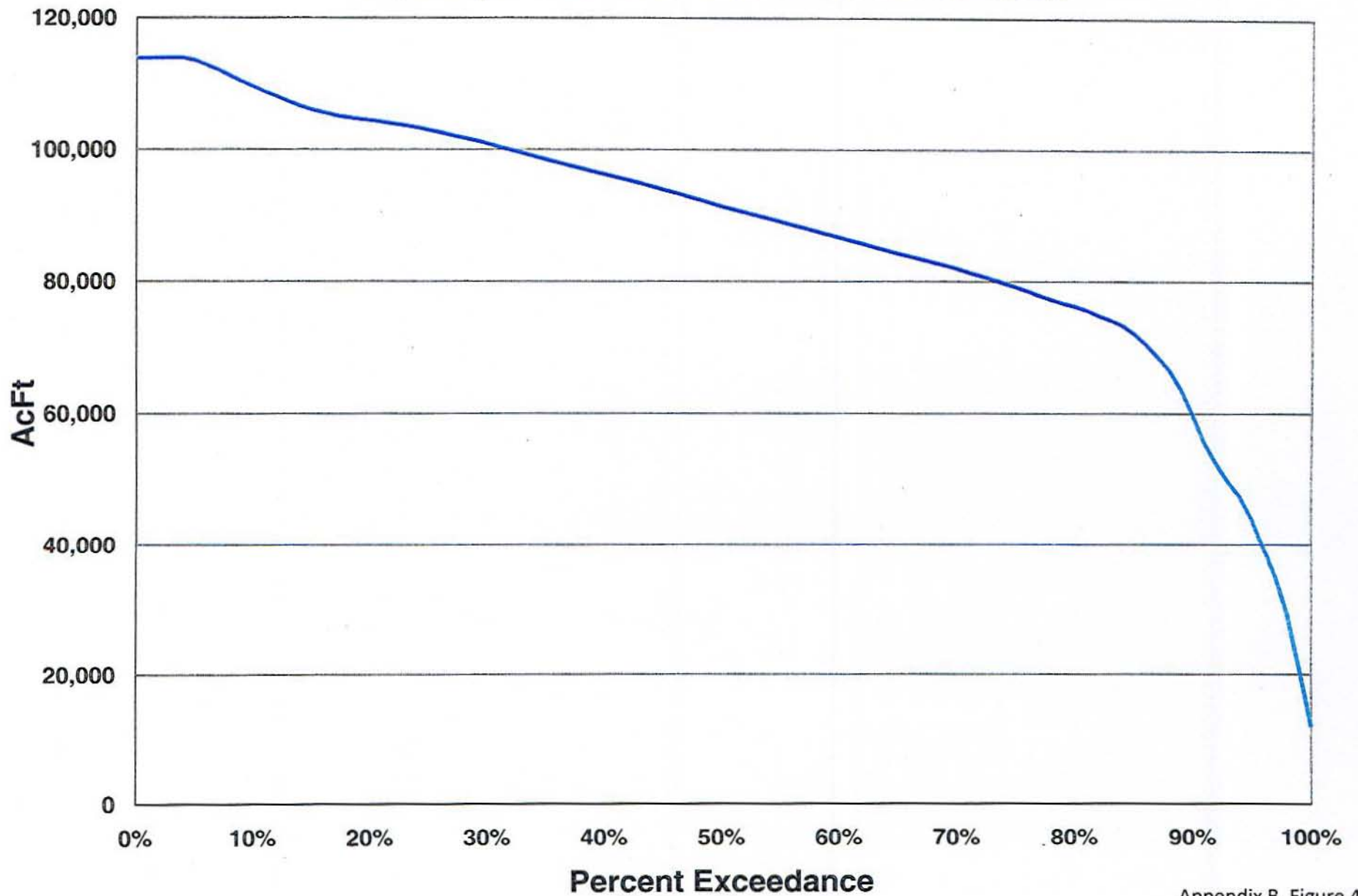
Mean Monthly Gross Reservoir Natural Flow  
(Water Years 1947 Through 1991)



# 72,000 Acre-Feet Enlargement of Gross Reservoir Frequency Exceedance - Gross Reservoir Outflow



## 72,000 Acre-Feet Enlargement of Gross Reservoir Frequency Exceedance - Gross Reservoir Contents





# 72,000 Acre-Feet Enlargement of Gross Reservoir Frequency Exceedance - Gross Reservoir Elevation

