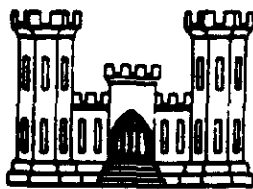


**NORTH FORK GRAND RIVER BASIN  
BOWMAN - HALEY DAM & LAKE  
NORTH DAKOTA**

**RESERVOIR  
REGULATION  
MANUAL**



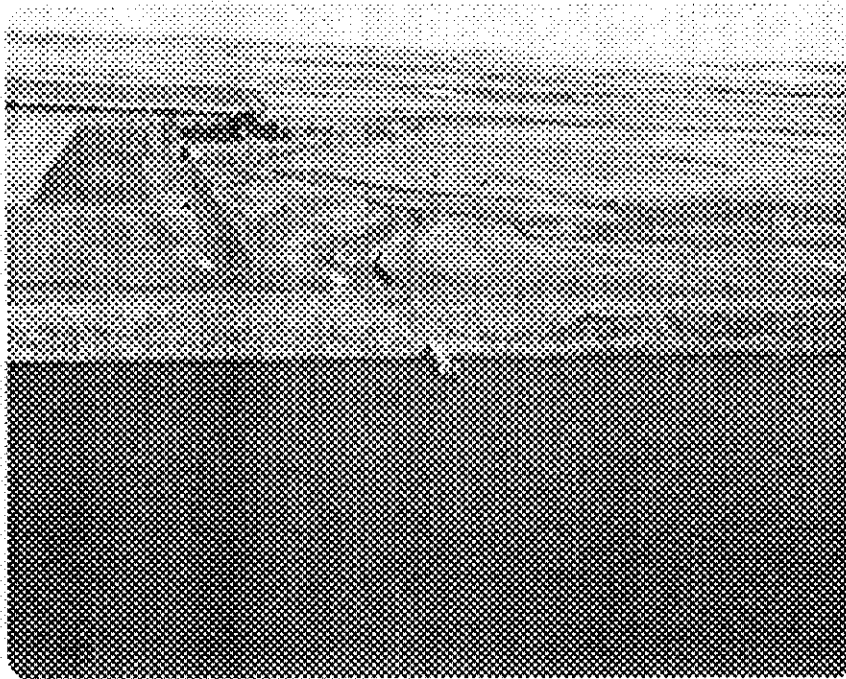
**U. S. ARMY ENGINEER DISTRICT, OMAHA  
CORPS OF ENGINEERS  
OMAHA, NEBRASKA**

RESERVOIR REGULATION MANUAL  
BOWMAN-HALEY DAM AND RESERVOIR  
NORTH DAKOTA

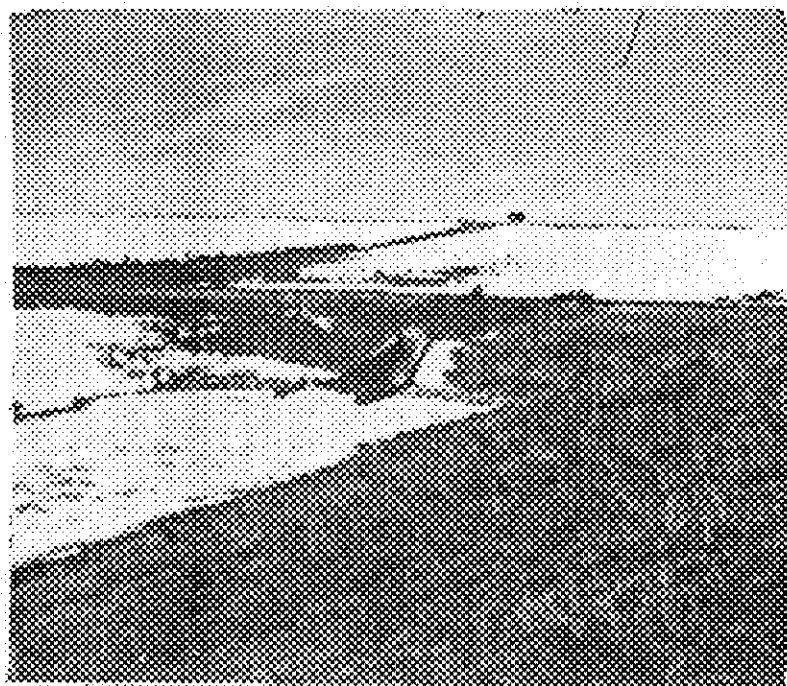
Prepared For  
U.S. Army Corps of Engineers  
Omaha District  
Omaha, Nebraska

Prepared By  
RIVER PRO'S  
Omaha, Nebraska

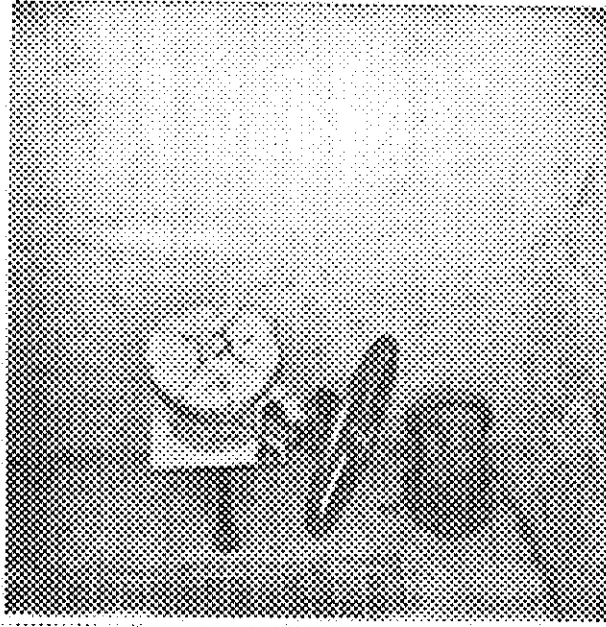
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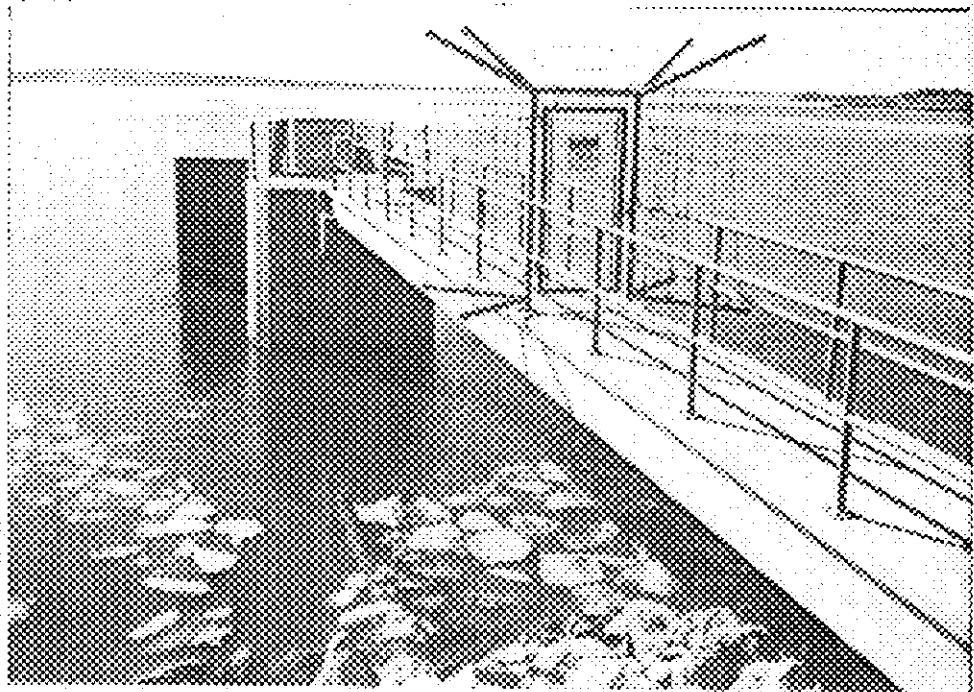
*Bowman-Haley Outlet Works  
and Discharge Channel*



*Bowman-Haley Outlet  
Discharge 2200 c.f.s. — 27 March 1978*



*Outlet Works --- 30-inch Gate Valve*



*Intake Bridge --- Morning Glory Spillway  
Bowman-Haley Lake*

RESERVOIR REGULATION MANUAL  
FOR  
BOWMAN-HALEY DAM AND RESERVOIR

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### SERVICE SPILLWAY

Type	Uncontrolled Morning-Glory
Throat Diameter	9.0 ft.
Conduit Diameter	10 ft.
Conduit Length	341 ft.
Crest Elevation	2754.8 ft., m.s.l.
Upstream Invert Elevation (P.T.)	2720.5 ft., m.s.l.
Downstream Invert Elevation	2712.0 ft., m.s.l.
Capacity (Elev. 2773)	2,925 c.f.s.
(Elev. 2780.67)	3,275 c.f.s.

### STILLING BASIN

Width	25 ft.
Length-Drop Section	57 ft.
Length-Basin	59 ft.
Floor Elevation	2700 ft., m.s.l.
Top Basin Side Walls	2721 ft., m.s.l.

### OUTLET WORKS

Type	Wet well forebay; gate valve control in dry well; discharge into service spillway conduit. 8" by-pass valve for low flow releases - discharge into 30" conduit.
Conduit Diameter	30 inches
Capacity at Top of Conservation Pool (El. 2754.8)	140 c.f.s.
Control	30-inch gate valve
Trashrack Invert Elevation	2740 ft., m.s.l.

RESERVOIR DATA - 1984 SURVEY

<u>Item</u>	<u>Elevation</u> (ft.,m.s.l.)	<u>Area</u> (acres)	<u>Gross Storage</u> (acre-ft)	<u>Incremental Storage</u> (acre-ft)
Bottom of Reservoir Multi-Purpose Pool	2720.0	0	0	18,765
Top of Multi-Purpose Pool	2754.8	1732	18,765	53,847
Reservoir Design Flood Storage				
Top of Res. Design Flood Pool	2773.0	4300	72,612	18,870
Add. Controlled Flood Storage				
Emergency Spillway Crest	2777.0	5131	91,482	20,366
Add. Controlled Flood Storage				
Fuse Plug Crest	2780.7	5848	111,848	**56,719
Surcharge Storage				
Max Pool-Spillway Design Flood	2789.0	7916	168,567	39,433
Freeboard Storage				
Top of Dam	2794.0	*9200	*208,000	

\*Extrapolated from Area-Capacity Table on Plate 14

\*\*Failure of Fuse Plug will result in total surcharge storage of 77,085 acre-feet between Emergency Spillway Crest and Design Maximum Pool Elevation.

EFFECTIVE FLOOD CONTROL STORAGE (Reservoir Release Limited to Service Spillway)

From Top of Multi-Purpose Pool  
to Top of Fuse Plug 93,083 acre-feet

SEDIMENT DEPOSITION IN RESERVOIR FOR 100-YEAR ECONOMIC PROJECT LIFE

In Multi-Purpose Pool	4050 acre-feet
In Flood Control Pool	<u>700 acre-feet</u>
TOTAL	4750 acre-feet

STANDARD PROJECT FLOOD DATA

Total Rainfall Volume, 84 hours	7.35 in.
Peak Inflow Rate	46,400 c.f.s.
Runoff Volume (5.16 inches)	122,700 acre-feet
Reservoir Routing for 90 percent of S.P.F.	
a. Max. Pool Elevation (no emergency spillway flow)	2780.7 ft., m.s.l.
b. Max. Discharge (service spillway)	2,950 c.f.s.

SPILLWAY DESIGN FLOOD DATA

Total Prob. Max. Rain - 90 hour	15.5 in.
Peak Inflow Rate	110,000 c.f.s.
Runoff Volume (12.7 inches)	302,000 acre-feet
Reservoir Routing	
a. Max. Pool Elevation	2789.0 ft., m.s.l.
b. Max. Combined Discharge (Emergency Spillway = 62,970 c.f.s.) (Service Spillway = 3,200 c.f.s.)	66,170 c.f.s.

RESERVOIR REGULATION MANUAL

FOR

BOWMAN-HALEY DAM AND RESERVOIR

SECTION I - INTRODUCTION

1-01. AUTHORITY. This Reservoir Manual has been prepared in compliance with instructions and information specified in ER-1110-2-240 and Chapter 6 of EM 1110-2-3600.

1-02. SCOPE. Bowman-Haley Dam and Reservoir was constructed and is operated under the supervision of the Corps of Engineers. The project is located in the southwest portion of the state of North Dakota on the North Fork of the Grand River. This Manual presents information pertinent to the regulation of storage in the reservoir for the authorized project purposes, which are flood protection, local water supply, and enhancement of recreation, fish, and wildlife habitat. This Manual is subject to future revision and updating as circumstances warrant.

## SECTION II - BASIN AND RIVER DESCRIPTION

2-01. LOCATION AND DESCRIPTION. Bowman-Haley Dam is located at the confluence of Spring Creek and the North Fork of the Grand River in a sparsely settled area of southwestern North Dakota. The drainage area contributing to the reservoir is 446 square miles, with approximately 312 square miles located in southwest North Dakota and about 134 square miles located in northwest South Dakota. The two major tributary streams are Spring Creek, with a drainage area of 225 square miles, and the North Fork, with a drainage area of 221 square miles. The map of the basin, shown on Plate 1, indicates basin drainage in an easterly direction and a highly concentrated drainage pattern with an average length to width ratio of about 0.75. Topography of the area lying upstream from the dam is moderate to steeply rolling hill land with an average channel slope of 7.5 feet per mile. Elevations vary from about 3300 feet, m.s.l., in the upper reaches of the basin to about 2720 feet, m.s.l., near the dam. Bowman-Haley Dam controls about 35 percent of the 1264 square mile drainage area of the North Fork of the Grand River and about 8 percent of the total Grand River basin area of 5510 square miles. In addition to Bowman-Haley Reservoir, another major storage structure is located in the Grand River basin. Plate 1 shows Shadehill Dam and Reservoir located a short distance downstream from the junction of the North and South Forks of the Grand River. This Bureau of Reclamation structure was completed in 1951 for the principal purposes of providing flood control and irrigation. The total drainage area upstream from Shadehill is 3120 square miles, of which about 446 square miles, or 14 percent is controlled by Bowman-Haley. The Shadehill structure and operation is discussed more fully in Section III.

2-02. CLIMATE. The North Fork basin is located in a semi-arid region with extremes of temperature and precipitation. Temperatures below zero degrees Fahrenheit occur frequently during the winter months, with freezing temperatures expected during the period from middle September to the end of May. Summertime temperatures in excess of 100 degrees Fahrenheit are frequently experienced. The mean annual temperature is about 43 degrees Fahrenheit. The mean annual precipitation is about 14.84 inches and has ranged from 22.35 inches in 1915 to 4.17 inches in 1936, as recorded at the Hettinger, North Dakota climatology station, located 30 miles east of the project. Normally, about 80 percent of the precipitation occurs during the period of April through September in the form of thunderstorms which often have high intensity and short duration centers. The annual excess of evaporation over precipitation is estimated to be 26 inches.

2-03. STREAMFLOW - RUNOFF. Runoff in the Grand River basin can result from either rainfall or snowmelt. Some rise occurs almost yearly in March or April from melting of the winter's snow accumulation. Summer rainfall runoff resulting from thunderstorm activity produces the relatively infrequent summer floods. Flows at the Haley gage have varied through wide limits, ranging from 14,100 c.f.s. on 7 April 1952 to periods of no flow on many occasions.

2-04. CHANNEL CAPACITIES. Bankfull discharge below the Bowman-Haley Dam is estimated to be about 2,300 c.f.s. During the period of available records, there have been seven floods which exceeded bankfull discharge at the Haley gage. Of these, the three greatest floods occurred as a result of spring snowmelt.

2-05. RIVER STAGE - DISCHARGE RELATIONSHIP. Plate 2 shows the open water discharge rating tables for the North Fork Grand River at Haley, North Dakota, and at White Butte, South Dakota; and for the South Fork Grand River at Cash, South Dakota. Stage-discharge relationships shown on these tables may shift; however, they are kept current using discharge measurements provided by the U.S. Geological Survey. Updated curves are on file in the Omaha District's Reservoir Regulation Section. Other U.S.G.S. gaging stations in the Grand River Basin include the South Fork of the Grand River at Buffalo, S.D.; the Grand River at Shadehill and Little Eagle, S.D.; and the Buffalo Creek tributary near Gascoyne, N.D.

2-06. TRAVEL TIME. Travel time for high flows from Bowman-Haley Dam to Shadehill Reservoir, a distance of approximately 80 miles, varies from 24 hours to 21 days depending on the discharge. Table No. 1 provides estimated streamflow travel times to selected locations between Bowman-Haley and Shadehill.

TABLE NO. 1

BOWMAN-HALEY DAM AND RESERVOIR  
ESTIMATED STREAMFLOW TRAVEL TIME FOR CERTAIN STATIONS  
ON THE NORTH FORK GRAND RIVER, NORTH AND SOUTH DAKOTA

<u>STATION*</u>	<u>DISTANCE BELOW DAM IN RIVER MILES</u>	<u>TRAVEL TIME FROM BOWMAN-HALEY DAM NEAR BANKFULL</u>	<u>APPROX. DISCHARGE OF 20 c.f.s.**</u>
Bowman-Haley Dam	0	---	---
Haley, N.D.	6	3-5 hrs.	1.25 days
State Line - N.D. & S.D.	20	7-10 hrs.	3 days
Ellingson Bridge	30	10-15 hrs.	4.5 days
Highway 8 (Lodgepole)	44	14-20 hrs.	7 days
White Butte Bridge	76	20-30 hrs.	15 days
Shadehill Reservoir	80	24-36 hrs.	21 days
Shadehill Dam	90	---	---

\*Stations listed may be found on any Highway Map of North and South Dakota.

\*\*Travel times were determined from observations made in 1974 when low flow releases were made from Bowman-Haley Reservoir to alleviate downstream drought conditions. The travel time for low flows is longer due to the time it takes to fill numerous pot holes before resuming steady flow. More recent observations show that a release of 200 c.f.s. from Bowman-Haley Reservoir requires about 6 days to reach Shadehill Reservoir.

2-07. DISCHARGE-DAMAGE CURVES. The principal area subject to flooding prior to construction of the project was the 80 mile river reach from Bowman-Haley damsite to Shadehill Reservoir. This area is essentially agricultural but includes four county bridges and 16 county road locations that are vulnerable to damage or destruction. The extensive fencing in the flood plain, necessary for the mixed livestock and grain agricultural economy, was subject to frequent damage from floods. Floods having an estimated frequency of

once in 50 years would inundate approximately 16,500 acres. A peak discharge frequency curve for the North Fork Grand River at Haley, North Dakota, is shown on Plate 3. This curve represents the probability relationship at Haley prior to completion of Bowman-Haley Dam. Flood damage estimates were made for the North Fork of the Grand River from the dam to the upper limits of Shadehill Reservoir. This area was divided into five study reaches with the reach limits based on the locations of stream gaging stations at Haley, North Dakota, and White Butte, South Dakota, and the location of surveyed channel and valley cross-sections. Plate 4 illustrates discharge-damage curves within these reaches and their location. These curves, based on 1971 prices, provide a basis for evaluating damages and benefits during a flood occurrence.

2-08. FLOOD DAMAGES. Historically, the greatest amount of damage was experienced during the snowmelt and ice jam flood of 1952. At 1986 price levels and conditions, total damages from recurrence of the 1950 flood is estimated at \$1,972,000 and \$2,456,000 from the 1952 event. The 1952 flood damages includes \$1,112,000 for damages to roads and bridges which had been damaged or destroyed in the 1950 flood, but had not been replaced prior to occurrence of the 1952 flood. The village of Haley, North Dakota is located in the flood plain. Because of its small size, potential damages to Haley are included in estimates of agricultural damages. There is no record of deaths attributed to floods on the North Fork. As of 1986, it is estimated that \$1,838,000 in flood damages have been prevented as a result of Bowman-Haley reservoir regulation.

2-09. FLOODS OF RECORD. Streamflow records on the North Fork of the Grand River near Haley, North Dakota, began in 1908 and have been collected to the present on an intermittent basis. Records from this station, which has a drainage area of 509 square miles, were utilized in developing the hydrologic studies for Bowman-Haley Dam. A description of some of the significant flood events that have occurred at this location are presented below.

a. 1952 Flood. During the winter of 1951-52, a very heavy snowpack accumulated over the Grand River basin in North and South Dakota. Average water equivalent of the snowpack over the North Fork above the Haley gage was about four inches. Most of this snowpack was underlain by ice and frozen soil. A large volume of snowmelt runoff resulted when temperatures rose into the 50's on 5 and 6 April and into the 70's on 7 April. The resulting flood set a record peak discharge of 14,100 c.f.s. and a maximum gage height of 17.03 feet at the Haley gaging station on 7 April 1952, with

a volume of about 95,000 acre-feet in 14 days. This is equivalent to 3.5 inches of runoff from the drainage area.

b. 1950 Flood. This flood originated from conditions similar to those which produced the 1952 flood. A heavy snow accumulation followed by melting conditions in early April produced a peak discharge of 11,300 c.f.s. and a maximum gage height of 17.10 feet at Haley on 15 April 1950. Volume of the flood was 71,000 acre-feet in 18 days or about 2.6 inches from the drainage area.

c. 1914 Flood. The greatest flood of record from rainfall occurred on 21 June 1914. It was caused by rainfall occurring on 20 and 21 June which was part of a sequence of rainstorms that produced the wettest June of record in North Dakota up to that time. Peak discharge at the Haley gaging station for this flood was 6,500 c.f.s. The flood volume for the event is not known.

d. Other Floods (Snowmelt). Additional snowmelt floods of record at the Haley gaging station occurred on 31 March 1913 with a peak discharge of 8,100 c.f.s., on 23 March 1947 with a peak of 5,640 c.f.s., and during March 1949 for which no peak discharge estimate is available but which produced an ice-affected peak stage of 14.0 feet, approximately two feet above bankfull. On 12 March 1972, backwater due to ice produced a peak stage of 11.62 feet with a discharge of 1,550 c.f.s. The maximum mean daily inflow into Bowman-Haley Reservoir experienced since closure was 5,130 c.f.s. on 27 March 1978. This event produced a maximum pool elevation of 2762.66 feet, m.s.l., which is the highest pool level of record.

e. Other Floods (Rainfall). A significant rainfall flood event occurred on 13 June 1915 when a peak discharge of 4,000 c.f.s. was estimated at the Haley gaging station. Other rainfall flood events occurred on 30 July 1951 with a peak discharge at Haley of 2,860 c.f.s. and on 20 June 1953 with a peak discharge of 2,510 c.f.s.

2-10. DESIGN FLOODS. Three synthetic flood events were developed for the Bowman-Haley project; (1) a Reservoir Design Flood, (2) a Standard Project Flood and (3) a Spillway Design Flood. Pertinent information for these floods is discussed below. Additional data concerning these events are presented in Section X of this Manual.

a. Reservoir Design Flood. A 50-year frequency flood event was selected as the Reservoir Design Flood for Bowman-Haley Dam. This was considered to be adequate in view of the rural nature of the protected area. The peak inflow into the reservoir for this event is 23,700 c.f.s. with a 3.5-day volume of 57,125 acre-feet.

b. Standard Project Flood. A Standard Project Flood for Bowman-Haley Reservoir was derived using procedures outlined in EM 1110-2-1411. Peak inflow into the reservoir for this flood is 46,400 c.f.s. and the 3.5-day volume is 122,700 acre-feet, which represents a 6-hour runoff of 5.16 inches from the area contributing to the reservoir.

c. Spillway Design Flood. The Probable Maximum Flood was selected for design of the emergency spillway and embankment height for Bowman-Haley Dam. The flood was developed using rainfall values from "Hydrometeorological Report No. 33". Peak inflow into the reservoir for the Probable Maximum Flood is 110,000 c.f.s. with a 4-day volume of 302,000 acre-feet from a 12-hour runoff of 12.7 inches from the 446 square mile drainage area above Bowman-Haley Dam.

### SECTION III - WATER RESOURCES DEVELOPMENT

3-01. GENERAL. The principal water problems of the North Fork basin prior to construction of Bowman-Haley Dam were flooding and lack of a firm water supply to support the industrial and municipal growth potential of the basin. Existing ground water supplies are of poorer quality than the water available from North Fork flows. Water stored in Bowman-Haley Reservoir is intended to permit realization of a portion of the economic growth potential of the basin. In addition, the reservoir has and will continue to provide water-based recreation facilities in an area lacking in recreational opportunities.

3-02. PUBLIC HEARINGS. At public hearings held at Lemmon, South Dakota, in April 1945 and at Bowman, North Dakota, in August 1956, the consensus of testimony indicated that local interests generally desired a solution to the flood and water supply problems of the North Fork basin. At the 1956 hearings North Dakota interests urged construction of a multiple-purpose dam and reservoir on the North Fork to be located on public domain land in the vicinity of Haley, North Dakota, for the purposes of flood control, municipal water supply, irrigation and recreation. South Dakota interests requested that full consideration be given to possible adverse effects of such a project on the operation of the existing Shadehill Reservoir. Local interests generally agreed that remaining water problems elsewhere in the Grand River basin were not serious. In subsequent contacts, state and local interests modified their initial views to exclude irrigation in favor of sufficient municipal and industrial water supply.

3-03. SHADEHILL DAM. In August 1951, the Bureau of Reclamation completed construction of the multiple-purpose Shadehill Dam located on the Grand River at the junction of the North and South Forks of the Grand River near Shadehill, South Dakota (See Plate 1). The principal functions of the project are flood control and irrigation. In addition a limited amount of municipal water supply, fish and wildlife enhancement, and recreation are also provided. Shadehill Reservoir has a flood control allocation of 218,300 A.F. between elevations 2271.9 and 2302.0 feet, m.s.l. Through 1986 the project had prevented flood damages estimated at \$7,742,300 on the Grand and Missouri Rivers.

3-04. SHADEHILL DAM IRRIGATION. The multiple-purpose pool storage at Shadehill was sized to supply water for irrigation of 9,700 acres in the Shadehill Unit. However, the irrigation plan never fully developed because of the effects

of the sodium content of the water on the irrigated land. Following extensive and detailed studies it was concluded that water from Shadehill Reservoir could be used for sustained irrigation if certain limitations of soils, leaching water, soil amendments, and drainage are observed. A definite plan report covering 6,700 acres which met these limitations was approved by the Bureau of Reclamation, and released for distribution. On 17 December 1963; however, landowners within the area voted 24 to 21 against formation of an irrigation district. Further action on development of the area was then deferred until the attitude of the landowners was more favorable. In June 1975 the West River Conservancy Sub-District was formed combining all of the original individual contracts for water supply from the reservoir into one contract. Total acreage contracted for by the Conservancy District was 5,000 acres. In addition, the South Dakota Department of Game, Fish and Parks contracted water supply for 20 acres resulting in a total contracted acreage of 5,020 acres. However, as of 1985, only 3,064 acres have been developed and the present contract is for that amount.

3-05. SHADEHILL DAM FLOOD CONTROL. In 1961, pending more extensive irrigation development, an additional 51,500 acre-feet of space in Shadehill Reservoir between elevations 2260.0 and 2272.0 was allocated to flood control. Evacuation of this space was made possible by the Bureau's modification of the outlet works in December 1960 to increase the discharge capability into the Grand River from 35 c.f.s. to 600 c.f.s. The original design capacity of 35 c.f.s. was insufficient to supply the increasing water demands of downstream interests. The field working agreement between the Corps and Bureau for flood control was revised on 10 August 1961 to reflect this modification. Justification for enlarging the outlet capacity was to provide the capability for evacuating the reallocated flood storage of 51,500 acre-feet to elevation 2260 by 1 March each year. This was to continue for the 10-year period from 1961 until 1971 for Missouri River main stem replacement storage purposes. Benefits were assigned accordingly. Subsequent to the August 1961 agreement, the release criteria from Shadehill Dam were changed because of downstream constraints. This resulted in reduced benefits for flood control when the pool level was in the zone between elevations 2260.0 and 2272.0. In addition, the Corps of Engineers had constructed Bowman-Haley Reservoir. As a result, the Corps requested that the 1961 field working agreement be terminated and that responsibility for operation of Shadehill Reservoir between pool elevations 2260.0 and 2272.0 revert to the Bureau of Reclamation. In accordance with a revised field working agreement dated 15 May 1972, the space between elevations 2260.0 and 2272.0 (51,500 acre-feet) was reallocated to conservation use. Operation of the reservoir between elevations 2272.0 and

2302.0 shall be construed as a flood control operation and releases will be determined by the District Engineer except for minimum releases required to meet downstream conservation requirements. Additional information regarding this project is given in the Shadehill Reservoir Regulation Manual.

3-06. EFFECT OF BOWMAN-HALEY ON SHADEHILL RESERVOIR. During planning studies for the Bowman-Haley project, it was determined that storage regulation at Bowman-Haley Reservoir would have a negligible effect on the operation of Shadehill Reservoir. Estimates indicated that the gross average annual reduction of inflow to Shadehill Reservoir would only be about 5 percent.

3-07. SOIL CONSERVATION STATE AND LOCAL PROJECTS. There are no Soil Conservation Service watershed projects in the North Fork basin. Soil Conservation Service records indicate that approximately 450 private stock water dams are located in Bowman County, North Dakota, and approximately 150 in Perkins County, South Dakota. A small amount of private irrigation using water pumped directly from the river occurs along the North Fork and tributaries. The municipally owned and private water facilities obtain their water supply from wells.

3-08. LOCAL PROTECTION. In June 1959, the Corps of Engineers completed a local protection project consisting of a levee and channel improvement on Buffalo Creek at Scranton, North Dakota. Buffalo Creek is a left bank tributary of the North Fork and enters the mainstream about 20 miles downstream from the Haley gage. The project was constructed under authority of Public Law 685. The cost of the improvement was \$121,500, of which \$103,000 was Federal cost. Operation of Bowman-Haley Reservoir has no effect on this project.

3-09. WATER QUALITY. A water quality program for Bowman-Haley Reservoir was initiated in May 1971. The objectives of this program are to provide information required for appraisal of water quality conditions in the reservoir as required by ER 1130-2-415. Water quality sampling sites have been established on the three main tributaries of the reservoir, Spring Creek, Alkali Creek, and the North Fork of the Grand River, in the reservoir and downstream of the outlet works. Water quality sampling is conducted by area personnel and chemical analyses are accomplished by the Missouri River Division Laboratory. All special studies are conducted by Omaha District water quality personnel. Data collected to date indicates that Bowman-Haley has extremely poor water quality with numerous exceedences of state water

quality standards. Some authorized project purposes cannot be met because of poor water quality. A two-part report on water quality is prepared annually for submission to the Office of the Chief of Engineers. On 8 April 1985, a public meeting was held in Bowman to discuss procedures that might be employed to improve water quality in the lake. Installing a low level outlet to release water from the bottom of the lake was discussed. A design memorandum is currently being prepared on this outlet.

3-10. STATE WATER LAWS. No interstate water compact exists between the States of North and South Dakota for distribution of Grand River waters. A water right to store water in Bowman-Haley Dam dated 1966 was acquired by the project sponsor. This right was finalized or perfected in October 1980. The North Dakota Water Commission is responsible for administering water rights in the State. In the early 1980's there were four water permits downstream of Bowman-Haley Dam within the State of North Dakota and five permits upstream of the impoundment.

## SECTION IV - PROJECT HISTORY AND DEVELOPMENT

4-01. HISTORY. The Bowman-Haley Dam was authorized for construction under the Flood Control Act of 1962 (P.L. 87-874) substantially in accordance with the recommendations of the Chief of Engineers in House Document 574, Eighty-seventh Congress, at an estimated cost of \$2,670,000. The authorization provided that the project be constructed, operated and maintained by the Chief of Engineers under the direction of the Secretary of the Army. Authorized project purposes were flood control, municipal and industrial water supply, general recreation and fish and wildlife enhancement. Construction began in July 1964. The embankment closure was made on 22 August 1966 and some permanent storage was accomplished in the dead storage pool during the fall and winter of 1966-67. The outlet gate was ordered closed on 7 March 1967. The reservoir reached the top of the multi-purpose pool (elevation 2754.8 feet, m.s.l.) on 22 March 1969 resulting in the initial discharge from the lake. Operational history of the project for the period from March 1967 through December 1985 is presented on Plates 5A and 5B.

4-02. EMBANKMENT. The Bowman-Haley Dam consists of a rolled earthfill with 1 on 3 seeded side slopes, except where riprap is required to prevent erosion by wave action. The dam embankment is approximately 5730 feet long, has a crest width of 25 feet and a top elevation of 2794.0 feet, m.s.l., which is approximately 79 feet above the riverbed. A general plan of the project is presented on Plate 6.

4-03. FREEBOARD. Freeboard refers to the difference in elevation between the maximum water surface elevation reached in routing the spillway design flood through the reservoir and the top of the earth embankment. The freeboard is provided to avoid the possibility of water going over the top of the dam by wind or wave action when the pool is operating at maximum surcharge. Wind and wave action include vertical wave height, wave run-up and wind set-up. With an effective fetch length of 2.4 miles and a 60 mph wind speed, the wave and run-up effect on the 1 on 3 riprapped slope was 4.0 feet. The wind set-up effect was determined to be 0.8 feet resulting in a total wind effect of 4.8 feet above the still pool elevation. A minimum freeboard requirement of 5 feet was adopted for the embankment.

4-04. FUSE PLUG. A spillway fuse plug, as shown on Plate 7, has been constructed across the emergency spillway to permit storage between the spillway crest elevation (2777.0 feet, m.s.l.) and the top of the fuse plug (elevation 2780.7 feet, m.s.l.). The crest of the fuse plug is the maximum pool

elevation reached in routing 90 percent of the Standard Project Flood through the reservoir. The plug was designed to fail when overtopped by floods of greater magnitude. The crest elevation of the fuse plug was based on economic considerations since it was desired to minimize the cost of maintenance of the plug in the event of emergency spillway use.

4-05. SERVICE SPILLWAY AND OUTLET WORKS. The service spillway intake structure is the morning-glory shaft type as shown on Plate 8. The crest of the circular riser, which has an internal diameter of 9 feet, is at elevation 2754.8 feet, m.s.l. Three 10-ft. high guide piers are located on top of the crest to minimize vortex formation and maintain a converging flow into the drop inlet. The morning-glory intake structure connects to a 10-foot diameter circular conduit through the embankment. The conduit has a length of 341 feet with upstream and downstream invert elevations of 2720.5 feet, m.s.l. and 2712.0 feet, m.s.l., respectively. A parabolic drop curve connects the conduit exit portal with the stilling basin. The basin is designed to contain and dissipate the energy of discharges to approximately 2,950 c.f.s., which is the reservoir release through the outlet works for the Standard Project Flood. This discharge was selected for stilling basin design because it is the maximum discharge passing through the service spillway before the emergency spillway begins to operate. Details of the stilling basin are shown on Plate 9. The discharge rating curve for the service spillway is shown on Plate 10.

4-06. CONTROLLED OUTLET. A low flow gated outlet is provided for the purpose of providing reservoir releases from 10 c.f.s. to 140 c.f.s. in order to satisfy minimum downstream flow requirements. A 30-inch gate valve for control of the low flow release, and an 8-inch bypass valve are contained in a manhole, or dry well, constructed within an extension of the downstream guide pier as shown on Plate 8. The 30-inch outlet discharges directly into the conduit through an opening in the conduit roof a short distance downstream from the gate valve. Flow into the low flow inlet manhole, or wet well, located immediately upstream from the dry well passes through two 4-foot square openings provided with removable trashracks. A slide gate that can be used in emergencies is installed in the wet well in front of the 30-inch pipe. Both manholes are provided with hatches and covers in the top deck. The manhole containing the gate valves will be dry during periods when the pool level is below elevation 2765 feet, m.s.l. Pool levels above this elevation, which has an exceedence frequency of once in 25 years, will flood the gate valve manhole but little or no damage to the regulating equipment is expected. The low flow outlet rating table is shown on Plate 11 and the rating

curves for various gate openings are shown on Plate 12.

4-07. GATE OPERATION. The 30-inch slide gate (emergency gate) in the wet well is equipped with six adjustable bronze-faced wedges and a 2-inch diameter stainless steel stem. The gate is raised or lowered with a lift which has a right angle gear drive coupling to permit use of the wheel wrench for operation of the gate from the top of the intake structure. The wheel wrench, along with the portable guardrails, are stored in the reservoir water stage recorder house. The 8-inch and 30-inch gate valves are operated with handwheels which remain in place. The 30-inch valve is equipped with a gear box and an indicator.

4-08. EMERGENCY SPILLWAY. The emergency spillway, located beyond the right abutment of the dam embankment, consists of a trapezoidal earth channel with 1 on 3 side slopes and 650-foot bottom width. As shown on Plate 7 the spillway channel bottom has a 400-foot flat crest at an elevation of 2777.0 feet, m.s.l. near the upstream end of the channel. Downstream from this point the channel has a bed slope of 0.002 feet per foot. The rating curve for the emergency spillway is shown on Plate 13.

4-09. RESERVOIR. Two storage zones are provided in the reservoir, a multiple-purpose zone and a flood control zone. The multiple-purpose zone of 18,765 acre-feet includes storage for water supply, fish and wildlife and recreation. In addition, this zone contains space for storing an estimated 100 years of sediment deposition. The water supply storage was developed for maximum possible yield from the contributing drainage area. Because of the rural nature of the area for which flood protection is provided, flood control storage is based on controlling the runoff from a flood event having an exceedence frequency of once in 50 years. The storage required to control this event is about 51,000 acre-feet at a reservoir elevation of 2772.1 feet, m.s.l. In addition, the storage required to control the 1952 flood, which is the flood of record, was 52,500 acre-feet at a reservoir elevation of 2772.8 feet, m.s.l. Based on studies for these two events, a pool elevation of 2773.0 feet, m.s.l. was selected as the top of the Reservoir Design Flood zone. This provides design flood storage of 53,847 acre-feet. During the design phase of the project, studies indicated that the combination of spillway excavation and embankment height requirements resulted in a higher dam being the most economical to construct. The crest of the emergency spillway was raised to elevation 2777.0 feet, m.s.l., which resulted in additional controlled storage of 18,870 acre-feet. The effective flood control zone for the completed project extends from elevation 2754.8 to 2777.0 feet, m.s.l.,

and has the capability to control a flood equivalent to about 72 percent of the Standard Project Flood. Additional controlled storage of 20,366 acre-feet is also available between the spillway crest elevation (2777.0 feet, m.s.l.) and the fuse plug crest elevation (2780.7 feet, m.s.l.) providing the fuse plug remains intact. The spillway fuse plug is designed to fail if overtopped by any event exceeding 90 percent of the Standard Project Flood.

4-10. AREA-CAPACITY DATA. The initial area curve for the reservoir was determined using topographical maps with 10-foot contour intervals. The initial reservoir capacity curve was derived by computing volumes using the average end-area method. Current reservoir area and capacity tables are based on measurements taken during the 1984 aggradation survey. The current Area-Capacity table is shown on Plate 14.

4-11. STORAGE ALLOCATIONS. The pertinent data for Bowman-Haley Reservoir are presented at the front of this Manual. The data shown are based on the reservoir survey taken in 1984. The storage values determined from that survey are somewhat different than the values used in the Survey Report studies published in 1961, which were based on topographic data available at that time. For example, the storage to the top of the multi-purpose pool elevation of 2754.8 feet, m.s.l., from the Survey Report studies was 21,950 acre-feet. Later studies adjusted this value to 19,780 acre-feet. These values compare with the multi-purpose pool storage of 18,765 acre-feet determined from the 1984 reservoir survey. In addition, the storage lying between the top of the multi-purpose pool and the top of the Reservoir Design Flood Pool (elevation 2773.0 feet, m.s.l.) is 53,847 acre-feet, as determined from the 1984 reservoir survey, compared with 59,500 acre-feet presented in the Survey Report. These differences and other changes made as the project design studies progressed have not resulted in any significant changes in project operation. The studies made in developing the storage requirements for the multi-purpose pool were based on the water demand for municipal and industrial use plus the requirements for water rights, streamflow use and pool losses as outlined in the following Table No. 2.

TABLE NO. 2

## AVERAGE ANNUAL RESERVOIR OPERATIONS--MULTIPURPOSE ZONE

Municipal and Industrial Demand:	
Average, acre-feet	2,900
Normal, acre-feet	3,000
Firm, acre-feet	1,800
Streamflow and Existing Water Rights:	
Normal, acre-feet	880
Firm, acre-feet	550
Evaporation and Seepage Losses, Annual:	
Maximum, acre-feet	5,100
Average, acre-feet	4,405
Minimum, acre-feet	2,415

4-12. SEDIMENTATION. Estimates of sediment deposition in Bowman-Haley Reservoir were made from direct measurements of sediment transport for the North Fork at the Haley gage and through correlation between the Haley and Shadehill gaging stations and between the Haley and Wakpala gaging stations on the Grand River. On the basis of these estimates, assuming a 100-year economic life and a 95 percent reservoir trap efficiency, provisions were made for 4,750 acre-feet of sediment storage. Most of the sediment inflow into the reservoir is deposited in the multi-purpose pool area, with the remainder in the flood control zone. Flood routings to determine embankment height and emergency spillway discharges were based on the depleted reservoir capacity condition. Sedimentation investigations to observe and document the sedimentation phenomena within the reservoir proper and in the channel reaches both upstream and downstream will be accomplished under a continuing program. In general, the planning of this program, the observation techniques utilized, the extent of surveys, analysis of basic data and submission of technical memoranda or reports are in accordance with guides and instructions outlined in EM 1110-2-4000. Reservoir aggradation ranges have been established at a number of locations and are shown on Plate 15. These ranges were established in 1968 and were resurveyed in 1973 and 1984. The scheduling of future resurveys and associated observations will be dependent upon the frequency and duration of heavy runoff periods. It is intended; however, that the maximum interval between resurveys will be no longer than 10 years. Documentation of channel changes downstream of the project are also planned when operating conditions dictate. The results obtained from the sedimentation resurvey made in 1984 have been used to adjust and update the reservoir area capacity curves. The Corps of Engineers is responsible for all activities, operations, and studies connected with this sedimentation program.

4-13. LAND ACQUISITION. Fee title was acquired to lands and improvements in the Bowman-Haley project area using the following criteria; (1) lands required for the dam and appurtenant structures, (2) lands required for adequate public use and access, (3) all lands lying below the fuse plug elevation of 2780.67 feet, m.s.l., using a blocking out procedure along established property description lines, except in the upper reaches of the reservoir where the fee taking elevation was 2773.0 feet, m.s.l., to satisfy Fish and Wildlife Service wildlife habitat requirements. In addition, flowage easement rights were acquired in the upper reaches of the reservoir for all lands between elevation 2780.7 feet, m.s.l., and the blockout elevations of the fee taking. Information regarding the lands acquired for the project are presented in the following Table No. 3.

TABLE NO. 3

LANDS ACQUIRED

Public Domain Land	3,280 acres
Private Land, Fee (Blockout of 2780.7 feet, M.S.L. contour) (Lower reaches of Reservoir)	1,775 acres
Private Land, Fee (Blockout of 2773.0 feet, M.S.L. contour) (Upper reaches of Reservoir)	1,685 acres
Private Land, Easement (Between 2773.0 and 2780.7 feet, M.S.L.)	<u>930 acres</u>
TOTAL	7,670 acres

4-14. RELOCATION. Construction of the Bowman-Haley Dam required relocation and/or alteration to existing roads, power and telephone lines and an existing school which would have been adversely affected by operation of the reservoir. Flowage easements were secured in some areas to permit occasional flooding of bridges and road rights-of-way in lieu of abandoning or relocating these facilities. In some areas where power and telephone lines were above the multi-purpose pool level, but below elevation 2781.0, the lines were raised to insure continued service. The rural elementary school, known as Wilson School No. 1, was relocated since reservoir pool elevations during flood periods would have inundated the original schoolyard and basement of the school. The existing building was moved to a new site 3-1/2 miles northwest of the original site. New foundation, water, sanitary and electrical facilities were provided sufficient to meet minimum requirements of the North Dakota State Board of Education.

4-15. RECREATION. Bowman-Haley Lake has a total water surface area of 1,732 acres at the top of the multiple-purpose pool level (elevation 2754.8 feet, m.s.l.), and a normal annual fluctuation of approximately 2 feet. The lake and surrounding shoreline provides a recreation area plus fish and wildlife benefits in a section of North Dakota that has only minor water-based recreational facilities. The North Shore Recreational Area, located on the left bank above the dam, was developed to receive the heaviest use. This area includes roads, a parking area, trees and picnic and camping facilities. Also located in this area adjacent to the parking lot is a concrete boat launching ramp built on approximately a 14 percent grade. The top elevation of the ramp is at 2761.8 feet, m.s.l., and the bottom at 2745.0 feet, m.s.l. The picnic and camping facilities are located above elevation 2780.7 feet, m.s.l. Development of the Point and South Shore areas includes tree plantings on the South Shore and an access road and picnic facilities on the Point. The following tabulation reflects the declining interest in recreational use of the lake since its closure. The decline in lake water quality has been cited by some residents as a reason for this decrease.

TABLE NO. 4

TOTAL VISITORS PER YEAR  
BOWMAN-HALEY LAKE, NORTH DAKOTA

1967	20,700	1977	46,900
1968	31,950	1978	32,342
1969	89,650	1979	24,500
1970	91,850	1980	31,000
1971	100,100	1981	31,200
1972	98,200	1982	30,500
1973	67,400	1983	33,100
1974	31,000	1984	12,760
1975	31,600	*1985	35,222
1976	28,518	1986	36,331

\*Car counters installed in 1985.

4-16. WILDLIFE HABITAT. Approximately 3,845 acres of project lands located in the extreme upper reaches of the Spring Creek arm and the North Fork of the Grand River arm of the project are allocated for Wildlife Management purposes. The project boundary line around the Wildlife Management area has been fenced in order to obtain a leasing agreement with the North Dakota Game and Fish Department.

4-17. IRRIGATION. During early public hearings, local interests requested construction of a multi-purpose dam and reservoir to include the storage for irrigation. Due to supply limits of the North Fork water resources, the request for irrigation was dropped in favor of sufficient municipal and industrial water supply. Refer to Section III of this report for further discussion of water resources development in the basin.

4-18. OPERATIONAL HISTORY. Reservoir storage began in Bowman-Haley Lake in March 1967 and the multi-purpose pool was initially filled in March 1969. Plates 5A and 5B present pool elevations and reservoir monthly inflows and outflows for the period from March 1967 through December 1985.

## SECTION V - ORGANIZATION FOR RESERVOIR REGULATION

5-01. GENERAL. Engineering Regulation 1110-2-1400, dated 24 April 1970, assigns Corps of Engineers' reservoir regulation responsibilities in the Missouri River Basin to the Missouri River Division Engineer. This Engineering Regulation also permits delegation of certain reservoir regulation responsibilities to the District Engineer in whose area the project is located. The responsibility for assembly and interpretation of data affecting current reservoir regulation and for accomplishing routine regulation of Bowman-Haley Reservoir in accordance with plans agreed on in advance has been delegated to the Omaha District Engineer. The Division Engineer, through the Missouri River Division Reservoir Control Center, monitors and review the regulation activities performed by the Omaha District. The organizational structure of the Omaha District for regulation of Bowman-Haley Dam and Reservoir is shown on Plate 16.

5-02. CORPS OF ENGINEERS. The operation of Bowman-Haley Dam and Reservoir involves three units of the Omaha District Organization as follows:

a. Reservoir Regulation Section, Engineering Division. This section is responsible for matters pertaining to the regulation of the reservoir. Section personnel are responsible for providing regulation orders to the Garrison Project Manager regarding low level gate adjustments and for coordinating water supply releases requested by the Bowman County Water Resources District. The Reservoir Regulation Section is responsible for procurement of meteorologic and hydrologic data necessary for regulation of the project. They are also responsible for making advance estimates of streamflow from snow cover and/or rainfall reports, for determining reservoir inflow and outflow, and for alerting field operating personnel of potential flood occurrences. The Section also prepares and submits required regulation reports to higher authority.

b. Operations Division. The Operations Division plans and directs the maintenance of the project. They establish the standards of maintenance and provide proper staffing to accomplish these objectives.

c. Garrison Project Manager. The Project Manager's staff performs functions relating to operation, maintenance and regulation requested by the Operations Division and the Reservoir Regulation Section of the Omaha District Office. The Project Manager will not have a full time dam tender in residence at the project. He will utilize personnel from the Riverdale, North Dakota, office to operate the low level outlet gates as ordered. When releases are ordered through

the low flow outlet for any purpose the actual time of opening or adjusting each gate change is to be furnished to the Reservoir Regulation Section of the Hydrologic Engineering Branch, Engineering Division, Omaha District, as soon as possible. Instructions to field personnel for regulation of Bowman-Haley Dam and Reservoir are presented as Exhibit I of this Manual.

5-03. BOWMAN COUNTY WATER RESOURCES DISTRICT. The Bowman County Water Resources District, formerly Bowman County Water Management District, is the local project sponsor and has contracted for water from the reservoir. In this capacity they have the authority to withdraw water from the lake and order the Corps of Engineers, Omaha District, to make releases from the reservoir. They also have the authority to construct any such works, plants, pipelines and appliances as may be necessary and convenient for the purpose of water diversion or withdrawal.

5-04. COMMUNICATION. Since no dam tender is in residence at the project, direct communication with the project is not possible. Radio and telephone facilities are currently available between the Omaha District Office and the Garrison Project Manager's Office and, if required, project personnel can travel approximately 200 miles by auto to the project site. A telemark gage and data collection platform (D.C.P.) have been installed in order to provide pool elevation data and, in addition, there is a pool gage observer near the site who can be reached by telephone for emergency reports of weather and streamflow conditions. Telephone numbers of appropriate personnel and/or offices are listed in Exhibit I.

5-05. REGULATION ORDERS. Issuance of regulation orders is only required for operation of the low flow outlet since the service spillway and emergency spillway operate automatically. In the absence of an on-site dam tender, regulation orders for the low flow outlet are issued verbally to the Project Manager by personnel of the Omaha District Reservoir Regulation Section. The Project Manager dispatches personnel to the site to perform the required changes in valve settings. The verbal orders are confirmed in writing with a copy furnished to the Missouri River Division Reservoir Control Center. The written orders will contain a brief statement giving the background and reasons for issuance of the order.

5-06. COORDINATION REQUIRED BETWEEN CORPS AND OTHER AGENCIES. Coordination concerning reservoir regulation activities is between the Corps, Bowman County Water Resources District, State of North Dakota Water Commission,

North Dakota Game and Fish Department and the Bureau of Reclamation as appropriate. Normal maintenance of the dam and recreation areas are accomplished through License Agreement with the local sponsor.

5-07. PUBLIC INFORMATION. Since the project's flood control releases are made through the unregulated flood control outlet, the need to provide advance warning of such discharge is minimized. The National Weather Service, through the use of its various networks, issues flood warning bulletins to local news media, i.e., newspapers, radio and television. Contact between the Weather Service and the Omaha District is maintained on a continuing basis.

SECTION VI - COLLECTION AND DISTRIBUTION OF BASIC HYDROLOGIC DATA

6-01. GENERAL HYDROLOGIC DATA. Within the States of North Dakota and South Dakota, various State and Federal agencies have over the years established a system of stream and precipitation gages. The U.S. Geological Survey, the National Weather Service, Bureau of Reclamation, Soil Conservation Service, States of North Dakota, South Dakota and the Corps of Engineers contribute personnel and/or funds to the support of this system. Streamflow and precipitation gages judged most useful for regulation of Bowman-Haley Reservoir are listed in Tables No. 5 and 6 and are shown on Plate 17. Gage readings from these stations are collected and reported as discussed in paragraph 6-03. The Omaha District Reservoir Regulation Section has access to the National Weather Service via computer terminals. This serves as a means of collecting and distributing a wide variety of meteorological and hydrologic information. Stage-discharge relationships for stream gaging stations located on the North Fork at Haley, North Dakota, the North Fork at White Butte, South Dakota, and the South Fork at Cash, South Dakota, are shown on Plate 2. These ratings will be revised as additional discharge measurements indicate.

TABLE NO. 5

BOWMAN-HALEY DAM AND RESERVOIR  
STREAM GAGING STATIONS

	<u>STATION</u>	<u>GAGE TYPE</u>	<u>OPERATING AGENCY</u>
1.	North Fork, Grand River at Bowman-Haley Dam, ND	Recorder with DCP* and Telemark 701-275-6230 (FTS Operator 8-783-5771)	Corps of Engineers
2.	North Fork, Grand River at Haley, North Dakota	Recorder	U.S.G.S.
3.	North Fork, Grand River near White Butte, SD	Recorder	U.S.G.S.
4.	South Fork, Grand River at Buffalo, SD	Recorder	U.S.G.S.
5.	South Fork, Grand River near Cash, South Dakota	Recorder	U.S.G.S.

U.S.G.S. - United States Geological Survey  
\*DCP - Data Collection Platform

Note: Station Locations Shown on Plate No. 22

TABLE NO. 6

BOWMAN-HALEY DAM AND RESERVOIR  
PRECIPITATION STATIONS

(Nr = Non-Recording, R = Recording)

<u>STATION</u>	<u>TYPE</u>
1. Bison, South Dakota	NR
2. Bowman, North Dakota, Court House	R
3. Bowman, North Dakota, 11 SE	NR
4. Bowman-Haley Dam, North Dakota	DCP**
5. Buffalo, South Dakota	R
6. Glad Valley, South Dakota, 2W*	NR
7. Hettinger, North Dakota*	NR
8. Isabel, South Dakota	R
9. Ladner, South Dakota, 8SW	R
10. Lemmon, South Dakota*	R
11. Lodgepole, South Dakota, 10NW*	NR
12. Lodgepole, South Dakota, 9S	R
13. Ludlow, South Dakota	NR
14. McIntosh, South Dakota	R
15. McLaughlin, South Dakota*	NR
16. Meadow, South Dakota	R
17. Mobridge, South Dakota*	R
18. Amidon, North Dakota*	NR
19. Ralph, South Dakota	NR
20. Peeder, North Dakota	NR
21. Selfridge, North Dakota	NR
22. Shadehill Dam, South Dakota*	NR
23. Timber Lake, South Dakota	NR

\*Snowfall reports from these stations.

\*\*DCP - Data Collection Platform

6-02. RESERVOIR DATA. Reservoir elevations are obtained and recorded by a conventional "bubbler type" water level recorder. The reservoir elevation data is transmitted through the Missouri River Division Water Control Data Collection and Management Computer System. The system includes transmitting the data from the Data Collection Platform (DCP) to the Geostationary Operational Environmental Satellite (GOES). The data is then relayed through the GOES satellite to a ground station located at the District Office in Omaha where it is processed and entered into the data base. A staff gage is attached to the service spillway intake structure for visual observation of the pool level. A wire-weight gage is also located on the walkway to the intake tower. A bubbler gage has also been installed downstream from the dam in the tailwater channel. Although gage readings are available from this tailwater recorder, outflows through the service or emergency spillways will normally be based on water surface elevations obtained from the DCP pool level recorder or from the wire-weight gage readings and the rating curve shown on Plate 10. Low-flow-outlet releases will be determined in a similar manner, utilizing the rating tables shown on Plate 11 or the curves shown on Plate 12. Inflows will be computed on the basis of outflows, storage changes, and estimated evaporation.

6-03. OBSERVER DATA COLLECTION AND REPORTING CRITERIA. In the absence of a full time dam tender, the Reservoir Regulation Section has obtained the services of a local resident to read the pool level gage twice weekly and mail in a weekly card report of these observations along with daily precipitation amounts. Special telephone reports are also furnished in the event that the reservoir level rises in excess of 1.0 feet in a 24-hour period or if precipitation of 0.50 inch or more occurs. The pool recording gage, data collection platform, and telemark installation are serviced on a routine basis by personnel of the District Office. Private individuals have been hired to read and report river stages at the stream gaging stations listed in Table No. 5. Daily or weekly readings are taken, depending upon the season of the year, and a record of the readings is maintained by the U.S.G.S. Readings are taken at more frequent intervals during high water periods. These gage readings are relayed to the Section by the National Weather Service via datacol computer as conditions warrant. Reports of precipitation and snow depths are also provided by the National Weather Service.

6-04. REPORTING FORMS AND DISSEMINATION OF DATA. In addition to the observer's Weekly Reservoir Record Card which lists a daily pool reading and precipitation amounts, U.S.G.S. personnel remove the recorder tape from the pool and

tailwater gages on a monthly basis and forward them to the Omaha District Reservoir Regulation Section where a computer printout of the 24-hour elevations is prepared. Precipitation and temperature data from Lemmon, South Dakota, are furnished daily from the National Weather Service via computer terminals. Using the information as described above, the Section prepares a Monthly Reservoir Report (Provisional Record MRD Form 0168) for submission to the Missouri River Division. A copy of this report for the month of March 1985 is shown on Plate 18.

SECTION VII - FORECASTS AND ANALYSIS PERTINENT TO RESERVOIR  
REGULATION

7-01. WEATHER FORECASTS. The National Weather Service (NWS) prepares and distributes to the general public forecasts of precipitation, temperature, river stages and other meteorological data. The District Reservoir Regulation Section receives these data from the NWS via computer terminal and National Facsimile Networks. When appropriate, such as in situations when substantial reservoir inflow is anticipated from upstream flood runoff, the Corps of Engineers may issue warnings of flood producing releases from the reservoir. Warnings may be issued over the following radio stations in the general area; KBJM - 1400 KC, Lemmon, South Dakota; KDIX - 1230 KC, Dickinson, North Dakota; and several Bismarck, North Dakota, radio stations.

7-02. SEASONAL WATER SUPPLY FORECASTS. Forecasts of seasonal runoff above Bowman-Haley Dam can be prepared on the basis of winter precipitation. These forecasts are based on an analysis comparing November - February precipitation amounts recorded at three National Weather Service precipitation stations with March - April inflow at Bowman-Haley Reservoir. The results of this study are presented on Plate 19. In addition to the analysis described above, there are some years when field snow surveys have been taken in the basin to determine water equivalent of the late winter -early spring snowpack. The data from these surveys have been correlated with the resulting stream runoff to provide a basis for estimating snowmelt inflow into Bowman-Haley reservoir. The results of this study are shown on Plate 20.

7-03. RUNOFF RELATIONSHIPS. A 6-hour unit hydrograph for the Bowman-Haley Damsite developed in the Survey Report Studies for the project is shown on Plate 21. The unit hydrograph was used as a basis for developing reservoir inflow hydrographs for the Standard Project flood and the Spillway Design Flood. The unit hydrograph may be utilized to forecast potential reservoir inflow by applying estimated basin runoff amounts from an actual storm event.

7-04. ANNUAL CHANCE OF LAKE REFILL. Plate 22 shows a graph indicating percent chance of fill of the reservoir from different starting elevations. This graph is based on the historical record of reservoir inflows.

7-05. FLOOD DAMAGE ANALYSIS. Flood damages prevented by the Bowman-Haley Dam and Lake Project are evaluated when it is

determined that flooding has been prevented or that more serious flooding would have occurred had not the project been present. Flood damages prevented by the project are evaluated by comparing discharges occurring at selected locations downstream from the dam with the project operating to discharges that would have occurred at these same locations without the project. Updated discharge-damage curves for the reaches downstream from the dam are utilized to determine damages for discharges that occurred with the project in operation and for estimated discharges that would have occurred without the project. The difference between the damages for these two conditions represents the damages prevented by the project.

7-06. RESERVOIR EVAPORATION. The annual excess of evaporation over precipitation is estimated to be 26 inches. This value is based on 0.7 of the Weather Bureau 4-foot Class A type evaporation pan located at Shadehill Dam. The Shadehill site is approximately 80 miles downstream and is climatologically similar to Bowman-Haley Damsite. The daily evaporation values for Shadehill are recorded on cards which are received at regular intervals from the Bureau of Reclamation.

SECTION VIII - MULTI-PURPOSE REGULATION

8-01. GENERAL. Regulation of the multi-purpose storage zone in Bowman-Haley Reservoir was intended to be for the purpose of providing municipal and industrial water supply. Waters impounded in the reservoir below the top of the multi-purpose pool elevation of 2754.8 feet will be retained unless releases are required for water supply, downstream water right requirements, or as otherwise requested by the Bowman County Water Resources District.

8-02. WATER SUPPLY. During planning of the project, the cities of Bowman, Reeder, Gascoyne and Scranton signified their intent to use water from the project for municipal and industrial purposes. Storage was provided in the multi-purpose zone to meet the estimated future needs of the communities in the area. However, as of March 1986, water from the reservoir has not been used for water supply by those communities. In planning the project, runoff at the damsite was estimated as shown in Table No. 7.

TABLE NO. 7

ESTIMATED RUNOFF AT BOWMAN-HALEY SITE

Maximum Annual Flow	96,700 acre-feet
Median Annual Flow	15,900 acre-feet
Average Annual Flow	20,400 acre-feet
Minimum Annual Flow	1,420 acre-feet

The extreme variations in annual runoff required a multi-purpose impoundment capacity sized to yield the highest firm annual yield which could be obtained without excessive evaporation and seepage losses. Using these criteria and an assumed chronological recurrence of the past hydrologic cycle, reservoir operation studies indicated a need for 20,000 acre-feet of gross storage and 16,000 acre-feet of active storage. (The 1984 reservoir survey indicated that the multi-purpose pool storage is actually 18,765 acre-feet.)

8-03. AGREEMENT WITH BOWMAN COUNTY WATER RESOURCES DISTRICT.

In accordance with provisions of the Water Supply Act of 1958 as amended, and the resolution of assurances dated 12 March 1964, the sponsoring entity is required to repay the project investment costs allocated to storage for future municipal and industrial water supply during the economic life of the project, but in no event is the repayment period to exceed 50

years. Repayment for operation and maintenance must begin when water is first used for municipal and industrial water supply. The project investment costs allocated to municipal and industrial water supply were exempt from accrual of interest during the first 10 years after water was first available for use or until water was first used, but in no event was the interest-free period to extend beyond 10 years. The interest-free period began on 1 April 1967, when water supply in the conservation pool was first available for municipal and industrial use. Following initial fill of the multi-purpose pool, the Corps of Engineers, Omaha District, and the Bowman County Water Resources District discussed the Resource District's obligation for development and repayment of the water supply function of the project. The local sponsors' first payment of \$24,703 for project cost was made in March 1978 and payments have continued on an annual basis. The contract for water storage space in Bowman-Haley Lake was finalized on 10 November 1981. A copy of this contract is provided as Exhibit II of this Manual. The contract states the cost that the Water Resources District is required to pay.

8-04. REGULATION IN ABSENCE OF CONTRACT. Prior to execution of the water supply contract, releases were made from reservoir storage during 1974, 1976, 1977 and 1980 by the Corps of Engineers in response to requests from downstream interests to augment streamflow during drought declaration periods. The justification for these releases is contained in Engineering Manual 1165-2-105, entitled "Water Resources Policies and Authorities".

8-05. RECREATION AND FISH AND WILDLIFE. Recreational use and quantity of the fishery at the project has been reported to be adversely affected by the poor quality of water in the lake. The data presented in Table No. 4, paragraph 4-15 shows that there has been a decline in visitors per year since the dam was closed. Water quality of the lake may be enhanced by partially evacuating the pool during the fall or winter and refilling with a better quality of water during the spring runoff season. The chance of successfully refilling the pool by this procedure is shown on Plate 22. However, after the river below the dam has frozen over, caution should be exercised in making any release. In early March of 1986, low level gated releases as high as 60 c.f.s. were made prior to the breakup of downstream ice in an attempt to remove poor quality water from the reservoir. These releases were based on knowledge that the snowpack over the area above the dam was adequate to refill the multipurpose pool. The experience gained from this operation indicated that releases of 10 to 15 c.f.s. could be made in early February without causing any significant downstream problems. If releases are made in the winter, the river

downstream should be closely monitored for possible adverse effects. In October 1985, at the request of the Bowman County Water Resources District, the lake was lowered approximately 1 foot from elevation 2753.0 to elevation 2752.0 feet, m.s.l., in an attempt to improve the water quality in the lake. Because of the potential impact on Shadehill Reservoir, the Bureau of Reclamation was consulted prior to the releases and a press release was made.

8-06. DROUGHT CONTINGENCY PLAN - BOWMAN-HALEY DAM AND LAKE.

a. General. Section 216 of Public Law 91-611, Rivers and Harbors Act of 1970, gives authority to water control managers to review the operation of Corps of Engineers multi-purpose projects. After review Congress is advised if modifying the structures is recommended to improve the quality of environment in the overall public interest. Using this authority a drought contingency plan has also been prepared for Bowman-Haley Lake using the guidance provided in Engineering Regulation No. 1110-2-1941. The plan is divided into two phases. Phase 1 evaluates and establishes the limits of flexibility under existing authorities and Phase 2 evaluates the feasibility of further action if constraints now existing are removed. Phase 1 is described below. No action is required at Bowman-Haley for Phase 2.

b. Project Flexibility - Phase 1. The existing water control plan for Bowman-Haley Lake provides for filling the multi-purpose pool and spilling excess flows. The project is automatically regulated during high flow periods by means of an ungated service outlet (morning-glory drop inlet). The water in the multi-purpose or conservation zone is obligated via contract to the local sponsor, the Bowman County Water Resources District. Any request for release from this zone will be referred to them. Several downstream water users have water rights senior to Bowman-Haley Dam that may require a release of water from the reservoir. In the event that the water supply contract with the Water Resources District becomes void, any release made from the conservation storage zone will be determined by the Corps under its regulation authority (EM 1165-2-105). This regulation authorizes the release of recent reservoir inflow to augment downstream flow for domestic consumption.

c. Coordination. Coordination with North and South Dakota state agencies and Federal agencies is needed in exercising a drought contingency plan. Both states have contingency plans and confirmation of the extent and degree of severity should be verified and coordinated with the appropriate agencies. Table No. 8 shows a listing of agencies involved in drought activities. Reservoir Regulation Section personnel routinely monitor precipitation and streamflow for high stages and potential flooding. They

are also observant for prolonged deficiencies in precipitation and reduced streamflow. Information is collected on the Drought Severity Chart provided to the Section by a National Weather Service Weather Fax (NAMFX) machine. This chart, a copy of which is shown on Plate 23 for the month of July 1977, is a report of drought conditions in all areas of the United States. All of the conditions leading up to the declaration of a drought emergency would most likely be known by the involved agencies prior to any definite request for assistance.

d. Drought Contingency Plan.

(1) Monitor precipitation, streamflow, the Palmer Index and other agency declarations to determine if a drought exists.

(2) Notify the Chief of Engineers that a drought condition exists and coordinate information with appropriate state and federal agencies as outlined in ER 1110-2-240.

(3) As long as the water supply contract with the Bowman County Water Resources District is in effect, all requests for water from the reservoir will be referred to them for determination.

(4) In the absence of an effective water supply contract and after a drought and a need for water has been established, a release as agreed on can be made of recent reservoir inflow. The release should be coordinated with the local sponsor and the State of North Dakota.

TABLE NO. 8

BOWMAN-HALEY DAM AND LAKE  
DROUGHT AGENCIES

1. North Dakota

Disaster Emergency Services  
FTS-8-783-4011 - Telephone No: 224-2111  
Commercial - Telephone No: 701-224-2111  
24 Hour Hotline- Telephone No: 701-224-2121  
Governor of North Dakota - Telephone No: 701-224-2200  
(State Drought Coordinator)

2. South Dakota

South Dakota Emergency and Disaster Service  
7000 Telephone No: 773-2231  
Telephone No: 773-2231  
Telephone No: 605-773-3212  
(Drought Assistance Director)

## SECTION IX - FLOOD CONTROL REGULATION

9-01. GENERAL. The flood control storage of Bowman-Haley Reservoir is regulated for reduction and prevention of flood damages along the North Fork of the Grand River between Bowman-Haley and Shadehill Dams.

9-02. METHOD OF REGULATION. In general, the method of flood control regulation of Bowman-Haley Dam and Reservoir may be classified as Method B, defined in EM 1110-2-3600. In this plan the flood capacity is based on control of a project design flood. The operation consists of releasing an established amount of water (ungated service spillway capacity corresponding to pool elevation) and storing the excess inflow.

9-03. PROPOSED PLAN OF REGULATION. Regulation for flood control is automatically controlled by the ungated morning-glory service spillway. Opening of the low flow outlet will not be required during flood periods as this would have little or no flood control effect. The size of the outlet conduit was designed so that discharges from the service spillway would not exceed the capacity of the downstream channel for all floods smaller than reservoir design flood magnitude. The service spillway has sufficient capacity to evacuate the flood control zone within a reasonable period of time in order to provide protection for the embankment against recurring events. Reservoir routing studies show that the service spillway can evacuate 75 percent of the flood storage capacity in slightly less than 10 days and can evacuate 90 percent of the flood storage capacity in approximately 14 days. The emergency spillway is capable of passing the Spillway Design Flood beginning 10 days after occurrence of the maximum pool elevation from the Reservoir Design Flood routing. The embankment freeboard above the maximum pool reached in routing the Spillway Design Flood is 5 feet.

9-04. EMERGENCY FLOOD CONTROL REGULATION. The ungated service spillway and emergency spillway will automatically provide the necessary emergency regulation of the project. No immediate regulation measures are necessary requiring the services of a dam tender. When pool levels of 2265 feet, m.s.l., or above occur, or are expected to occur, it is proposed that personnel from the Garrison Project Office be dispatched to the site to observe the overall performance of the project and perform any specific maintenance duties required by the Omaha District Operation and Maintenance Manual.

9-05. REPORTS OF RESERVOIR OPERATION. During severe flood periods, a summary of hydrologic conditions and reservoir operations will be furnished daily to the Office, Chief of Engineers, as part of the flood report required by paragraph 6-05, EM 1110-2-3600. The Reservoir Control Center, Missouri River Division, will be kept informed by telephone of hydrologic conditions in the Grand River Basin during the progress of flood control operations. In addition, copies of special directives to the Garrison Project Office will be mailed to the Division Office.

## SECTION X - EXAMPLES OF FLOOD CONTROL REGULATION

10-01. GENERAL. Three design floods were developed for the Bowman-Haley project. They are the Reservoir Design Flood, Standard Project Flood and Spillway Design Flood (Probable Maximum Flood). Descriptive data on each flood are presented in paragraph 2-10. Information regarding the routing of these floods through the reservoir is presented in this Section.

10-02. RESERVOIR DESIGN FLOOD. As discussed in paragraph 2-10, the 50-year frequency flood was selected as the Reservoir Design Flood for the Bowman-Haley project. The routing of this flood through the reservoir is shown on Plate 24. The top of the authorized flood zone, elevation 2773.0 feet, m.s.l., was based on the routing of this flood and the 1952 flood of record. This provides an authorized flood storage of 53,847 acre-feet lying between the top of the multi-purpose pool elevation of 2754.8 feet, m.s.l., and 2773.0 feet, m.s.l. Since the emergency spillway crest elevation for the dam is at elevation 2777.0 feet, m.s.l., the total controlled flood storage between the top of the multi-purpose pool (elevation 2754.8 feet, m.s.l.) and the emergency spillway crest is 72,717 acre-feet. There is an additional 20,366 acre-feet of controlled storage between the emergency spillway crest and the crest elevation of the fuse plug (2780.7 feet, m.s.l.).

10-03. STANDARD PROJECT FLOOD. The Standard Project Flood for Bowman-Haley Reservoir was derived using procedures outlined in EM 1110-2-1411. Standard Project Storm precipitation is 7.35 inches for a 24-hour period and was divided into 6-hour periods and arranged in the typical pattern shown in EM 1110-2-1411. Initial loss of 1.0 inch and infiltration loss of 0.15 inches per hour were deducted from the Standard Project Storm rainfall to obtain runoff values. These values were applied to the 6-hour unit hydrograph shown on Plate 21 to obtain the Standard Project Flood hydrograph shown on Plate 25. The Standard Project Flood runoff is 5.16 inches and the peak discharge is 46,400 c.f.s. with a 3.5-day flood volume of 122,700 acre-feet. The reservoir routing for the Standard Project Flood would overflow the spillway fuse plug at a depth of about one foot. If failure of the fuse plug occurred at this level of overtopping, the maximum peak discharge through the emergency spillway would be about 14,500 c.f.s. Any erosion from this failure would be confined to the spillway channel but the effects would be relatively minimal due to the remote location of the spillway. The reservoir routing for a modified flood hydrograph representing 90 percent of the Standard Project Flood results in a maximum water surface

elevation equal to the fuse plug crest elevation of 2780.7 feet, m.s.l. This routing is illustrated on Plate 25. Reference is also made to paragraph 2-10.

10-04. SPILLWAY DESIGN FLOOD. The probable maximum flood was selected as the spillway design flood. The flood was derived by standard procedures utilizing probable maximum rainfall values obtained from "Hydrometeorological Report No. 33". Initial loss of 1 inch and infiltration loss of 0.15 inches per hour were deducted from the probable maximum rainfall to obtain runoff amounts. These runoff values were applied to the unit hydrograph for the Bowman-Haley damsite shown on Plate 21. During the two 6-hour runoff periods, the runoff values were 11.8 and 0.9 inches, respectively. The resulting hydrograph as shown on Plate 26 has a peak discharge of 110,000 c.f.s. and a 4-day volume of 302,000 acre-feet. The probable maximum snowmelt flood was also investigated and found to have about the same volume of runoff as the probable maximum rainstorm flood but since it occurred over a longer time period, the maximum pool level reached in routing the flood through the reservoir was lower than for the rainfall event. As shown on Plate 26, the design flood was routed through the reservoir following a 10-day drawdown from the Reservoir Design Flood routing. When the routed probable maximum flood reached elevation 2780.7 feet, m.s.l., it was assumed that the fuse plug washed out and the remaining inflow was routed through the full emergency spillway. This routing resulted in a maximum storage of 168,567 acre-feet at elevation 2789.03 with an emergency spillway discharge of 62,971 c.f.s. and a service spillway discharge of 3,206 c.f.s. A freeboard height of five feet, as discussed in paragraph 4-03, was added to elevation 2789.0 to establish the top of dam elevation of 2794.0 feet, m.s.l. For comparison purposes a second routing was made assuming that the fuse plug would not fail. This resulted in a maximum pool elevation of 2790.2 feet, m.s.l., which is 3.8 feet lower than the embankment crest. In the event of a Spillway Design Flood, velocities would be erosive throughout the length of the spillway and damage to the earth spillway channel would be expected. However, because of the spillway location, no damage to the dam embankment is expected.

10-05. EFFECT OF THE RESERVOIR ON PAST FLOODS. The largest flood of record on the North Fork of the Grand River at the Haley gage was the April 1952 snowmelt flood. This flood, as shown on Plate 27, has an estimated peak inflow of 12,350 c.f.s. at the damsite. Routing this flood hydrograph through the reservoir results in a peak outflow of 2,547 c.f.s. and a maximum pool elevation of about 2772.8 feet, m.s.l. The second largest flood of record was the April 1950 snowmelt flood. The volume and peak of this flood was less than the

1952 flood, and the reservoir storage volume required for control is also smaller. Additional smaller floods of record from snowmelt and from rainfall have occurred, but the reservoir would easily control these floods. Plots of pool levels, inflows, and outflows for flood events occurring after March 1967 are illustrated on Plates 5A and 5B of this Manual. A lake level frequency curve computed from these data is shown on Plate 28.

EXHIBIT I  
STANDING INSTRUCTIONS TO FIELD PERSONNEL  
FOR  
REGULATION OF  
BOWMAN-HALEY DAM AND RESERVOIR

STANDING INSTRUCTIONS TO FIELD PERSONNEL  
FOR REGULATION  
BOWMAN-HALEY DAM AND RESERVOIR

1. GENERAL. Reservoir Regulation during flood periods is automatic and the service of operating personnel will not be required. Regulation of the low flow outlet valve will not be required during flood periods since its limited capacity will have little or no flood control effect. Release of water through the low flow outlet will be made to meet the requirements for authorized project purposes.

2. RESPONSIBILITY.

a. Omaha District. The Omaha District Reservoir Regulation Section is responsible for coordinating with the Bowman County Water Resources District any release of reservoir water through the low level outlet. Inquiries relating to regulation of the reservoir are to be referred to the Section for an appropriate response. This Section prepares reports of daily reservoir pool levels and reservoir inflow and outflow.

b. Garrison Area. The Garrison Project Manager has the prime responsibility for routine inspection and maintenance of the dam and appurtenances to insure that they are operable. Inspection of the project to determine maintenance is covered in the Operation and Maintenance Manual for the project, dated 1981. The Project Manager will provide for opening or adjusting the low level outlet as ordered by the District Reservoir Regulation Section. In addition, he will be responsible for collecting water quality samples as directed by the Omaha District Water Quality Unit. The Project Manager is also responsible for monitoring the area for significant meteorological event that may affect the project and/or its operation and to notify the Omaha District as required.

c. Bowman County Water Resources District. This District is responsible for agreements contained in the water supply contract, dated 10 November 1981. Under the terms of this contract, they are solely responsible for regulating releases or reservoir withdrawals from the multi-purpose storage zone. The Resources District is responsible for funding, operating and maintaining any approved facilities that they may install for the purpose of diversion and/or withdrawal of water from the reservoir.

3. COORDINATION AND WARNING OF FLOOD CONDITIONS. A local resident living near the project is now under contract with the Omaha District to collect and report reservoir pool levels and other hydrologic data. These reports are furnished weekly to the Reservoir Regulation Section. More frequent reports are made when 0.50 inches of rain occur or

when the pool rises 1.0 foot or more in a 24-hour period. These pool observations are made from the wire-weight gage or, if necessary, from the staff gage on the exterior of the service spillway tower. A telephone telemetering device has been installed in conjunction with the reservoir pool gage and may be utilized by Area and District personnel to obtain pool level readings at any time. A satellite Data Collection Platform (DCP) transmits pertinent reservoir data to the Omaha District Reservoir Regulation Section. This equipment is maintained by Section personnel.

4. REPORTS. The Garrison Project Manager will notify Omaha District Reservoir Regulation Section personnel immediately if he has knowledge of rainfall of 3 inches or more occurring in a 24-hour period over the area or if the pool level rises more than two feet in a 24-hour period. In addition, if the pool level rises so that there is a possibility of emergency spillway operation, he should immediately contact Section personnel. If this is not possible, he should dispatch an observer to the project and warn downstream interests of potential high discharges. The Project Manager will also submit a complete record of all project hydrologic and meteorologic data collected by or reported to his staff to the Section as soon as practicable after each flood event. A "Telephone Directory of Reservoir Regulation Personnel and Field Offices" is updated periodically and provided to the Project Manager. A directory showing current pertinent telephone numbers and addresses is presented in the following table.



EXHIBIT II

WATER SUPPLY CONTRACT

BETWEEN

UNITED STATES OF AMERICA

AND

BOWMAN COUNTY, NORTH DAKOTA WATER MANAGEMENT DISTRICT

CONTRACT BETWEEN THE UNITED STATES OF AMERICA

AND

THE BOWMAN COUNTY WATER MANAGEMENT DISTRICT

FOR

WATER STORAGE SPACE IN BOWMAN-HALEY RESERVOIR

THIS CONTRACT, entered into this 10th day of November 1981 by and between the United States of America, (hereinafter called the "Government"), represented by the Contracting Officer and the Bowman County Water Management District, of Bowman, North Dakota, (hereinafter called the "District"),  
WITNESSETH:

WHEREAS, the Flood Control Act of 1962 (Public Law 87-874, 87th Congress), authorized the construction, operation, and maintenance of the Bowman-Haley Dam and Reservoir on the Grand River in North Dakota (hereinafter called the "Project"); and

WHEREAS, the Board of Commissioners of the District, on 3 December 1962, levied a tax in the amount of not less than two (2) mills on all taxable real and personal property within the County of Bowman, North Dakota, for the promotion, development, and construction of the Bowman-Haley Dam and Reservoir; and

WHEREAS, the Board of Commissioners of the District, by resolution dated 12 March 1964, requested the U.S. Army Corps of Engineers to include 21,900 acre-feet of water supply storage in Bowman-Haley Dam and Reservoir which was estimated to yield 3,000 acre-feet annually at the project site for future municipal and industrial water supply needs; and

WHEREAS, the Board of Commissioners of the District, by resolution dated 12 March 1964, gave assurances of local cooperation to the United States of America that the District would: a. prevent encroachment on the flow-carrying capacity of the North Fork channel below the reservoir to the extent needed to provide for effective reservoir operation; b. obtain the water rights needed for storage and use of water, resolve any conflicts in water rights necessary to assure water yields required for effective operation of the project, use the water in a manner consistent with Federal and State laws, and hold and save the United States free from damages due to the storage and withdrawal of water by the users; c. pay the United States, in accordance with the Water Supply Act of 1958, as amended, the first costs and the annual operation, maintenance, and replacement costs allocated to water supply, presently estimated at \$743,000 and \$2,700, respectively, the final amounts to be determined after actual costs are known; d. hold and save the United States free from damages due to construction of the project; and

WHEREAS, the Government, by letter dated 26 June 1964, formally notified the District that the District's assurances had been approved and that the District is the sole local sponsor responsible for fulfilling the provisions of the District's assurances, including repayment of the water storage costs; and

WHEREAS, by resolution of the North Dakota State Water Commission, adopted 24 September 1963, 2,900 acre-feet of water was withdrawn from the Grand River and its tributaries for municipal use by the District; and

WHEREAS, by letter dated 3 May 1968 the Government advised the District that the Project had been placed in service in March 1967 and that one of the purposes was to provide a source of future water supply to the District; and

WHEREAS, the District is empowered to contract with the Government, pursuant to Section 61-16-11, North Dakota Century Code, as amended; and

WHEREAS, the District has all the necessary powers for accomplishment of the purposes of this contract, including those required by Section 221 of the Flood Control Act of 1970 (42 U.S.C. 1962 d-5b) (as amended); and

WHEREAS, the District desires to contract with the Government for the use of storage included in the Project for municipal and industrial water supply, and for payment of the cost thereof in accordance with the provisions of the Water Supply Act of 1958, as amended (43 U.S.C. 390b-f); and

NOW, THEREFORE, the Government and the District agree as follows:

ARTICLE 1 - Water Storage Space.

(a) Project Construction. The Government, subject to the directions of Federal law and any limitations imposed thereby, has designed and constructed the Project so as to include therein space for the storage of water by the District.

(b) Rights of District.

(1) The District shall have the right to utilize an undivided 100.0 percent of the total active storage space in the Project between elevations 2740.0 feet above mean sea level and 2754.8 feet above mean sea level, which total active storage space is estimated to contain 15,500 acre-feet. The District shall also have the right to utilize an undivided 100.0 percent of the inactive storage space between elevations 2715.0 and 2740.0, which storage space is estimated to contain 4,280 acre-feet of storage capacity, until such time as this storage space becomes unusable because of sediment deposits. With respect to the use of the inactive storage zone for withdrawal of water for municipal and industrial water supply purposes, the right to this storage space for such purposes is predicated upon the District installing intake facilities which will allow pumping from the reservoir rather than discharge through the project outlet works. The Contracting Officer assumes no responsibility for delivery of water from this inactive zone to the District except as specified above.

(2) Upon initiation of the use of the water in the storage space provided under Article 1(b) (1) and the making of payments under Article 5, the District shall have the right to withdraw water from the lake, or to order releases to be made by the Government through the outlet works in the Dam, subject

to the provisions of Article 1(c) and to the extent the aforesaid storage space will provide; and shall have the right to construct all such works, plants, pipelines, and appurtenances as may be necessary and convenient for the purpose of diversion or withdrawals, subject to the approval of the Contracting Officer as to design and location. The grant of an easement for right-of-way, across, in and upon land of the Government at the Project shall be by a separate instrument in a form satisfactory to the Secretary of the Army, without additional cost to the District, under the authority of and in accordance with the provisions of 10 U.S.C. 2669 and such other authorities as may be necessary. Subject to the conditions of such easement, the District shall have the right to use so much of the Project land as may reasonably be required in the exercise of the rights and privileges granted under this contract.

(c) Rights Reserved. The Government reserves the right to lower the water in the Project to elevation 2754.8 feet above mean sea level during such periods of time as are deemed necessary, in its sole discretion, for flood control purposes. The Government further reserves the right to take such measures within Project boundaries as may be necessary in the operation of the Project to preserve life and/or property, including the right not to make downstream releases during such periods of time as are deemed necessary, in its sole discretion, to inspect, maintain, or repair the Project.

(d) Quality or Availability of Water. The District recognizes that this contract provides storage space for raw water only. The Government makes no representations with respect to the quality or availability of water and assumes no responsibility therefor, or for the treatment of water.

(e) Sedimentation Surveys.

(1) Sedimentation surveys will be made by the Contracting Officer during the term of this contract at intervals not to exceed fifteen (15) years unless otherwise agreed to in writing by both parties. When, in the opinion of the Contracting Officer, the findings of such survey indicate any project purpose will be affected by unanticipated sedimentation distribution, there shall be an equitable redistribution of the sediment reserve storage space among the purposes served by the Project including municipal and industrial water supply. The total available remaining storage space in the Project will then be divided among the various Project features in the same ratio as was initially utilized. Adjusted pool elevations will be rounded to the nearest one-half foot. Such findings and the storage space allocated to municipal and industrial water supply shall be defined and described as an exhibit which will be made a part of this contract and the reservoir regulation manual will be modified accordingly.

(2) The Government assumes no responsibility for deviations from estimated rates of sedimentation, or the distribution thereof. Such deviations may cause unequal distribution of sediment reserve storage greater than estimated, and/or encroachment on the total storage at the Project.

ARTICLE 2 - Regulation of and Right to Use of Water. The regulation of the use of water withdrawn or released from the aforesaid storage space shall be the sole responsibility of the District. The District has the full responsibility to acquire in accordance with State laws and regulations, and, if necessary, to

establish or defend, any and all water rights needed for utilization of the storage provided under this contract. The Government shall not be responsible for diversions by others, nor will it become a party to any controversies involving the use of the storage space by the District except as such controversies may affect the operations of the Government.

ARTICLE 3 - Operation and Maintenance. The Government shall operate and maintain the Project and the District shall pay to the Government such share of the costs of such operation and maintenance as provided in Article 5. The District shall be responsible for operation and maintenance of all installations and facilities which it may construct for the diversion or withdrawal of water, and shall bear all costs of construction, operation and maintenance of such installations and facilities.

ARTICLE 4 - Measurement of Withdrawals and Releases. The District agrees to furnish and install, without cost to the Government, suitable meters or measuring devices satisfactory to the Contracting Officer for the measurement of water which is withdrawn from the Project by any means other than through the Project outlet works. The District shall furnish to the Government monthly statements of withdrawals made each day. Prior to the construction of any facilities for withdrawal of water from the Project, the District will obtain the Contracting Officer's approval of the design, location and installation of the facilities including the meters or measuring devices. Such devices shall be available for inspection by Government representatives at all reasonable times. Releases from the water supply storage space through the Project outlet works shall be made in accordance with written schedules furnished by the District and approved by the Contracting Officer and shall be subject to Article 1(c). The measure of all such releases shall be by means of a rating curve of the outlet works, or by such other suitable means as may be agreed upon prior to use of the water supply storage space.

ARTICLE 5 - Payments. In consideration of the right to utilize the aforesaid storage space in the Project for municipal and industrial water supply purposes, the District shall pay the following sums to the Government:

(a) Initial Project Investment Costs.

(1) The District shall repay to the Government, at the times and with interest on the unpaid balance as hereinafter specified, the amounts stated below which, as shown in Exhibit "A" attached to and made a part of this contract, constitute the entire actual amount of the construction costs, including interest during construction, allocated to the water storage right acquired by the District under this contract. The interest rate to be used for purposes of computing interest during construction and interest on the unpaid balance will be determined by the Secretary of the Treasury as of the beginning of the fiscal year in which construction of the Project is initiated, on the basis set forth in the Water Supply Act of 1958, as amended. For the Project, construction of which was initiated in FY 1964, this interest rate is 3.046 percent. The District shall repay:

100 percent of the construction cost of specific water supply facilities, \$ 0

19.1 percent of the total Project joint-use construction costs	\$799,727.67
Interest during construction,	\$ 25,257.68
Total amount of Project investment costs allocated to water supply	<u>\$824,985.35</u>

(2) The repayment sum of \$824,985.35 is subject to an adjustment for contributions by the District in the sums of \$24,703.90 in March of 1978 and \$35,270.25 in March 1979, 1980 and 1981 respectively. These contributions were made by the District to be applied toward the first, second, third and fourth annual payments due on the 31st day of March in each of the years 1978, 1979, 1980 and 1981. The total interest on the repayment sum of \$824,985.35 for the first year amounted to \$25,129.05. The first payment of \$24,703.90 was \$425.15 short of the total required. This sum was added to the principal. Total principal and interest after the first year amounted to \$825,410.50. The second, third, and fourth payments of \$35,270.25 each included an annual amount of \$10,128.25, \$10,436.75, and \$10,754.66 respectively to be applied to principal and \$25,142.00, \$24,833.50, and \$24,515.59 respectively to be applied to interest. After the net amount of the second, third, and fourth payments were deducted, the remaining capital and interest sum to be repaid is \$794,090.84. The annual payments during the remaining 46 year amortization period are \$32,316.05.

(3) Remaining payments will be made in annual installments not to exceed forty-six (46) years. Future annual installments are due on the 31st day of March of each succeeding year. A schedule of payments for the storage provided is attached as Exhibit "B" to this contract. The last annual installment shall be adjusted upward or downward when due to assure repayment of all the investment costs allocated to the storage space within 50 years.

(b) Major Capital Replacement Costs. The District will be required to pay the costs for any major capital replacement of specific water supply facilities. In addition, the District shall pay to the Government 27.0 percent of the costs of joint-use major capital replacement items, when incurred. Payment of costs, including interest during construction, shall be made either incrementally during construction, in lump sum upon completion of construction, or annually with interest on the unpaid balance. If paid annually, the District's share shall be paid within the life of the Project in not to exceed twenty-five (25) consecutive annual installments with the first payment to be made with the first annual payment on the Project investment costs becoming due after the day said major replacement costs are incurred. The first annual payment shall include interest on the investment cost accruing until the payment date. Annual payments thereafter will be due and payable on the anniversary of this repayment date. All annual payments shall include accrued interest on the unpaid balance at the Treasury rate as determined by the Secretary of the Treasury on the basis of the Water Supply Act of 1958, as amended, for use in the Government fiscal year in which the major capital replacement is initiated. The last annual payment shall be adjusted upward or downward when due to assure repayment of all the incurred costs within the repayment period.

(c) Annual Operation and Maintenance (O&M) Expense.

(1) Future Use Storage. The District will be required to pay 100 percent of the annual experienced O&M expense of specific water supply facilities. As the storage for future water supply demands is used, the share of the annual

experienced joint-use O&M expense which the District will be required to pay will be increased commensurate with the percentage of future water supply storage being used, up to a total of 27 percent of such expense.

(2) Payment. Payments for O&M expense for future use storage will be due and payable in advance on the date for payment of project investment costs as set forth in Article 5(a) (3) and shall be based on O&M expense for the Project in the Government fiscal year most recently ended. The amount of each annual payment will be the actual experienced O&M expense (specific plus allocated joint-use) for the preceding fiscal year or an estimate thereof when actual expense information is not available. Should future usage commence on other than the anniversary date of present usage, O&M expense for that portion of a year would be prorated by months in use prior to said anniversary date on the basis of the actual experienced joint-use O&M expense for the preceding Government fiscal year. The first payment, in such a case, shall be due and payable within 30 days from the date of scheduled first use of storage space. Subsequent annual payments shall be made on the date for payment of Project investment costs as set forth in Article 5(a) (3).

(d) Major Rehabilitation and Dam Safety Assurance Programs Costs. For costs associated with major rehabilitation programs, the percentages of specific and joint-use costs which the District will be required to pay will be in accordance with Article 5(c) for future use storage. For costs associated with dam safety assurance programs, the percentages of specific and joint-use costs which the District will be required to pay will be in accordance with Article 5(a) for future use storage.

(e) The District shall have the right at any time it so elects to prepay the indebtedness under this Article, in whole or in part, with accrued interest thereon to the date of such prepayment.

(f) Delinquent Payments. If the District shall fail to make any of the aforesaid payments when due, then the overdue payments shall bear interest compounded annually until paid. The interest rate to be used for overdue payments due under the provisions of Articles 5(a), 5(b), 5(c), and 5(d) above shall be that determined by the Secretary of the Treasury on the basis as set forth in the Water Supply Act of 1958, as amended, for use in the Government fiscal year in which each period of delinquency occurs. The amount charged on payments overdue for a period of less than one year shall be figured on a monthly basis. For example, if the payment is made within the first month after being overdue after a 15 day grace period from the anniversary date of the date of notification, one month's interest shall be charged. Thereafter a month's interest will be charged for any portion of each succeeding month that the payment is delinquent. This provision shall not be construed as giving the District a choice of either making payments when due or paying interest, nor shall it be construed as waiving any other rights of the Government, at law or in equity, which might result from any default by the District.

ARTICLE 6 - Water Conservation. There is a strong Federal interest in the efficient use of Federal projects and this objective may be served by effective management of the use of water from the system into which a Federal project is

integrated. Therefore, prior to the first use of storage space indicated in Article 1(b) (1), the District shall submit to the Contracting Officer for his approval a management plan which incorporates loss reduction measures and demand management practices which ensure that the available supply is used in an economically efficient and environmentally sensitive manner. The plan shall contain a program for implementation of specific time-phased measures. At not-to-exceed five-year intervals, the District and the Contracting Officer shall review and modify the plan as the results of the implementation of measures are made apparent and as the system supplies and user demands change.

ARTICLE 7 - Duration of Contract. This contract shall be effective when approved by the Secretary of the Army and shall continue in full force and effect for the life of the project.

ARTICLE 8 - Permanent Rights to Storage. Upon completion of payments by the District, as provided in Article 5(a) herein, the District shall have a permanent right, under the provisions of the Act of 16 October 1963 (Public Law 88-140, 43 U.S.C. 390e), to the use of the water supply storage space in the Project as provided in Article 1, subject to the following:

(a) The District shall continue payment of annual operation and maintenance costs allocated to water supply.

(b) The District shall bear the costs allocated to water supply of any necessary reconstruction, rehabilitation, or replacement of Project features which may be required to continue satisfactory operation of the Project. Such costs will be established by the Contracting Officer and repayment arrangements shall be in writing in accordance with the terms and conditions set forth in Article 5(b) for Major Replacement Costs, and be made a part of this contract.

(c) Upon completion of payments by the District as provided in Article 5(a), the Contracting Officer shall redetermine the storage space for municipal and industrial water supply in accordance with the provisions of Article 1(e). Such redetermination of reservoir storage capacity may be further adjusted from time to time as the result of sedimentation resurveys to reflect actual rates of sedimentation and the exhibit revised to show the revised storage space allocated to municipal and industrial water supply.

(d) The permanent rights of the District under this contract shall be continued so long as the Government continues to operate the Project. In the event the Government no longer operates the Project, such rights may be continued subject to the execution of a separate contract, or additional supplemental agreement providing for:

(1) continued operation by the District of such part of the facility as is necessary for utilization of the water supply storage space allocated to it;

(2) terms which will protect the public interest; and

(3) effective absolvment of the Government by the District from all liability in connection with such continued operation.

ARTICLE 9 - Release of Claims. The District shall hold and save the Government, including its officers, agents and employees harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the storage in the Project, or withdrawal or release of water from the Project, made or ordered by the District or as a result of the construction, operation, or maintenance of the water supply facilities and appurtenances thereto owned and operated by the District except for damages due to the sole fault or negligence of the United States, its officers, agents and employees, acting within the scope of their employment, or its contractors.

ARTICLE 10 - Assignment. The District shall not transfer or assign this contract or any rights acquired thereunder, nor sub-allot said water supply storage space or any part thereof, nor grant any interest, privilege or license whatsoever in connection with this contract, without the approval of the Secretary of the Army, provided that, unless contrary to the public interest, this restriction shall not be construed to apply to any water that may be obtained from the water supply storage space by the District and furnished to any third party or parties, nor any method of allocation thereof.

ARTICLE 11 - Officials Not to Benefit. No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

ARTICLE 12 - Covenant Against Contingent Fees. The District warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee excepting bona fide employees or bona fide established commercial or selling agencies maintained by the District for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this contract without liability or in its discretion to add to the contract price or consideration, or otherwise recover the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 13 - Environmental Quality. During any construction, operation and maintenance by District of any facilities, specific actions will be taken to control environmental pollution which could result from such activity and to comply with applicable Federal, State, and local laws and regulations concerning environmental pollution. Particular attention should be given to (1) reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases, and of smoke from temporary heaters; (2) reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion; (3) minimization of noise levels; (4) onsite and offsite disposal of waste and spoil; and (5) prevention of landscape defacement and damage.

ARTICLE 14 - Federal and State Laws.

(a) In acting under its rights and obligations hereunder, the District agrees to comply with all applicable Federal and State laws and regulations, including but not limited to the provisions of the Davis-Bacon Act (40 U.S.C. 276a

et seq.); the Contract Work Hours and Safety Standards Act (40 U.S.C. 327-333); Title 29, Code of Federal Regulations, Part 3; and Sections 210 and 305 of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646).

(b) The District furnishes, as part of this contract, an assurance (Exhibit C) that it will comply with Title VI of the Civil Rights Act of 1964 (78 Stat. 241, 42 U.S.C. 2000d, et seq.) and the Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations.

(c) Any discharges of water or pollutants into a navigable stream or tributary thereof resulting from the District's facilities and operations undertaken under this contract shall be performed only in accordance with applicable Federal, State, and local laws and regulations.

#### ARTICLE 15 - Definitions.

(a) Initial Project investment costs - The initial cost of the Project including: land acquisition; construction; interest during construction on the value of land, labor, materials used for planning and construction of the Project.

(b) Interest during construction - An amount of interest which accrues on expenditures for the establishment of Project services during the period between the actual outlay and the time the Project is first made available to the District for water storage.

(c) Specific costs - The costs of Project features normally serving only one particular project purpose.

(d) Joint-use costs - The costs of features used for any two or more Project purposes.

(e) Plant-in service date - The date when the Project is operational for water supply purposes. This date is the date that the Project is physically available to initiate deliberate impoundment.

(f) Annual operation and maintenance (O&M) expense - Annual expenses funded under the O&M, General account. These expenses include the daily project O&M costs as well as those O&M costs which are capitalized.

(g) Major replacement cost - Costs funded under the Construction, General account but not associated with initial Project investment costs.

(h) Fiscal Year - Refers to the Government's fiscal year. This year begins on 1 October and ends on 30 September. The September calendar year corresponds to the fiscal year.

(i) Life of the Project - This is the physical life of the Project.

(j) Major Rehabilitation - Program to facilitate accomplishment of significant, costly infrequent rehabilitation work at the project without unduly distorting the Operation and Maintenance, General budget. Cost sharing for this item will be in accordance with Article 5(c).


(k) Dam Safety Assurance Program - Program to provide for modification of the completed Project to rectify potential safety hazards in light of present day standards, technology, and circumstances. Cost sharing for this item will be in accordance with Article 5(a).

ARTICLE 16 - Approval of Contract. This contract shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

IN WITNESS WHEREOF, the parties have executed this contract as of the day and year first above written.



APPROVED:

THE UNITED STATES OF AMERICA

  
Asst. Secretary of the Army  
(Civil Works)


DATE: 29 July 1947

By:

  
  
V. D. STIPO  
Colonel, Corps of Engineers  
Commander and District Engineer  
Contracting Officer

ATTEST:

BOWMAN COUNTY WATER MANAGEMENT DISTRICT

  
(Secretary-Treasurer)

By:

  
  
(Chairman, Board of Commissioners)

Attachments

- Exhibit "A"
- Exhibit "B"
- Exhibit "C"
- Exhibit "D"

## EXHIBIT "A"

## I - LAKE STORAGE

<u>Feature</u>	<u>Elevation</u> (ft., m.s.l.)	<u>Usable</u> <u>Storage*</u> (ac. ft.)	<u>Percent of</u> <u>Conservation</u> <u>Storage</u>
Flood Control	2,754.8-2,773.0	59,300	
Conservation Storage for Water Supply	2,740.0-2,754.8	15,500 (15,500)	100.0
Total		(15,500)	100.0

\*Storage remaining after 100 years accumulation of sediment.

## II - ALLOCATION OF ACTUAL CONSTRUCTION COST

<u>Feature</u>	<u>Cost (\$)</u>	<u>Percent of Project</u> <u>Joint-Use</u> <u>Construction Cost</u>
Flood Control	\$2,311,254.83	
Specific	(0)	
Joint-Use	(2,311,254.83)	55.2
Recreation	672,945.09	
Specific	(178,872.50)	
Joint-Use	(494,072.59)	11.8
Water Supply	799,727.67	
Specific	(0)	
Joint-Use	(799,727.67)	19.1
Fish and Wildlife	582,000.76	
Specific	(0)	
Joint-Use	(582,000.76)	13.9
Total	\$4,365,928.35	100.0

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**III - INVESTMENT COSTS TO BE REPAYED BY USER FOR WATER SUPPLY STORAGE**

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**Future Use:**

Cost of 15,500 acre-feet of water supply storage (19.1% of \$4,187,055.85)	799,727.67
Interest during construction*	25,257.68
<b>Total investment future use</b>	<b>824,985.35</b>
<b>Total Investment cost under this contract</b>	<b>\$824,985.35</b>

\*Based on actual construction expenditures by quarter and an interest rate of 3.046 percent.

Exhibit B  
AMORTIZATION SCHEDULE  
PRESENT DEMAND

TOTAL COST  
NUMBER OF PAYMENTS  
INTEREST RATE, PERCENT

\$824,985.35  
50  
3.046

ANNUAL PAYMENT NUMBER	AMOUNT OF PAYMENT \$	INTEREST \$	ALLOCATED COST \$	BALANCE ALLOCATED COST \$
1	24703.90	24703.90 <sup>1/</sup>	0.00	825410.50
2	35270.25	25142.00	10128.25	815282.25
3	35270.25	24833.50	10436.75	804845.50
4	35270.25	24515.59	10754.66	794090.84 <sup>2/</sup>
5	32316.05	24188.01	8128.04	785962.80
6	32316.05	23940.43	8375.62	777587.17
7	32316.05	23685.31	8630.74	768956.43
8	32316.05	23422.41	8893.64	760062.79
9	32316.05	23151.51	9164.54	750898.25
10	32316.05	22872.36	9443.69	741454.57
11	32316.05	22584.71	9731.34	731723.22
12	32316.05	22288.29	10027.76	721695.46
13	32316.05	21982.84	10333.21	711362.25
14	32316.05	21668.09	10647.96	700714.30
15	32316.05	21343.76	10972.29	689742.01
16	32316.05	21009.54	11306.51	678435.50
17	32316.05	20665.15	11650.90	666784.59
18	32316.05	20310.26	12005.79	654778.80
19	32316.05	19944.56	12371.49	642407.31
20	32316.05	19567.73	12748.32	629658.99
21	32316.05	19179.41	13136.64	616522.35
22	32316.05	18779.27	13536.78	602985.57
23	32316.05	18366.94	13949.11	589036.47
24	32316.05	17942.05	14374.00	574662.47
25	32316.05	17504.22	14811.83	559850.63
26	32316.05	17053.05	15263.00	544587.64
27	32316.05	16588.14	15727.91	528859.72
28	32316.05	16109.07	16206.98	512652.74
29	32316.05	15615.40	16700.65	495952.09
30	32316.05	15106.70	17209.35	478742.74
31	32316.05	14582.50	17733.55	461009.20
32	32316.05	14042.34	18273.71	442735.49
33	32316.05	13485.72	18830.33	423905.16
34	32316.05	12912.15	19403.90	404501.26
35	32316.05	12321.11	19994.94	384506.32

<sup>1/</sup> Payment was \$425.15 short of total interest for first year. This amount was added to balance of allocated cost.

<sup>2/</sup> Represents remaining balance of allocated cost after applying contributions as of 31 March 1981 from District towards payments 1, 2, 3, and 4.

<u>ANNUAL PAYMENT NUMBER</u>	<u>AMOUNT OF PAYMENT</u> \$	<u>INTEREST</u> \$	<u>ALLOCATED COST</u> \$	<u>BALANCE ALLOCATED COST</u> \$
36	32316.05	11712.06	20603.99	363902.33
37	32316.05	11084.47	21231.58	342670.75
38	32316.05	10437.75	21878.30	320792.45
39	32316.05	9771.34	22544.71	298247.74
40	32316.05	9084.63	23231.42	275016.31
41	32316.05	8377.00	23939.05	251077.26
42	32316.05	7647.81	24668.24	226409.03
43	32316.05	6896.42	25419.63	200989.39
44	32316.05	6122.14	26193.91	174795.48
45	32316.05	5324.27	26991.78	147803.70
46	32316.05	4502.10	27813.95	119989.75
47	32316.05	3654.89	28661.16	91328.59
48	32316.05	2781.87	29534.18	61794.41
49	32316.05	1882.26	30433.79	31360.62
50	32315.86	955.24	31360.62	.00

**EXHIBIT C - ASSURANCE OF COMPLIANCE WITH THE DEPARTMENT OF DEFENSE  
DIRECTIVE UNDER TITLE VI OF THE CIVIL RIGHTS ACT OF 1964**

**BOWMAN COUNTY WATER MANAGEMENT DISTRICT**  
**(hereinafter called "Applicant-Recipient")**

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HEREBY AGREES THAT it will comply with title VI of the Civil Rights Act of 1964 (Public Law 88-352) and all requirements imposed by or pursuant to the Directive of the Department of Defense (32 Code of Federal Regulations Part 300, issued as Department of Defense Directive 5500.11, 28 December 1964) issued pursuant to that title, to the end that, in accordance with title VI of that Act and the Directive, no person in the United States shall, on the grounds of race, color, or national origin be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant-Recipient receives Federal financial assistance from Department of the Army and HEREBY GIVES ASSURANCE THAT it will immediately take any measures necessary to effectuate this agreement.

If any real property or structure thereon is provided or improved with the aid of Federal financial assistance extended to the Applicant-Recipient by this Department of the Army, assurance shall obligate the Applicant-Recipient, or in the case of any transfer of such property, any transferee, for the period during which the real property or structure is used for a purpose for which the Federal financial assistance is extended or for another purpose involving the provisions of similar services or benefits. If any personal property is so provided, this assurance shall obligate the Applicant-Recipient for the period during which it retains ownership or possession of the property. In all other cases, this assurance shall obligate the Applicant-Recipient for the period during which the Federal financial assistance is extended to it by Department of the Army.

THIS ASSURANCE is given in consideration of and for the purpose of obtaining any and all Federal grants, loans, contracts, property, discounts, or other Federal financial assistance extended after the date hereof to the Applicant-Recipient by the Department, including installment payments after such date on account of arrangements for Federal financial assistance which were approved before such date. The Applicant-Recipient recognizes and agrees that such Federal financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall have the right to seek judicial enforcement of this assurance. This assurance is binding

on the Applicant-Recipient, its successors, transferees, and assignees, and the person or persons whose signatures appear below are authorized to sign this assurance on behalf of the Appellant-Recipient.

DATED:

BOWMAN COUNTY WATER MANAGEMENT DISTRICT  
(Applicant-Recipient)

BY:



  
(Chairman, Board of Commissioners)

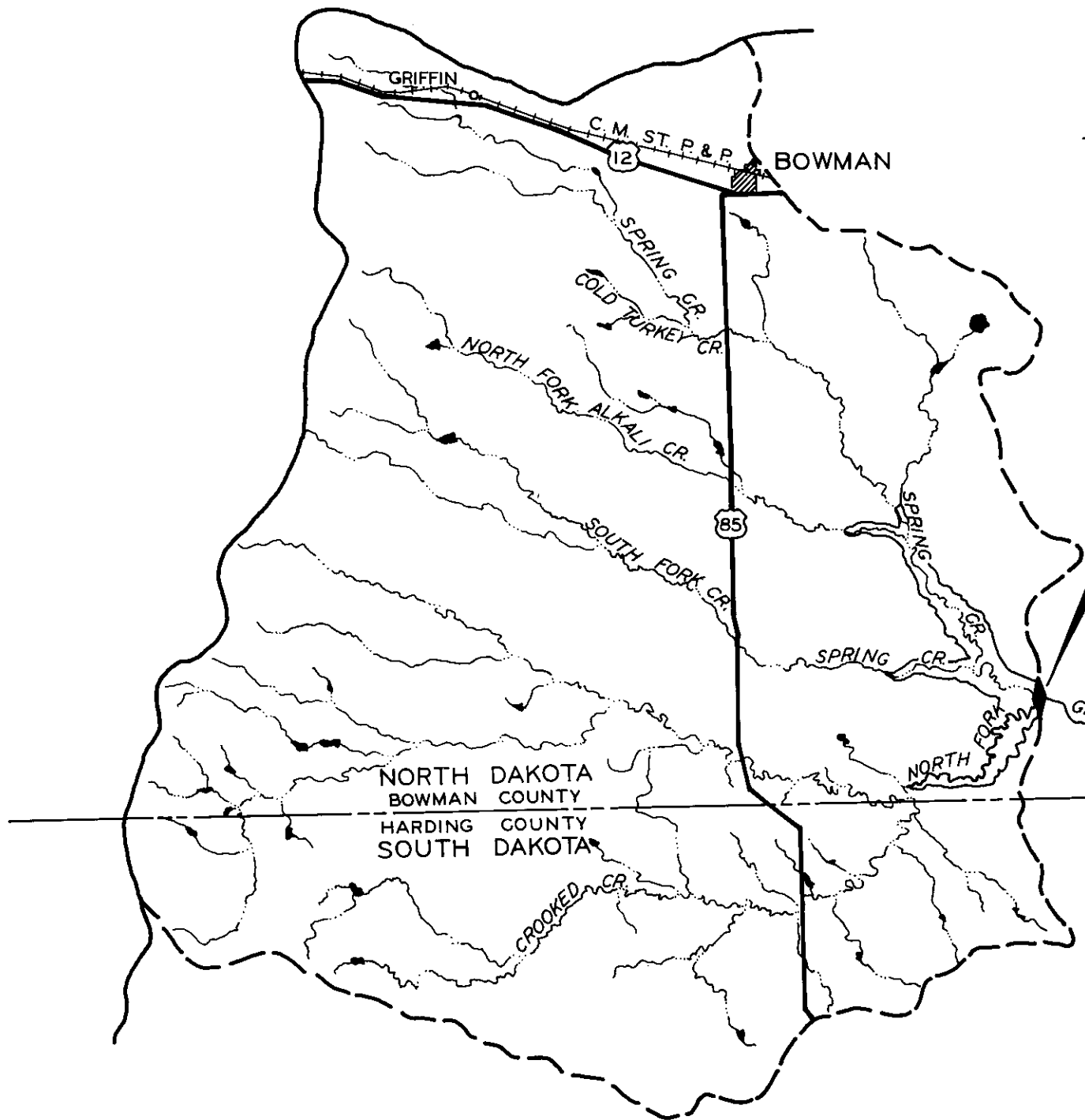
EXHIBIT D

CERTIFICATION

I John A. Amundson, Attorney for the Bowman County Water Management District, hereby certify that the foregoing agreement executed by the Chairman of the Bowman County Water Management District is within the scope of his authority to act upon behalf of the said District, and that in my capacity as Attorney for the User, I have considered the legal effect of Section 221 of the 1970 Flood Control Act (Public Law 91-611) and find that the User is legally and financially capable of entering into the contractual obligations contained in the foregoing agreement and that, upon acceptance, it will be legally enforceable.

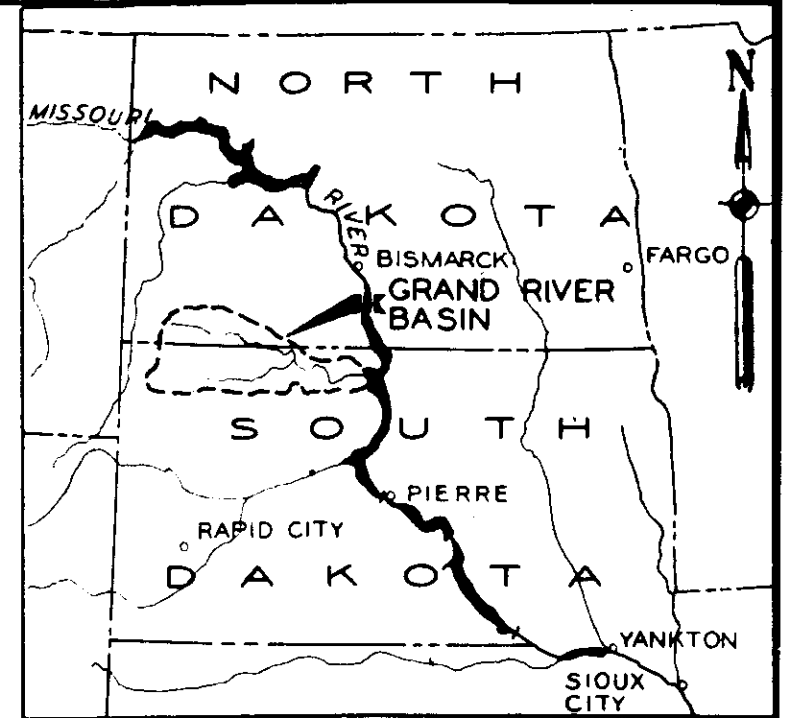
Given under my hand, this 10th day of November, 1981

  
 Attorney for the Bowman County Water Management District

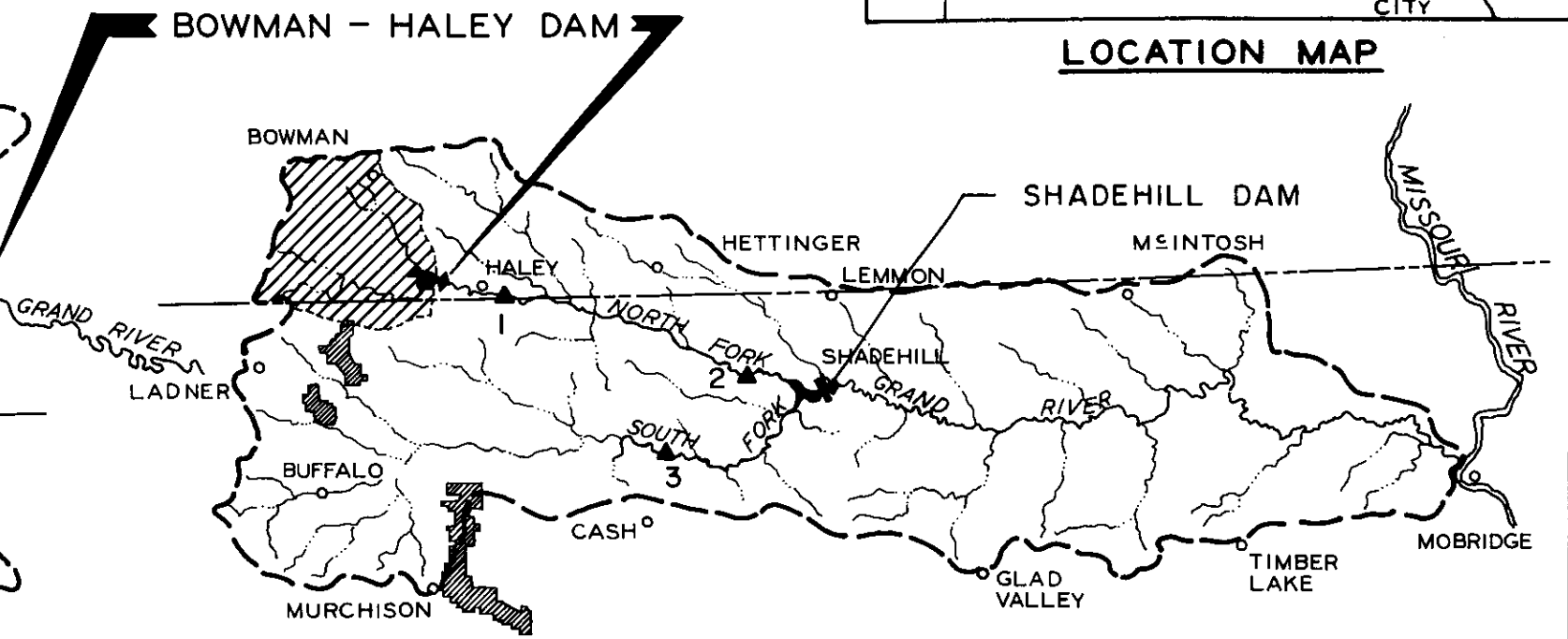


**BOWMAN - HALEY RESERVOIR  
DRAINAGE BASIN**

SCALE IN MILES  
0 1 3 6



**LOCATION MAP**



**GRAND RIVER BASIN MAP**

SCALE IN MILES  
0 6 12 24

▲ STREAM GAGING STATIONS

1. N. FORK OF GRAND R. AT HALEY, N. DAK.
2. N. FORK OF GRAND R. AT WHITE BUTTE, S. DAK.
3. S. FORK OF GRAND R. AT CASH, S. DAK.

GAGING STATIONS ARE ALSO LOCATED  
AT BOWMAN - HALEY AND  
SHADEHILL DAMS

NORTH FORK OF GRAND RIVER, NORTH DAKOTA  
BOWMAN - HALEY DAM SITE  
DRAINAGE BASIN  
& LOCATION MAP

U. S. ARMY ENGINEER DISTRICT, OMAHA  
CORPS OF ENGINEERS OMAHA, NEBRASKA

DISCHARGE RATING TABLES

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GAGE HEIGHT IN FEET	DISCHARGE IN C.F.S.		
	NORTH FORK GRAND RIVER AT HALEY, ND	NORTH FORK GRAND RIVER AT WHITE BUTTE, SD	SOUTH FORK GRAND RIVER AT CASH, SD
1			5
2		9	63
3		116	211
4	0	318	475
5	31	620	880
6	90	1,080	1,430
7	200	1,690	2,150
8	359	2,430	3,050
9	587	3,300	4,000
10	922	4,400	5,200
11	1,392	5,800	6,700
12	2,202	7,300	8,600
13	3,507	9,000	
14	5,317	11,200	
15	7,747	13,400	

FLOOD STAGES

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North Fork Grand River at Haley, ND	- 12 feet
North Fork Grand River at White Butte, SD	- 11 feet
South Fork Grand River at Cash, SD	- 12 feet

DISCHARGE RATINGS FOR  
NORTH AND SOUTH FORKS  
OF GRAND RIVER

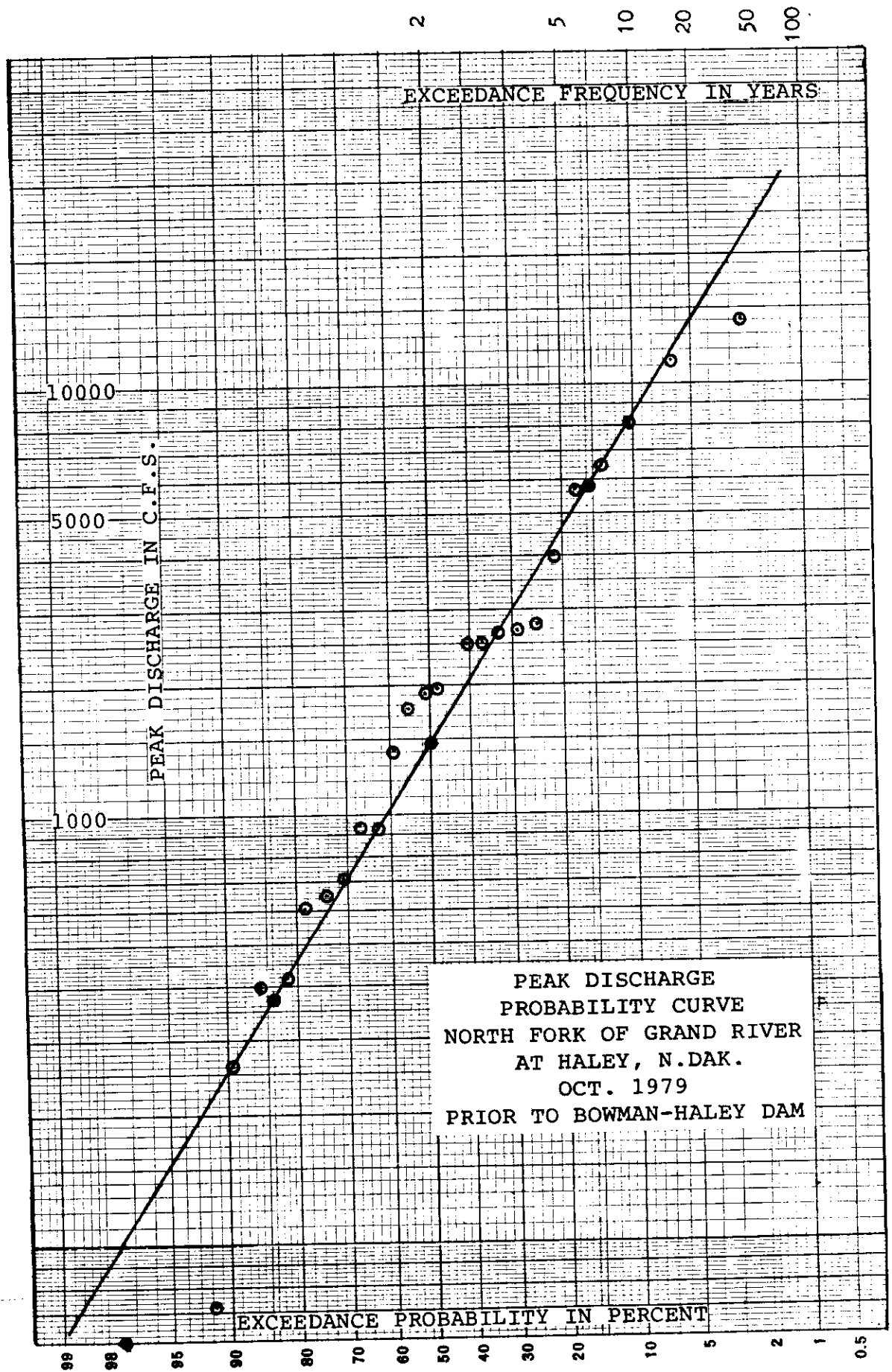
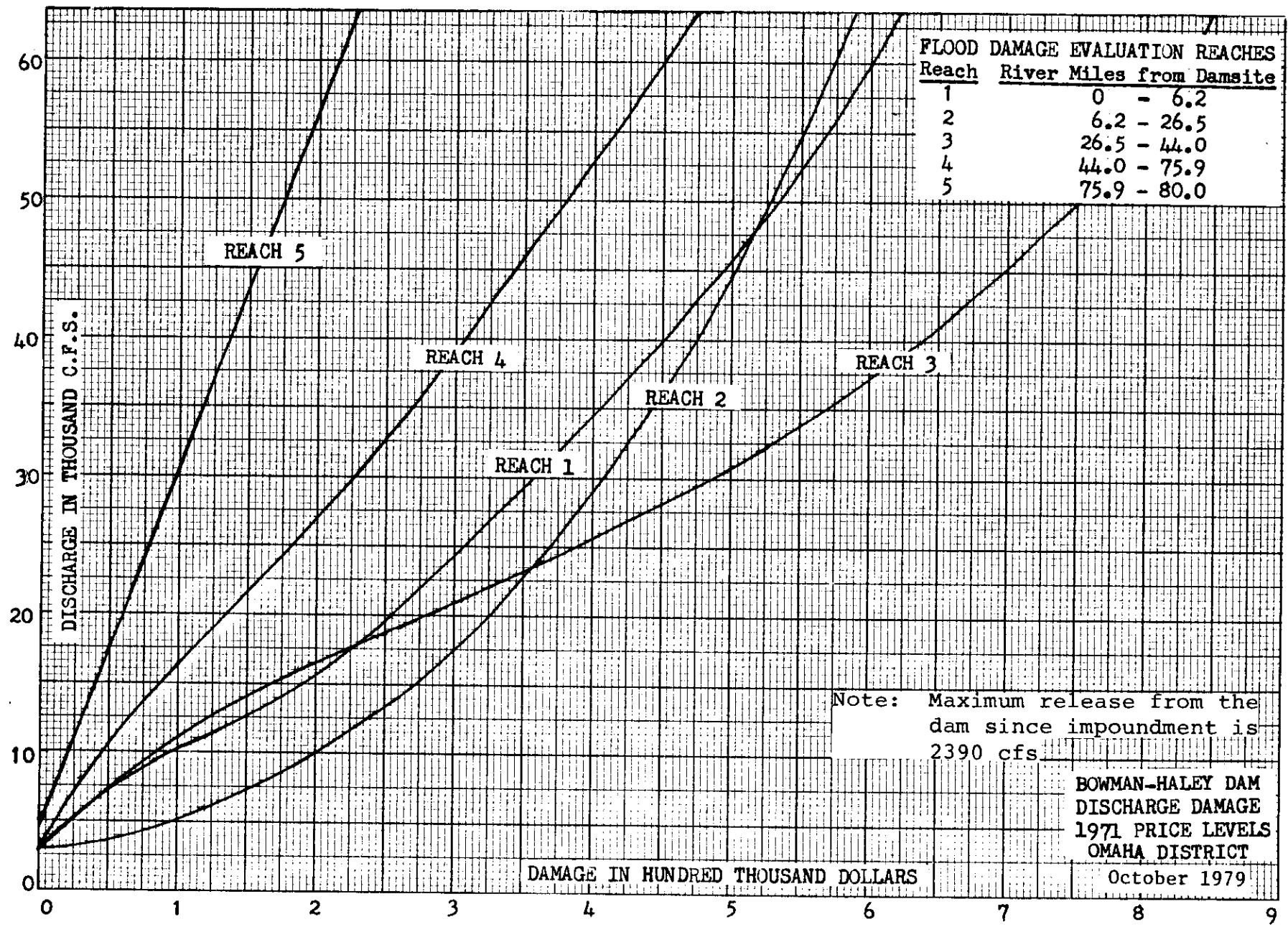
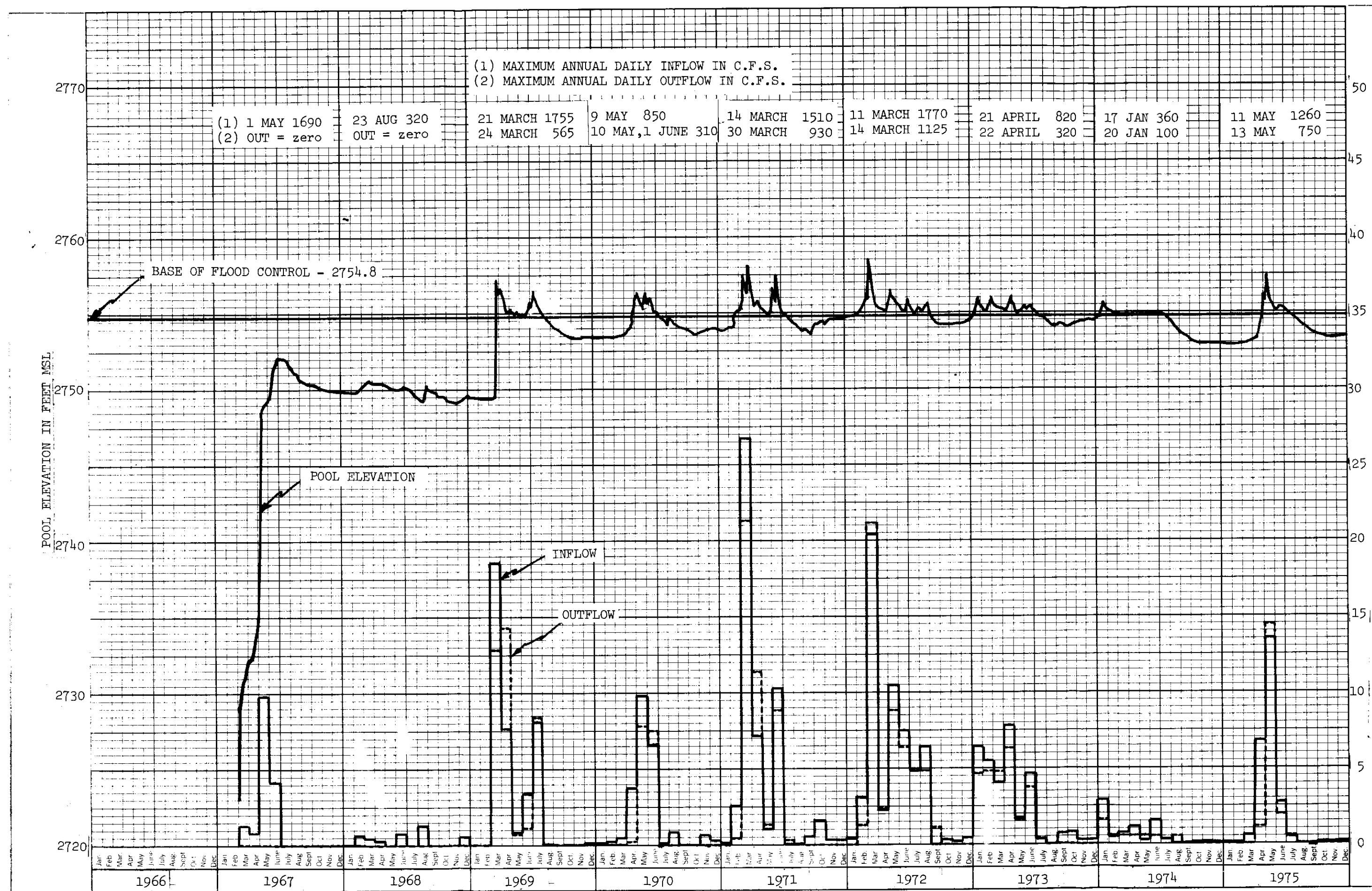


PLATE 4





(1) MAXIMUM ANNUAL DAILY INFLOW IN C.F.S.  
 (2) MAXIMUM ANNUAL DAILY OUTFLOW IN C.F.S.

(1) 1 MAY 1690	23 AUG 320	21 MARCH 1755	9 MAY 850	14 MARCH 1510	11 MARCH 1770	21 APRIL 820	17 JAN 360	11 MAY 1260
(2) OUT = zero	OUT = zero	24 MARCH 565	10 MAY, 1 JUNE 310	30 MARCH 930	14 MARCH 1125	22 APRIL 320	20 JAN 100	13 MAY 750

BASE OF FLOOD CONTROL - 2754.8

POOL ELEVATION

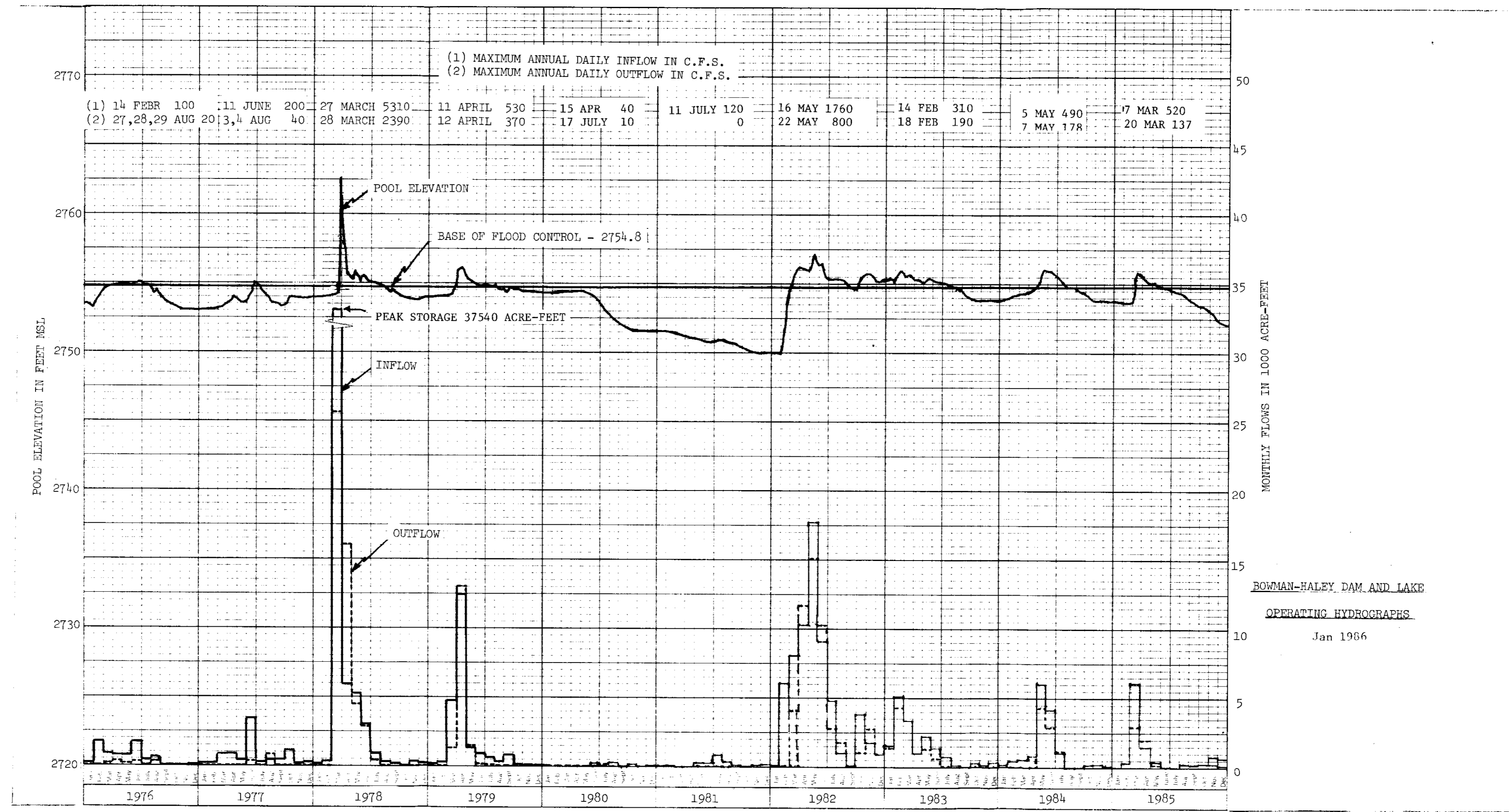
INFLOW

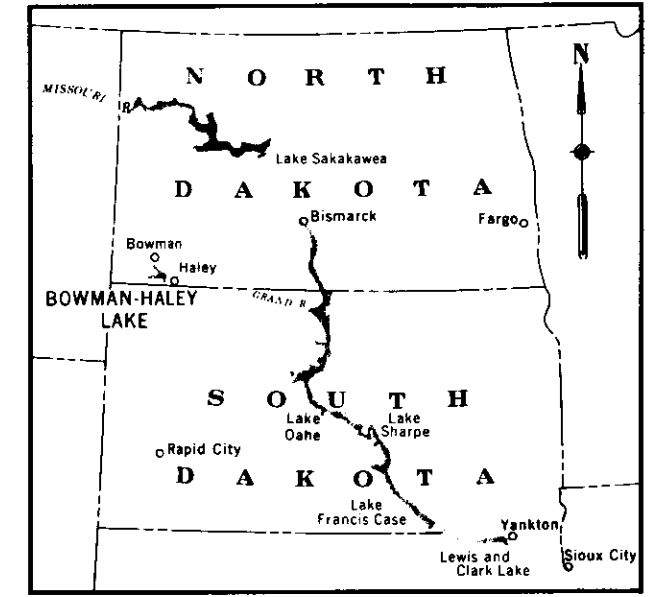
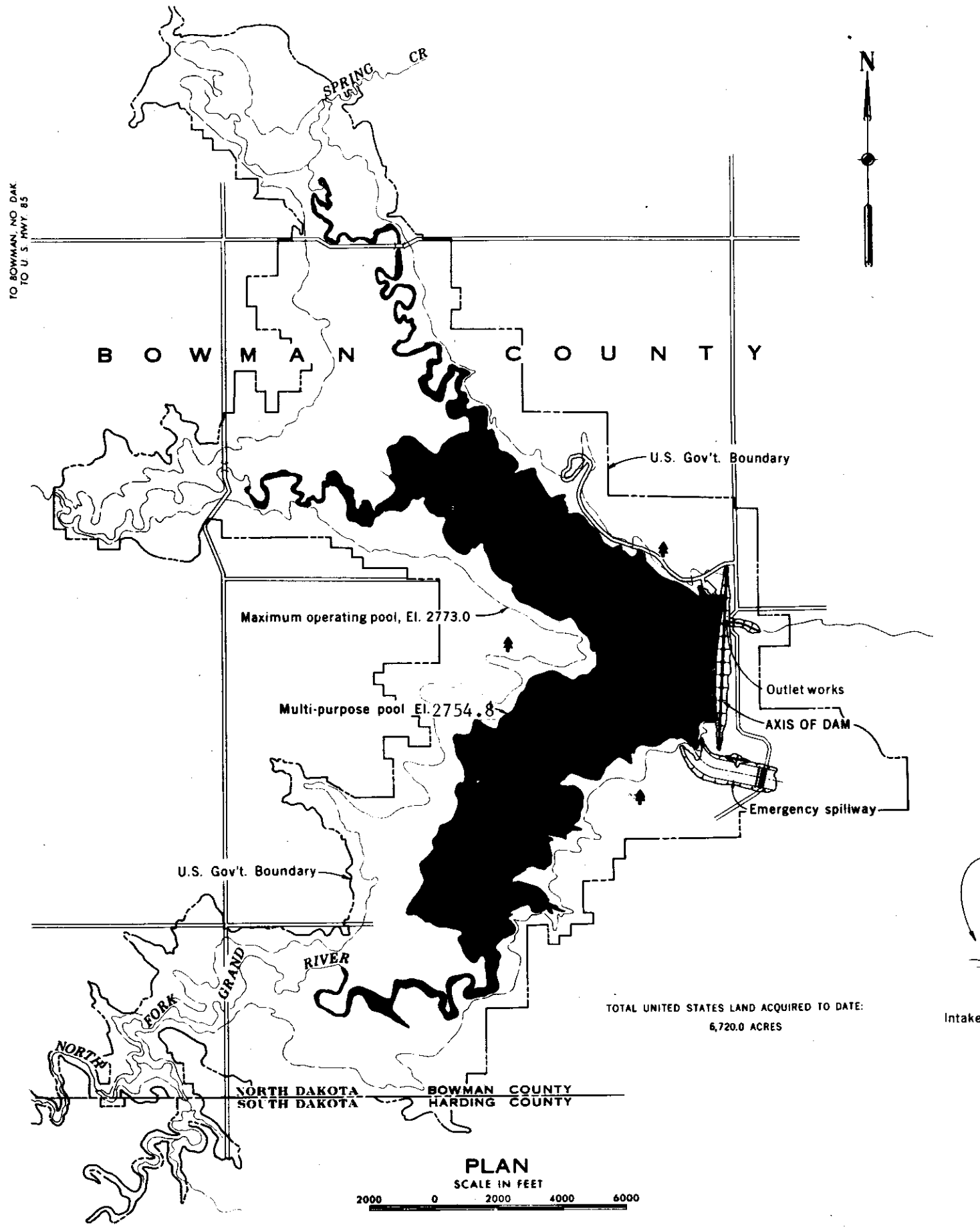
OUTFLOW

MONTHLY FLOWS IN 1000 ACRE-FEET

BOWMAN-HALEY DAM AND LAKE  
OPERATING HYDROGRAPHS

NOTE: DAM CLOSURE -- 22 AUGUST 1966  
 TOP OF DAM - 2794.0 MSL  
 SPILLWAY CREST - 2777.0 MSL  
 Jan 1986





GENERAL PLAN  
 FLOOD CONTROL PROJECT  
**BOWMAN-HALEY LAKE**  
**NORTH DAKOTA**  
 U. S. ARMY ENGINEER DISTRICT, OMAHA  
 CORPS OF ENGINEERS  
 OMAHA, NEBRASKA  
 MARCH 1980

NORTH FORK OF GRAND RIVER, NORTH DAKOTA  
BOWMAN - HALEY DAM & RESERVOIR  
DAM AND APPURTENANT WORKS

SPILLWAY PROFILE  
SECTIONS AND DETAILS  
March 1980

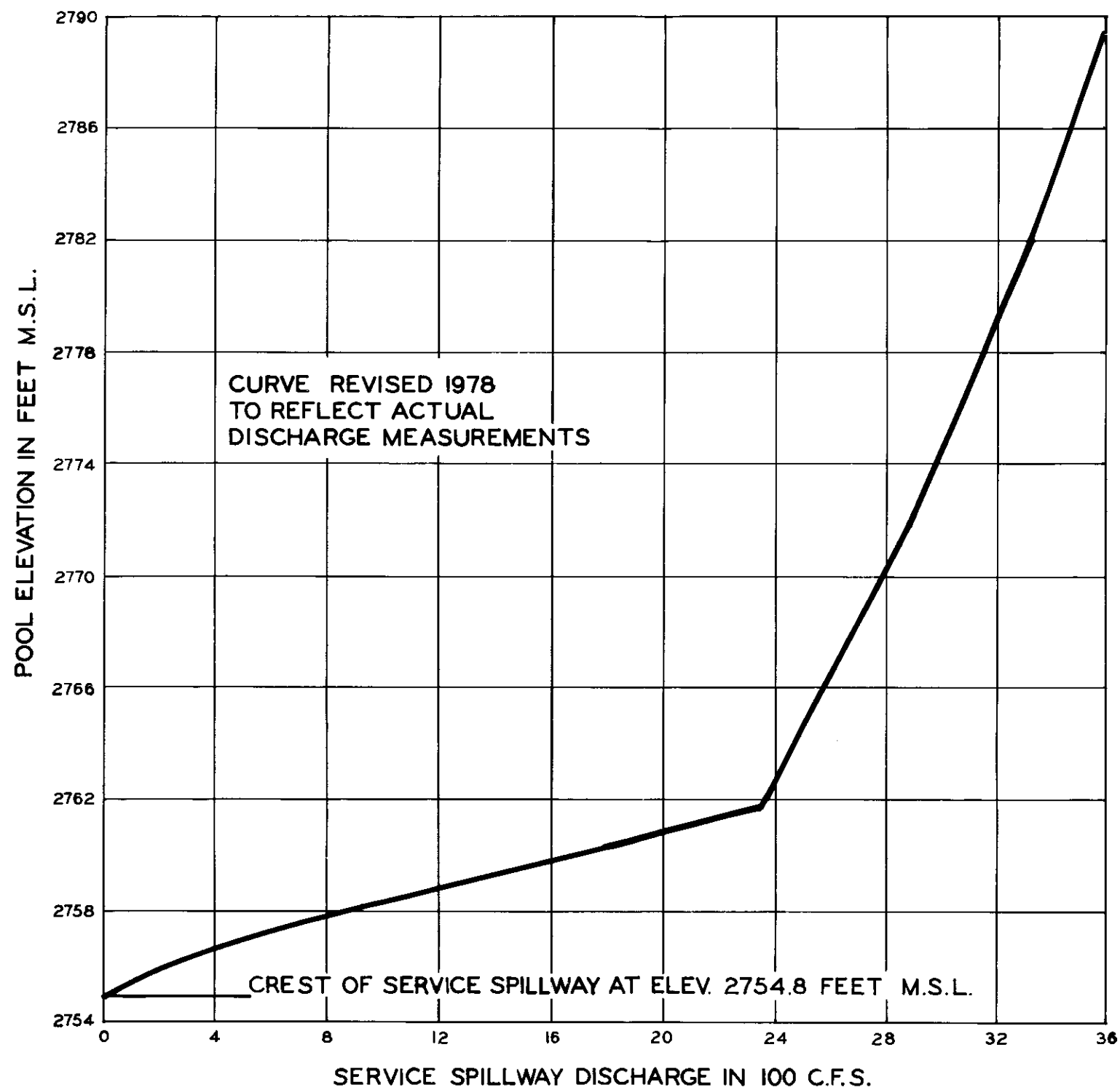




NORTH FORK OF GRAND RIVER, NORTH DAKOTA  
BOWMAN-HALEY DAM & RESERVOIR

STILLING BASIN  
PLAN AND SECTIONS

U.S. ARMY ENGINEER DISTRICT OMAHA  
CORPS OF ENGINEERS, OMAHA, NEBRASKA  
MARCH 1960



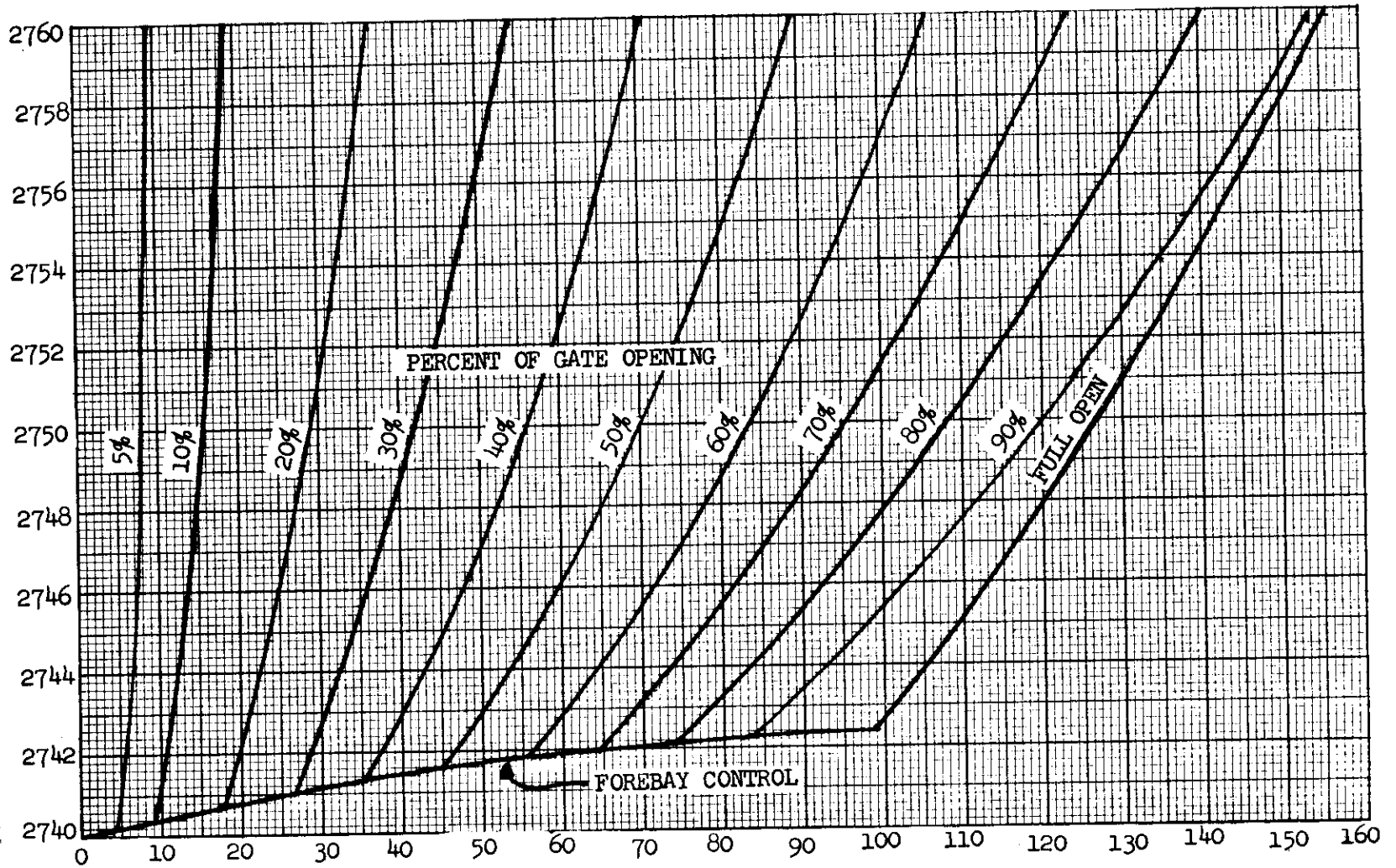
NORTH FORK OF GRAND RIVER, NORTH DAKOTA  
 BOWMAN-HALEY DAM & RESERVOIR  
 SERVICE SPILLWAY  
 RATING CURVE  
 U.S. ARMY ENGINEER DISTRICT OMAHA  
 CORPS OF ENGINEERS, OMAHA, NEBRASKA  
 MARCH 1980

# BOWMAN-HALEY DAM AND RESERVOIR

## 30-INCH LOW-FLOW DISCHARGE TABLE

POOL ELEVATION		POOL DEPTH IN FEET																																																																																																																																																																																																																																																																																																																
5'-1/2"	0	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0																																																																																																																																																																																																												
1	6	2.7	3.0	3.2	3.4	3.6	3.7	3.8	4.0	4.1	4.2	4.3	4.5	4.6	4.7	4.8	4.9	5.0	5.2	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0																																																																																																																																																																																																																																																
2	7	3.2	3.6	3.8	3.9	4.0	4.2	4.4	4.5	4.7	4.8	4.9	5.0	5.2	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0																																																																																																																																																																																																																																																					
3	8	3.6	4.1	4.3	4.5	4.6	4.8	5.0	5.1	5.3	5.4	5.6	5.8	6.0	6.2	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0																																																																																																																																																																																																																																																														
4	9	4.0	4.6	4.9	5.0	5.2	5.4	5.6	5.8	6.0	6.1	6.4	6.6	6.8	7.0	7.1	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0																																																																																																																																																																																																																																																																						
5	10	4.6	5.2	5.5	5.6	5.9	6.1	6.3	6.5	6.7	6.8	7.1	7.2	7.4	7.6	7.8	7.9	8.1	8.3	8.4	8.5	8.6	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0																																																																																																																																																																																																																																																																															
6	11	5.4	5.8	6.0	6.2	6.5	6.7	7.0	7.1	7.3	7.5	7.8	8.0	8.2	8.4	8.5	8.7	8.9	9.1	9.2	9.4	9.4	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15.0	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	18.0	18.1	18.2	18.3	18.4	18.5	18.6	18.7	18.8	18.9	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9	20.0																																																																																																																																																																																				
7	12	5.9	6.3	6.6	6.8	7.1	7.3	7.6	7.8	8.0	8.1	8.5	8.8	9.0	9.2	9.4	9.6	9.8	10.1	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.2	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4	18.6	18.8	19.0	19.2	19.4	19.6	19.8	20.0																																																																																																																																																																																																																																														
8	13	6.4	6.8	7.2	7.4	7.7	8.0	8.3	8.6	8.9	9.1	9.5	9.9	10.1	10.4	10.6	10.8	11.1	11.3	11.5	11.7	11.9	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.2	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4	18.6	18.8	19.0	19.2	19.4	19.6	19.8	20.0																																																																																																																																																																																																																																																				
9	14	6.9	7.3	7.7	8.0	8.3	8.6	8.9	9.1	9.5	9.9	10.1	10.4	10.6	10.8	11.1	11.3	11.5	11.7	11.9	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.2	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4	18.6	18.8	19.0	19.2	19.4	19.6	19.8	20.0																																																																																																																																																																																																																																																						
10	15	7.4	8.0	8.3	8.5	8.9	9.1	9.5	9.9	10.1	10.4	10.6	10.8	11.1	11.3	11.5	11.7	11.9	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.2	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4	18.6	18.8	19.0	19.2	19.4	19.6	19.8	20.0																																																																																																																																																																																																																																																								
11	16	8.0	8.5	8.9	9.1	9.5	9.8	10.1	10.4	10.7	11.0	11.3	11.6	11.9	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.2	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4	18.6	18.8	19.0	19.2	19.4	19.6	19.8	20.0																																																																																																																																																																																																																																																												
12	17	8.5	9.0	9.4	9.7	10.0	10.3	10.6	10.9	11.2	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.6	13.9	14.2	14.5	14.8	15.1	15.4	15.7	16.0	16.3	16.6	16.9	17.2	17.5	17.8	18.1	18.4	18.7	19.0	19.3	19.6	19.9	20.2	20.5	20.8	21.1	21.4	21.7	22.0	22.3	22.6	22.9	23.2	23.5	23.8	24.1	24.4	24.7	25.0	25.3	25.6	25.9	26.2	26.5	26.8	27.1	27.4	27.7	28.0	28.3	28.6	28.9	29.2	29.5	29.8	30.1	30.4	30.7	31.0	31.3	31.6	31.9	32.2	32.5	32.8	33.1	33.4	33.7	34.0	34.3	34.6	34.9	35.2	35.5	35.8	36.1	36.4	36.7	37.0	37.3	37.6	37.9	38.2	38.5	38.8	39.1	39.4	39.7	40.0	40.3	40.6	40.9	41.2	41.5	41.8	42.1	42.4	42.7	43.0	43.3	43.6	43.9	44.2	44.5	44.8	45.1	45.4	45.7	46.0	46.3	46.6	46.9	47.2	47.5	47.8	48.1	48.4	48.7	49.0	49.3	49.6	49.9	50.2	50.5	50.8	51.1	51.4	51.7	52.0	52.3	52.6	52.9	53.2	53.5	53.8	54.1	54.4	54.7	55.0	55.3	55.6	55.9	56.2	56.5	56.8	57.1	57.4	57.7	58.0	58.3	58.6	58.9	59.2	59.5	59.8	60.1	60.4	60.7	61.0	61.3	61.6	61.9	62.2	62.5	62.8	63.1	63.4	63.7	64.0	64.3	64.6	64.9	65.2	65.5	65.8	66.1	66.4	66.7	67.0	67.3	67.6	67.9	68.2	68.5	68.8	69.1	69.4	69.7	70.0	70.3	70.6	70.9	71.2	71.5	71.8	72.1	72.4	72.7	73.0	73.3	73.6	73.9	74.2	74.5	74.8	75.1	75.4	75.7	76.0	76.3	76.6	76.9	77.2	77.5	77.8	78.1	78.4	78.7	79.0	79.3	79.6	79.9	80.2	80.5	80.8	81.1	81.4	81.7	82.0	82.3	82.6	82.9	83.2	83.5	83.8	84.1	84.4	84.7	85.0	85.3	85.6	85.9	86.2	86.5	86.8	87.1	87.4	87.7	88.0	88.3	88.6	88.9	89.2	89.5	89.8	90.1	90.4	90.7	91.0	91.3	91.6	91.9	92.2	92.5	92.8	93.1	93.4	93.7	94.0	94.3	94.6	94.9	95.2	95.5	95.8	96.1	96.4	96.7	97.0	97.3	97.6	97.9	98.2	98.5	98.8	99.1	99.4	99.7	100.0
13	18	9.0	9.4	9.8	10.1	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1	14.4	14.7	15.0	15.3	15.6	15.9	16.2	16.5	16.8	17.1	17.4	17.7	18.0	18.3	18.6	18.9	19.2	19.5	19.8	20.1	20.4	20.7	21.0	21.3	21.6	21.9	22.2	22.5	22.8	23.1	23.4	23.7	24.0	24.3	24.6	24.9	25.2	25.5	25.8	26.1	26.4	26.7	27.0	27.3	27.6	27.9	28.2	28.5	28.8	29.1	29.4	29.7	30.0	30.3	30.6	30.9	31.2	31.5	31.8	32.1	32.4	32.7	33.0	33.3	33.6	33.9	34.2	34.5	34.8	35.1	35.4	35.7	36.0	36.3	36.6	36.9	37.2	37.5	37.8	38.1	38.4	38.7	39.0	39.3	39.6	39.9	40.2	40.5	40.8	41.1	41.4	41.7	42.0	42.3	42.6	42.9	43.2	43.5	43.8	44.1	44.4	44.7	45.0	45.3	45.6	45.9	46.2	46.5	46.8	47.1	47.4	47.7	48.0	48.3	48.6	48.9	49.2	49.5	49.8	50.1	50.4	50.7	51.0	51.3	51.6	51.9	52.2	52.5	52.8	53.1	53.4	53.7	54.0	54.3	54.6	54.9	55.2	55.5	55.8	56.1	56.4	56.7	57.0	57.3	57.6	57.9	58.2	58.5	58.8	59.1	59.4	59.7	60.0	60.3	60.6	60.9	61.2	61.5	61.8	62.1	62.4	62.7	63.0	63.3	63.6	63.9	64.2	64.5	64.8	65.1	65.4	65.7	66.0	66.3	66.6	66.9	67.2	67.5	67.8	68.1	68.4	68.7	69.0	69.3	69.6	69.9	70.2	70.5	70.8	71.1	71.4	71.7	72.0	72.3	72.6	72.9	73.2	73.5	73.8	74.1	74.4	74.7	75.0	75.3	75.6	75.9	76.2	76.5	76.8	77.1	77.4	77.7	78.0	78.3	78.6	78.9	79.2	79.5	79.8	80.1	80.4	80.7	81.0	81.3	81.6	81.9	82.2	82.5	82.8	83.1	83.4	83.7	84.0	84.3	84.6	84.9	85.2	85.5	85.8	86.1	86.4	86.7	87.0	87.3	87.6	87.9	88.2	88.5	88.8	89.1	89.4	89.7	90.0	90.3	90.6	90.9	91.2	91.5	91.8	92.1	92.4	92.7	93.0	93.3	93.6	93.9	9																					

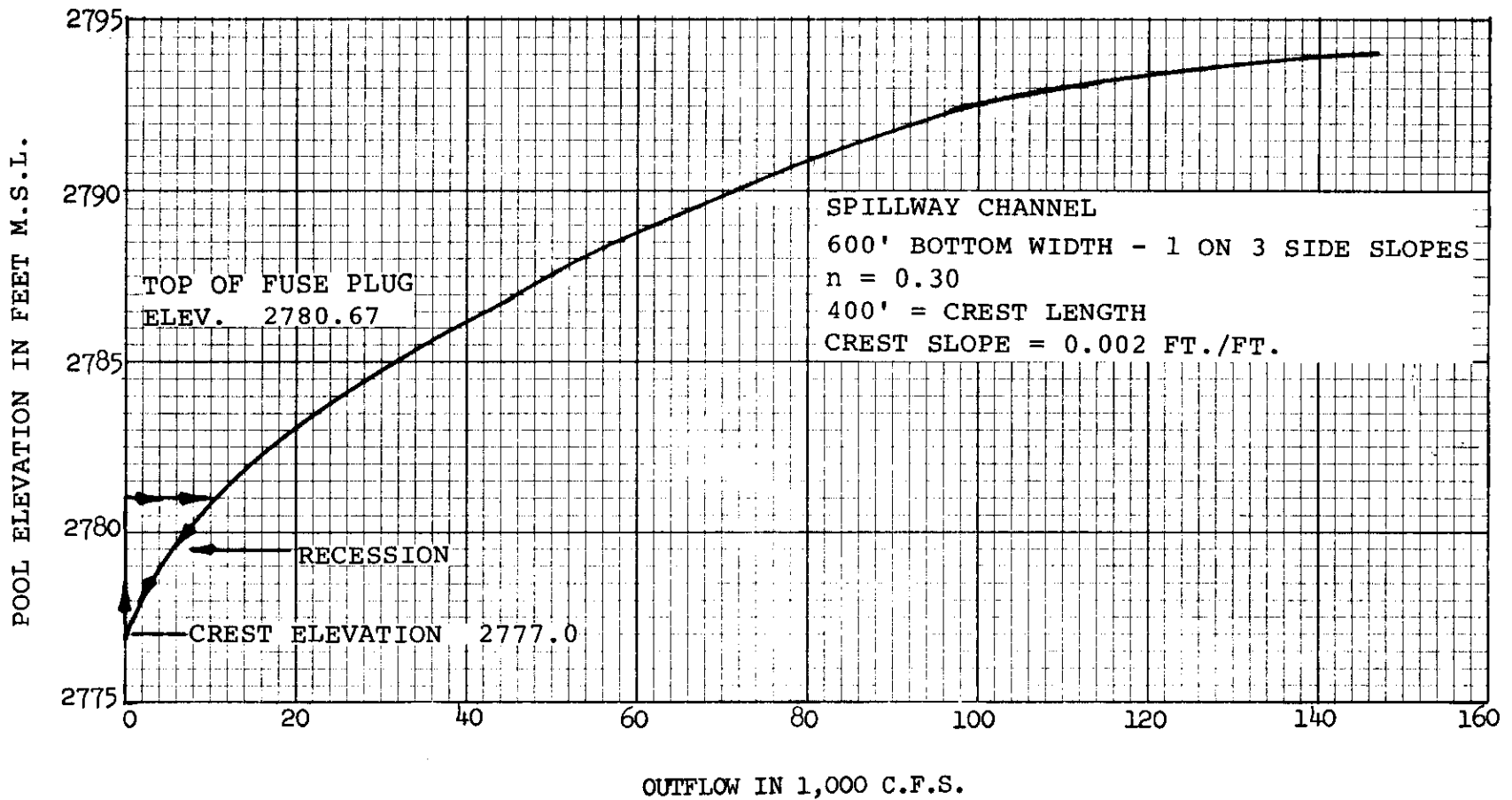
POOL ELEVATION IN FEET M.S.L.



DISCHARGE IN C.F.S.

BOWMAN-HALEY DAM AND RESERVOIR

30" LOW FLOW OUTLET  
RATING CURVE  
JUNE 1974



BOWMAN-HALEY DAM AND RESERVOIR

EMERGENCY SPILLWAY  
RATING CURVE  
JUNE 1974

BOWMAN-HALEY RESERVOIR

AREA IN ACRES

(1984 SURVEY)

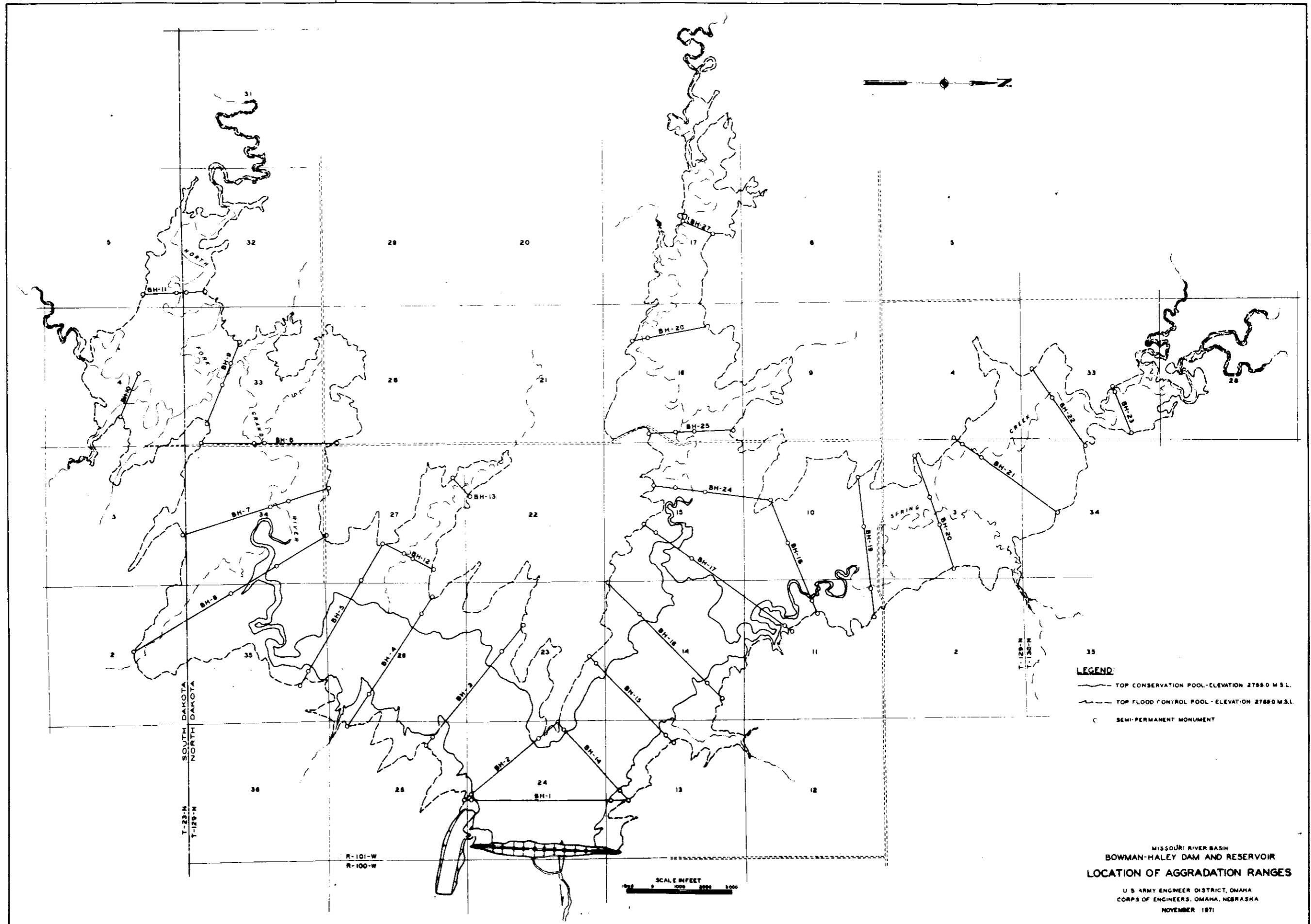
ELEV	0	1	2	3	4	5	6	7	8	9
2720	0	0	6	10	13	16	18	23	41	73
2730	107	133	160	199	248	300	347	393	446	504
2740	565	624	681	738	795	844	887	940	1015	1111
2750	1211	1297	1386	1495	1623	1759	1886	2009	2139	2276
2760	2415	2551	2687	2823	2959	3092	3221	3356	3504	3664
2770	3821	3967	4120	4299	4504	4722	4930	5131	5332	5533
2780	5723	5901	6097	6327	6590	6871	7141	7400	7658	7916
2790	8174									

BOWMAN-HALEY RESERVOIR

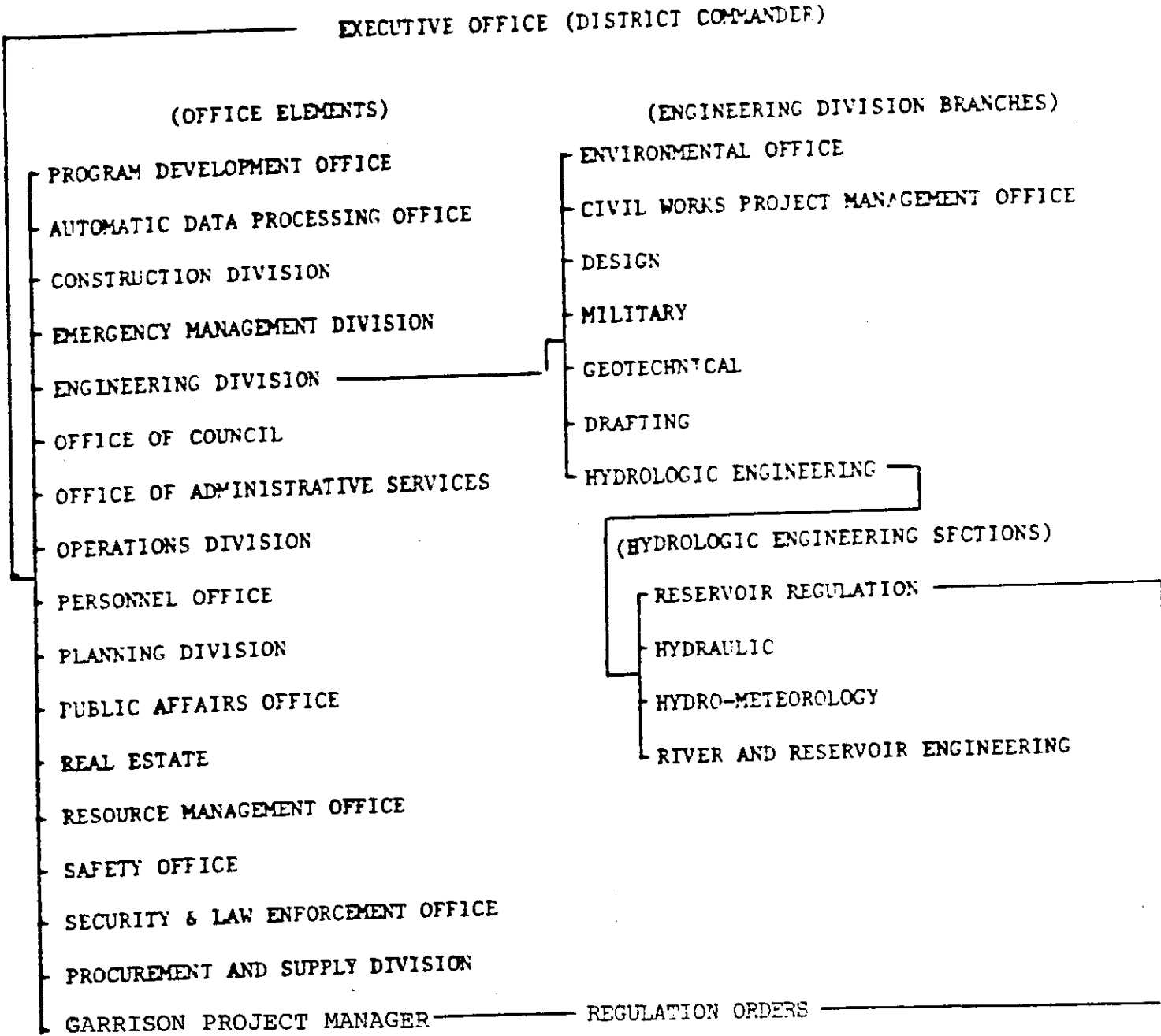
CAPACITY IN ACRE FEET

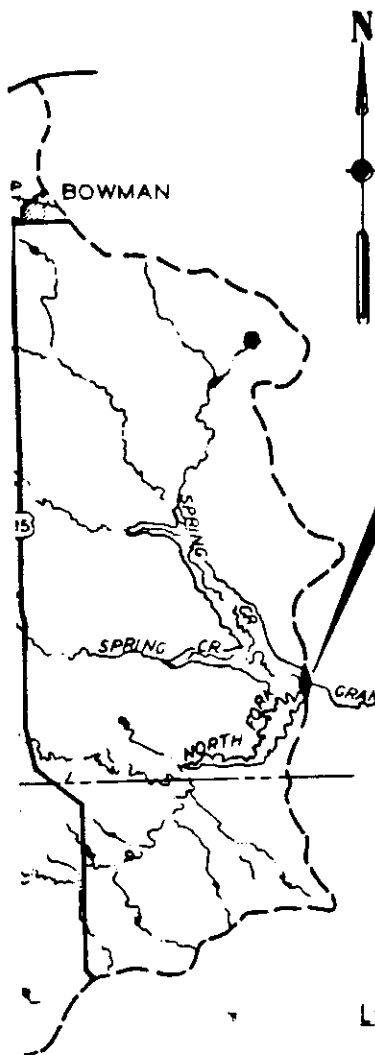
(1984 SURVEY)

ELEV	0	1	2	3	4	5	6	7	8	9
2720	0	0	4	13	25	39	58	75	104	154
2730	250	372	516	693	914	1189	1515	1883	2301	2775
2740	3309	3905	4558	5268	6035	6858	7724	8632	9604	10662
2750	11826	13084	14421	15857	17411	19103	20929	22875	24948	27154
2760	29500	31984	34603	37358	40249	43277	46434	49720	53147	56728
2770	60475	64371	68409	72612	77008	81621	86452	91482	96714	102146
2780	107780	113592	119583	125787	132237	138968	145980	153251	160780	168567
2790	176612									



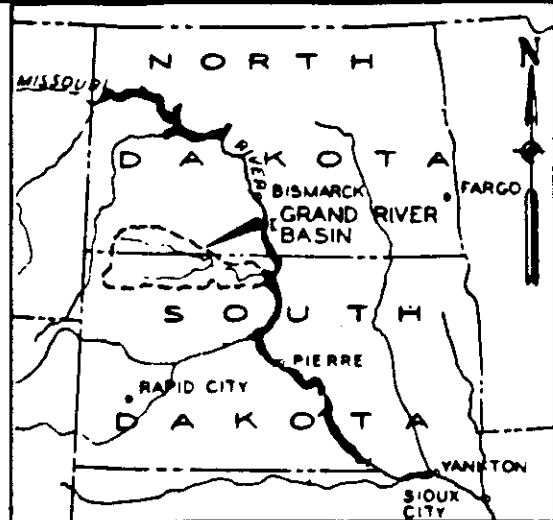
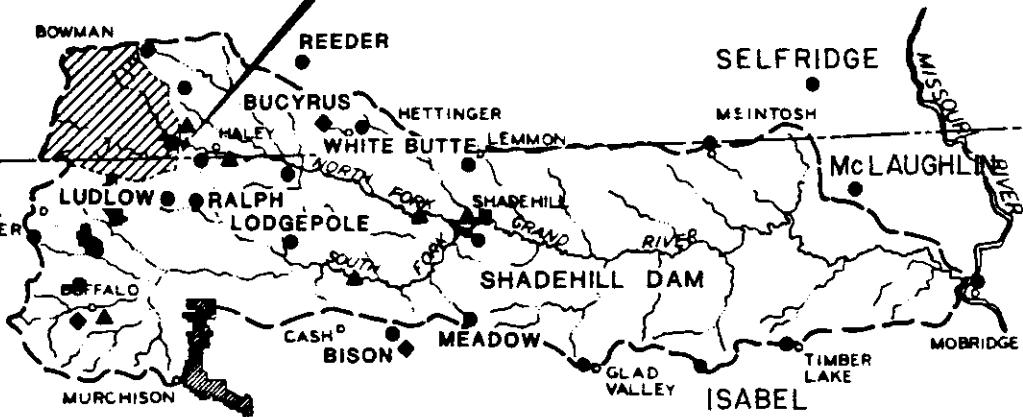
BOWMAN-HALEY DAM AND LAKE  
 ORGANIZATION CHART  
 OMAHA DISTRICT





● AMIDON

**BOWMAN - HALEY DAM**



**LOCATION MAP**

**GRAND RIVER BASIN MAP**

SCALE IN MILES  
0 6 12 24

**LEGEND:**

- RESERVOIR POOL GAGE & DCP
- ▲ STREAM GAGE
- PRECIPITATION STATION
- ◆ PLAIN SNOW SURVEY STATION

NORTH FORK OF GRAND RIVER, NORTH DAKOTA  
BOWMAN - HALEY DAM SITE  
**LOCATION OF STREAM GAGES  
AND PRECIPITATION STATION**

U.S. ARMY ENGINEER DISTRICT, OMAHA  
CORPS OF ENGINEERS OMAHA, NEBRASKA  
OCT 1967

**MONTHLY RESERVOIR OPERATION  
PROVISIONAL RECORD**

RCS: MRDED-R-2

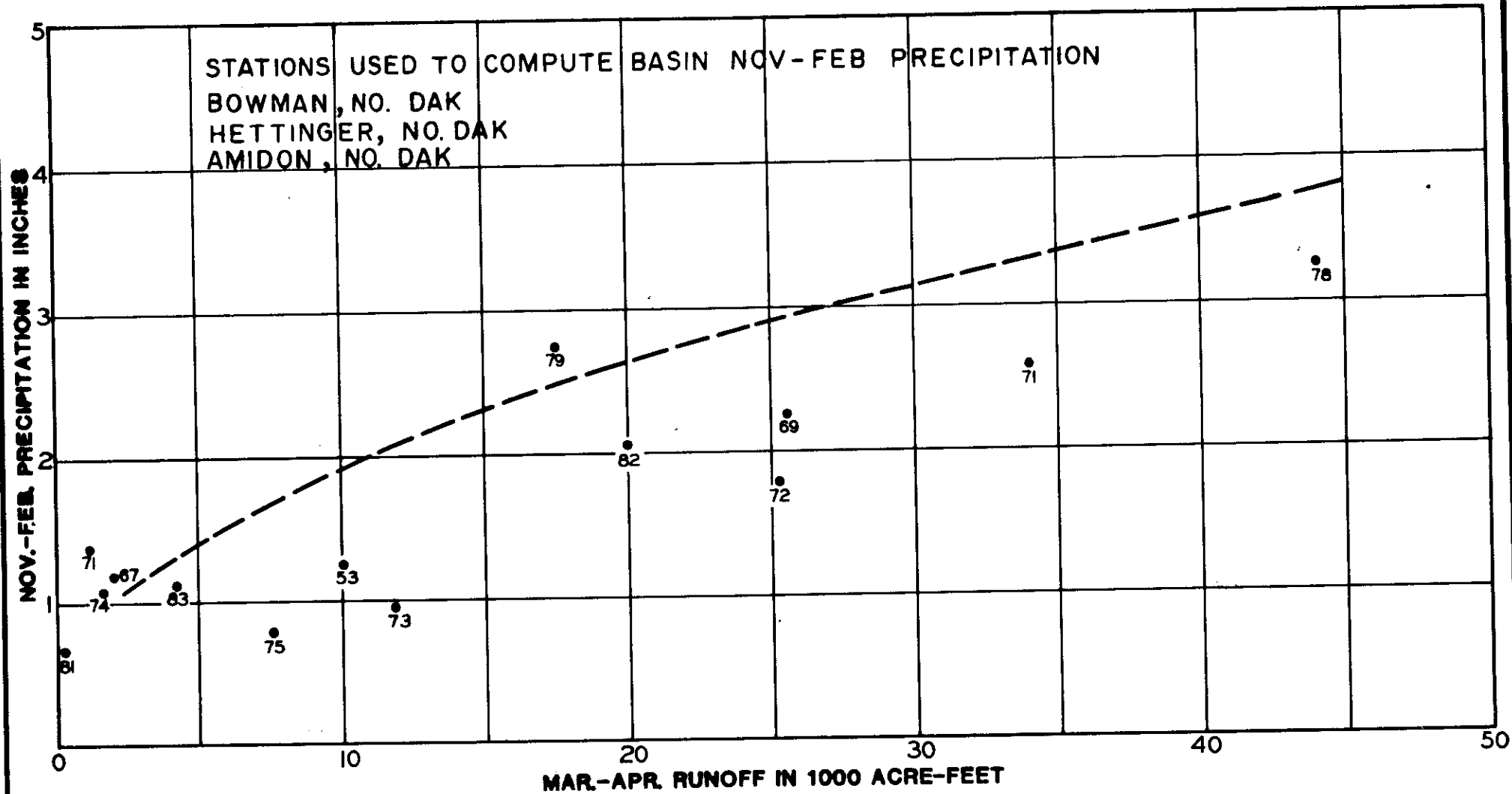
RESERVOIR BOWMAN-HALEY, NORTH DAKOTA	RIVER NORTH FORK OF GRAND RIVER	DISTRICT OMAHA
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MISSOURI RIVER DIVISION CORPS OF ENGINEERS, U. S. ARMY

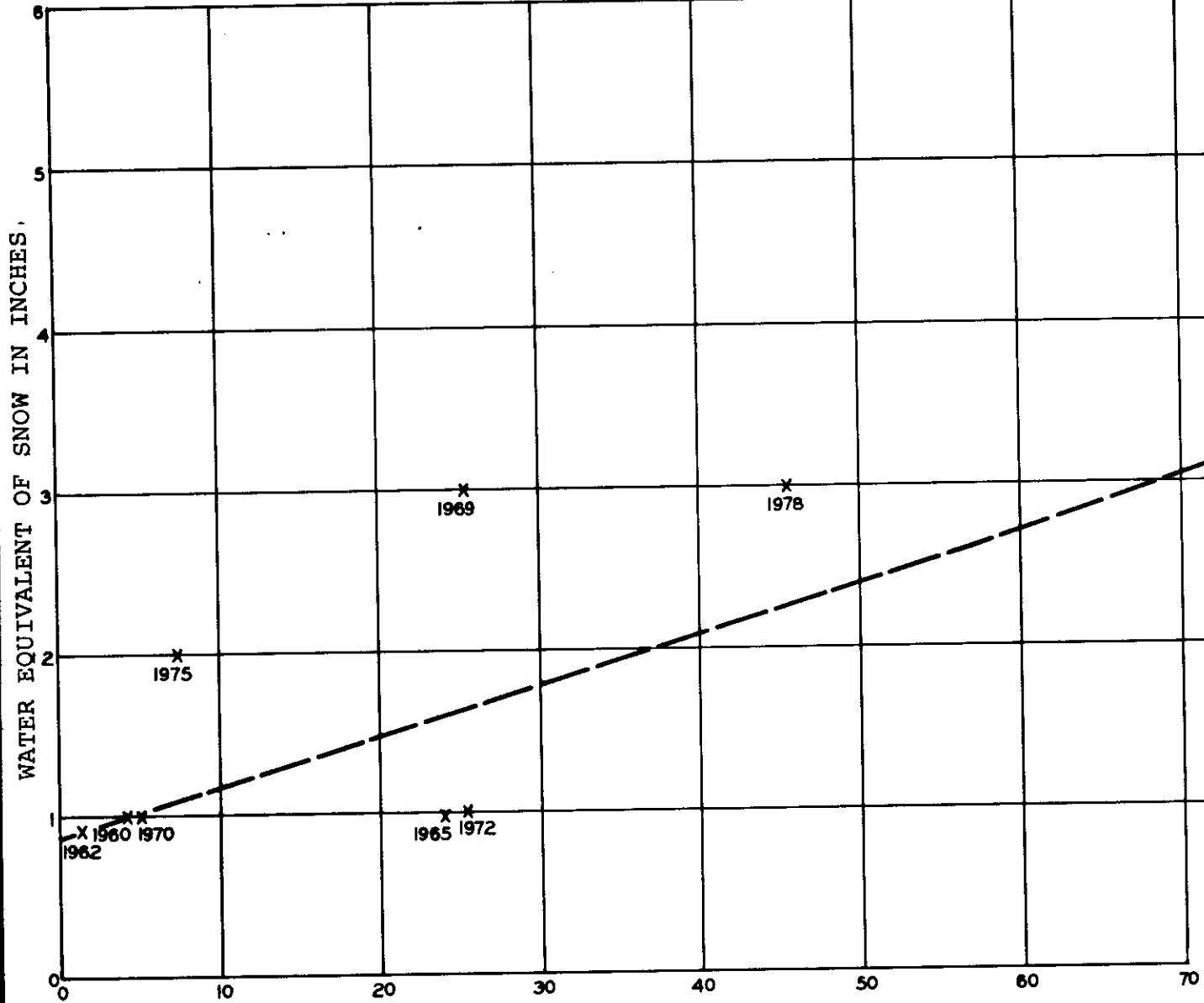
1	2	3	4		5
MONTH - YEAR MARCH 1985	RESERVOIR ELEVATION FEET ABOVE M. S. L. 12:00 MN ***	ESTIMATED EVAPORATION C. F. S. .	MEAN DISCHARGE 12 MN TO 12 MN IN C. F. S.		
			OUTFLOW	ESTIMATED INFLOW	
1	2753.71**		0**	15	
2	2753.76		0	40	
3	2753.79		0	25	
4	2753.80		0	5**	
5	2753.79		0	5	
6	2753.81		0	15	
7	2753.79		0	15	
8	2753.79		0	5	
9	2753.79		0	5	
10	2753.78		0	5	
11	2753.79		0	5	
12	2753.80		0	5	
13	2753.82		0	15	
14	2753.91		0	70	
15	2754.15		0	205	
16	2754.65		0	435	
17	2755.22		13	520*	
18	2755.59		65	410	
19	2755.75		116	265	
20	2755.80*		136	185	
21	2755.78		137*	120	
22	2755.75		136	105	
23	2755.72		129	105	
24	2755.67		118	75	
25	2755.63		110	75	
26	2755.60		103	75	
27	2755.56		95	60	
28	2755.53		91	65	
29	2755.49		82	50	
30	2755.45		73	40	
31	2755.44		70	65	
TOTAL (dsf)		95	1,475	3,085	
TOTAL (ac-ft)		185	2,925	6,120	
MEAN (cfs)		3	48	100	
END OF MONTH GROSS STORAGE 20,930 A.F.	MONTHLY CHANGE IN STORAGE + 3,010 A.F.	MAX. STORAGE 21,590 A.F.	MIN. STORAGE 17,950 A.F.		
DATE: 31 March		DATE: 20 March	DATE: 1 March		

REMARKS: 1. TOTAL REPORTED PRECIPITATION FOR MARCH - 11.5 INCHES OF SNOW.

\* Maximum    \*\* Minimum    \*\*\* Reading affected by wind

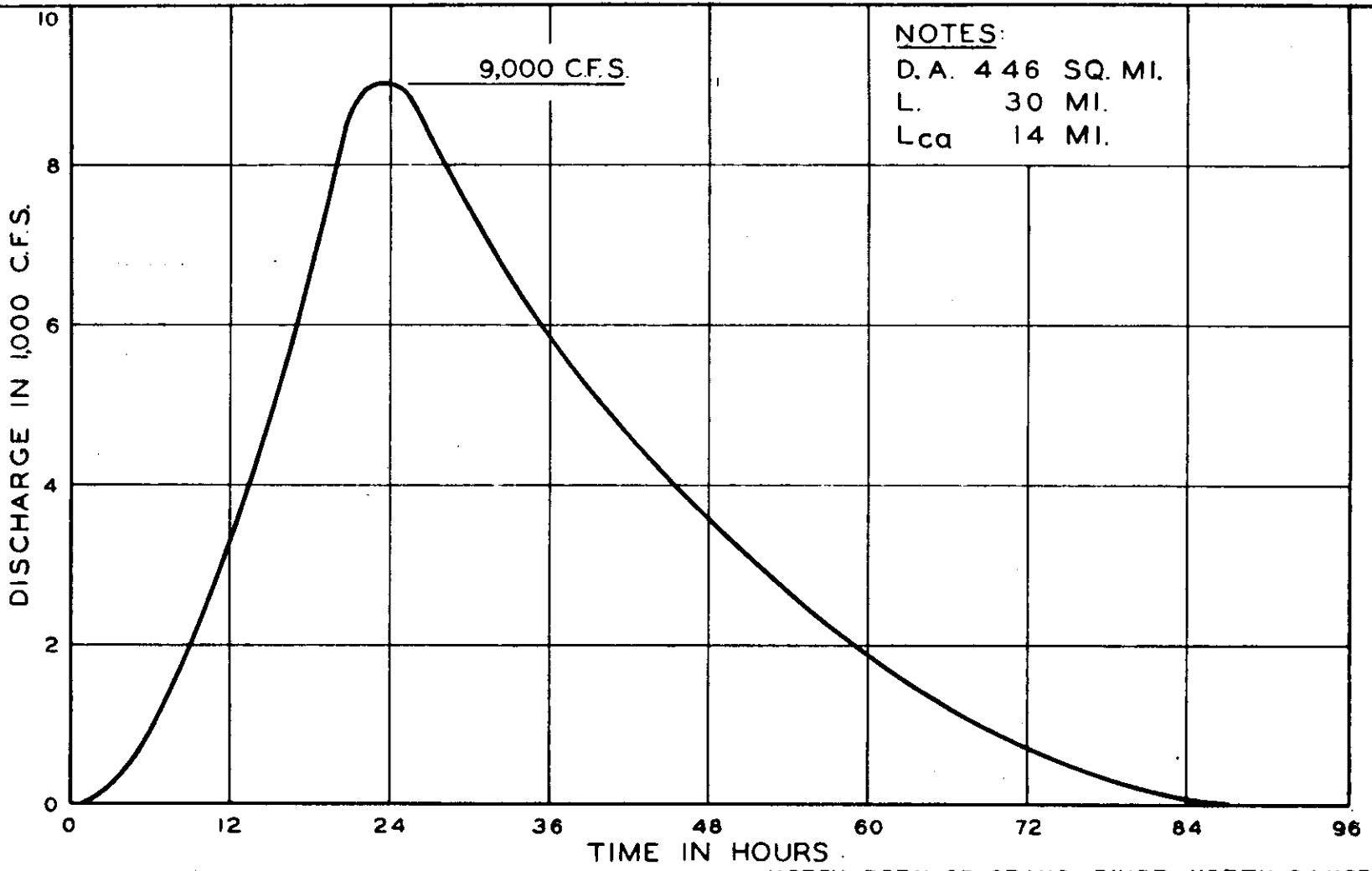


BOWMAN - HALEY DAM AND LAKE  
 FORECAST OF SEASONAL  
 WATER SUPPLY



ESTIMATED MARCH-APRIL RUNOFF IN 1000 ACRE FEET AT DAM SITE

BOWMAN-HALEY DAM AND LAKE  
 WATER EQUIVALENT OF LATE  
 SPRING SNOWPACK  
 VS.  
 MARCH-APRIL RUNOFF



NOTES:  
 D.A. 446 SQ. MI.  
 L. 30 MI.  
 Lca 14 MI.

NORTH FORK OF GRAND RIVER, NORTH DAKOTA  
**BOWMAN - HALEY DAM SITE**  
**HYDROLOGY**  
 6 - HOUR UNIT HYDROGRAPH  
 NORTH FORK, GRAND RIVER AT PROPOSED DAMSITE  
 U.S. ARMY ENGINEER DISTRICT, OMAHA  
 CORPS OF ENGINEERS OMAHA, NEBRASKA

# BOWMAN HALEY

## POOL ELEVATION VS. REFILL CHANGE

POOL ELEV. IN FEET, M.S.L. AT END OF DECEMBER

2760.0  
2755.0  
2750.0  
2745.0  
2740.0  
2735.0  
2730.0  
2725.0

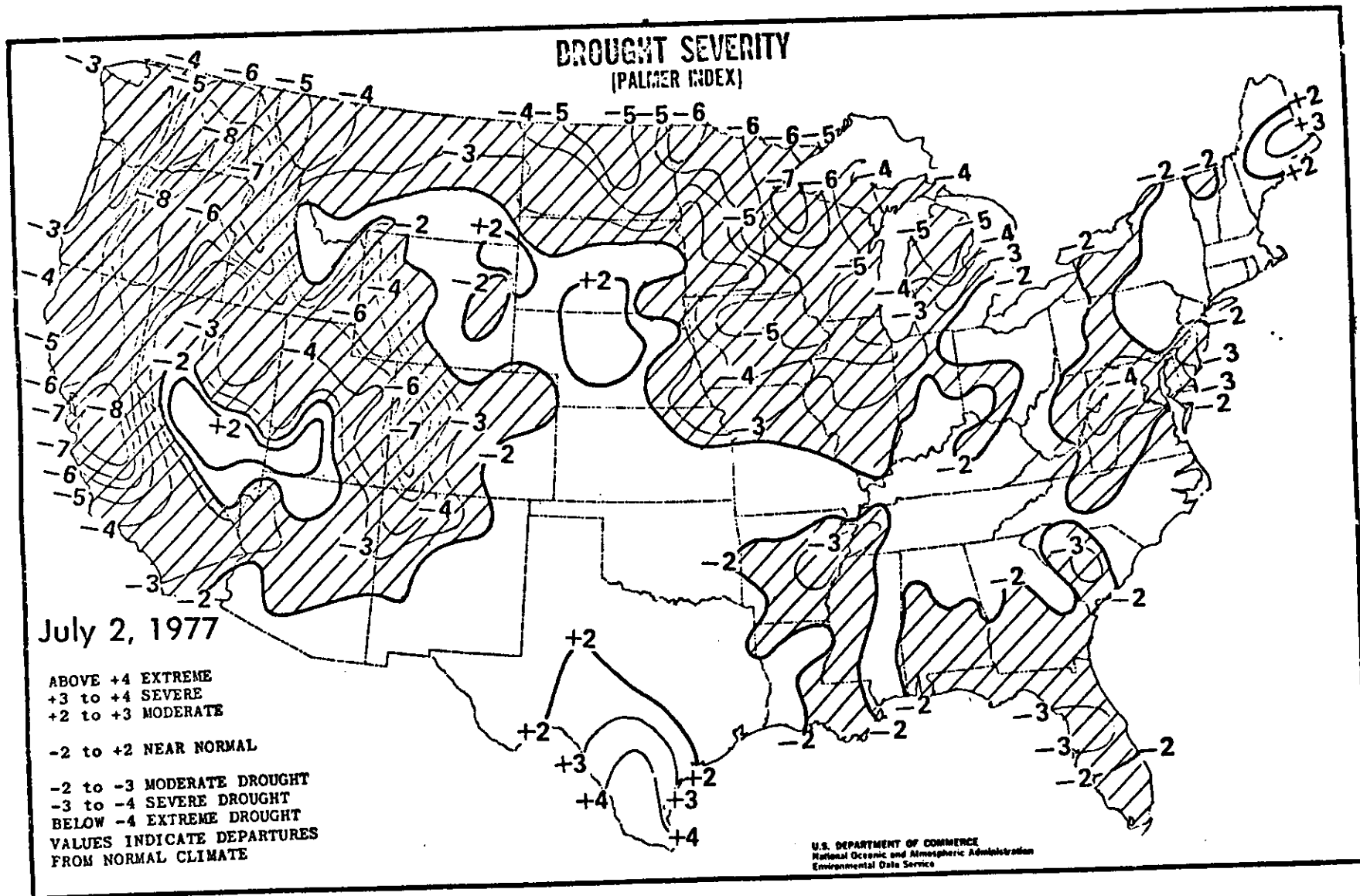
TOP OF MULTIPURPOSE POOL 2754.8 FT. MSL

NOTE: CURVE BASED ON 1967-84 RESERVOIR INFLOWS

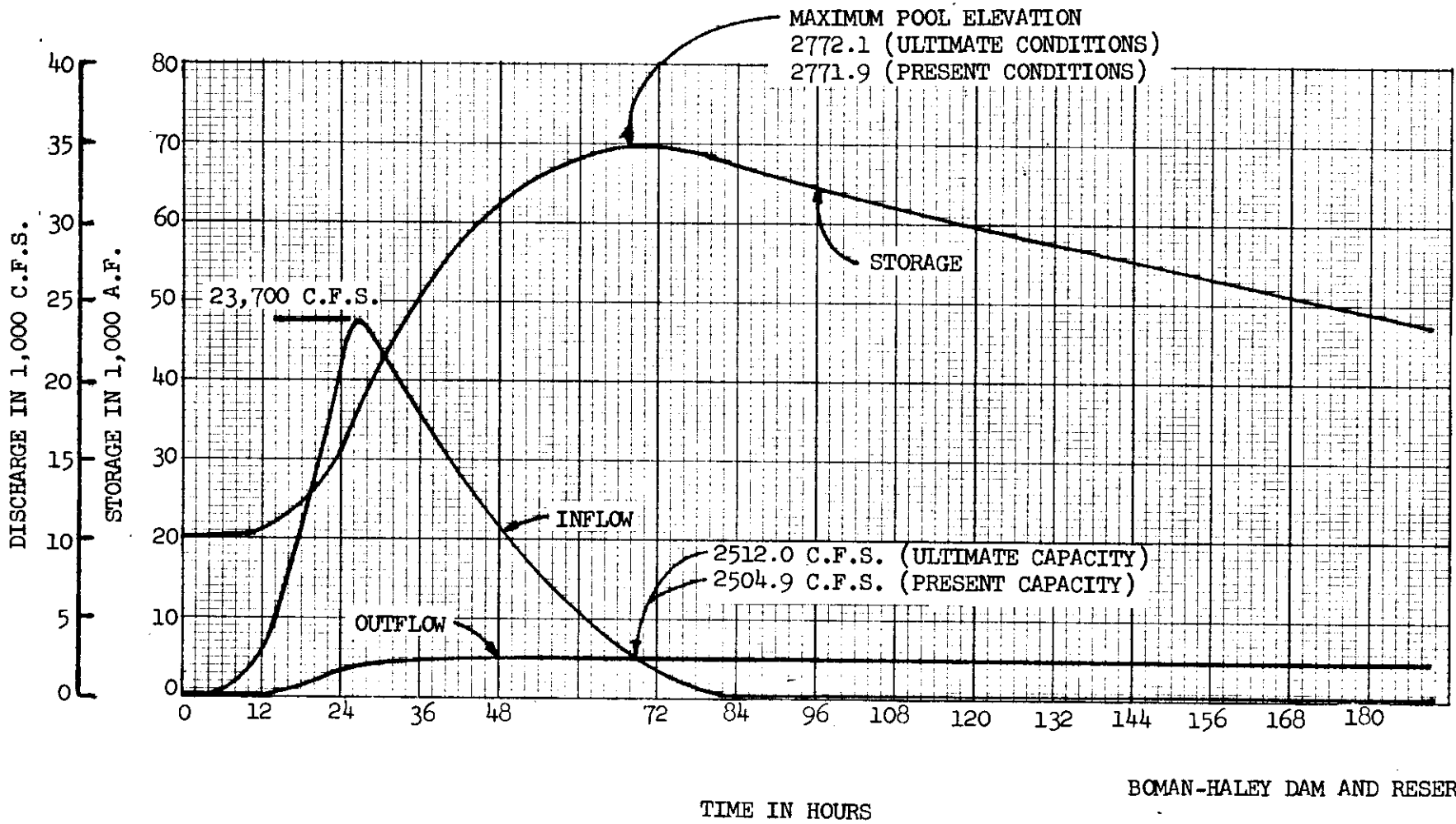
30% 40% 50% 60% 70% 80% 90% 100%

PERCENT CHANGE OF REFILL TO TOP OF

MULTIPURPOSE POOL BY END OF MAY



Drought Severity Chart (Palmer Index)

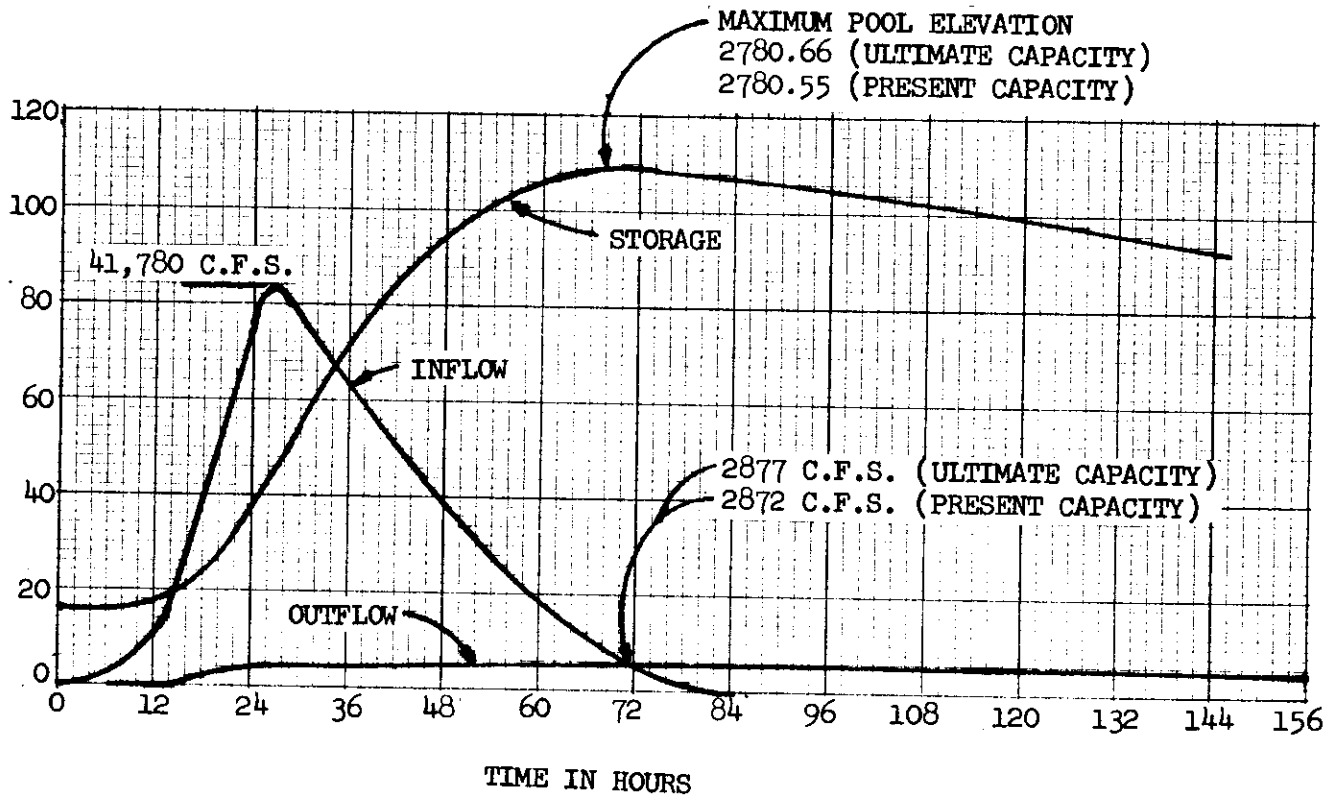


BOMAN-HALEY DAM AND RESERVOIR

RESERVOIR ROUTING  
 RESERVOIR DESIGN FLOOD  
 JUNE 1974

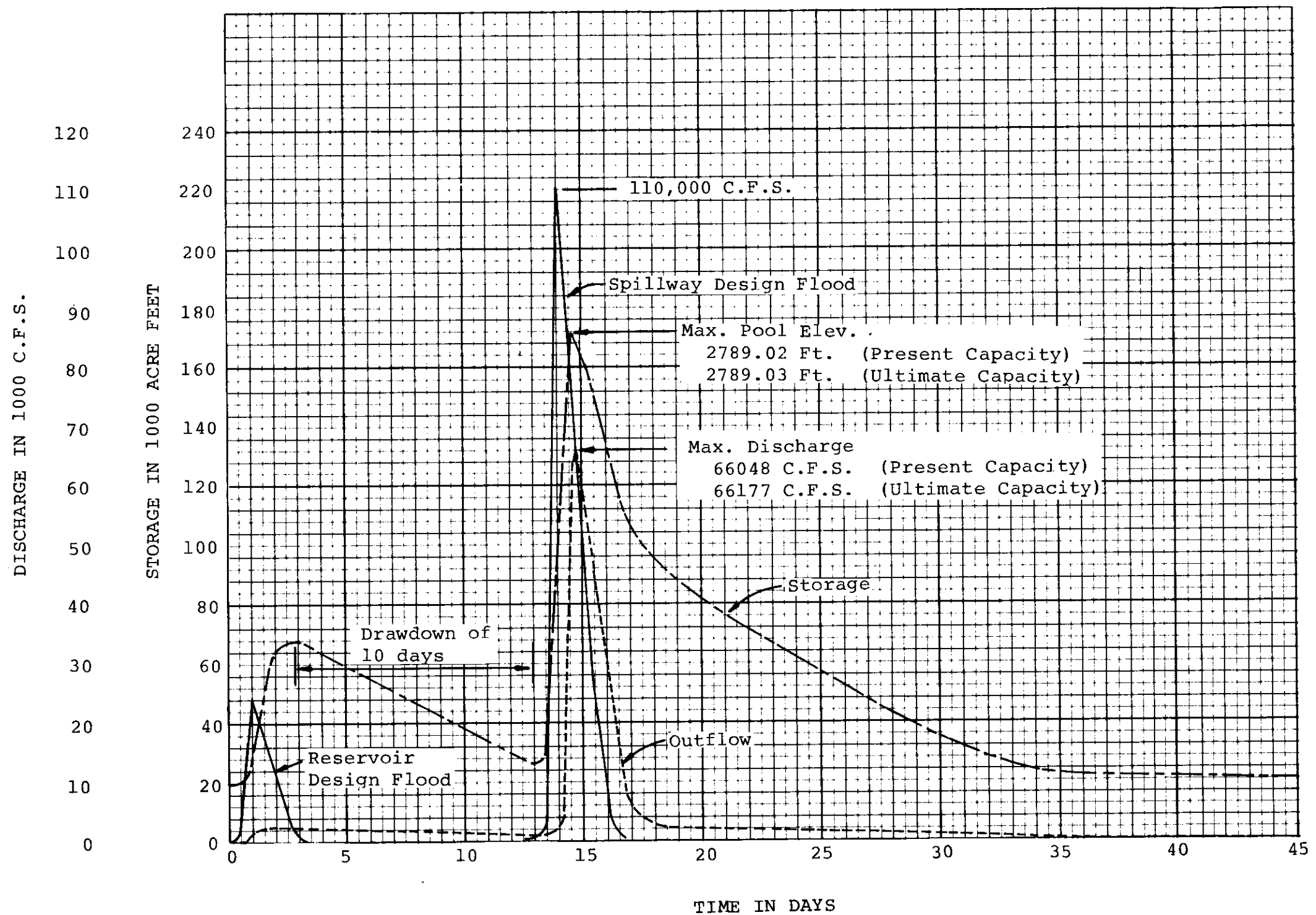
DISCHARGE IN 1,000 C.F.S.

STORAGE IN 1,000 A.F.



BOWMAN-HALEY DAM AND RESERVOIR

RESERVOIR ROUTING  
90% STANDARD PROJECT FLOOD  
JUNE 1974

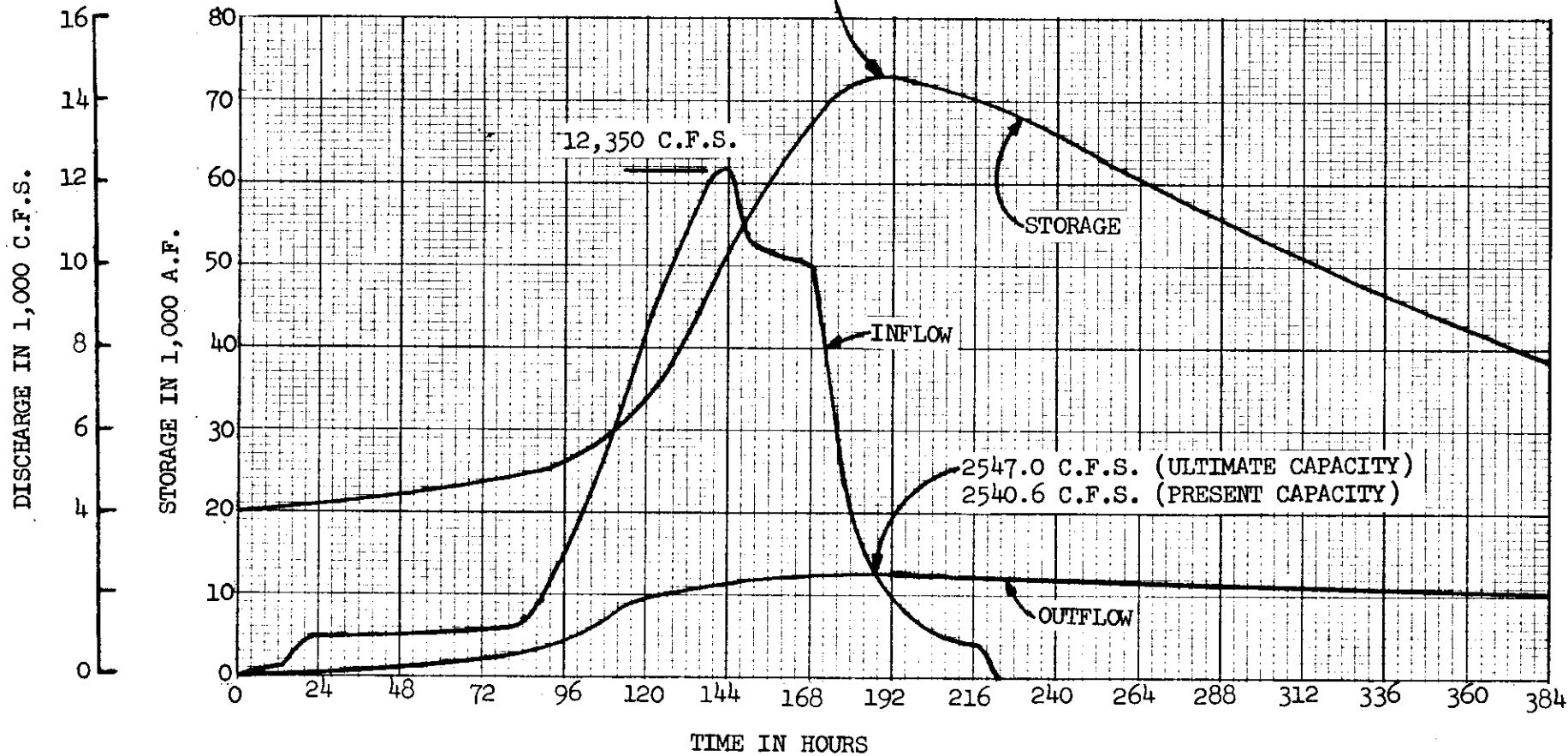


BOWMAN-HALEY DAM & RESERVOIR

RESERVOIR ROUTING  
SPILLWAY DESIGN FLOOD

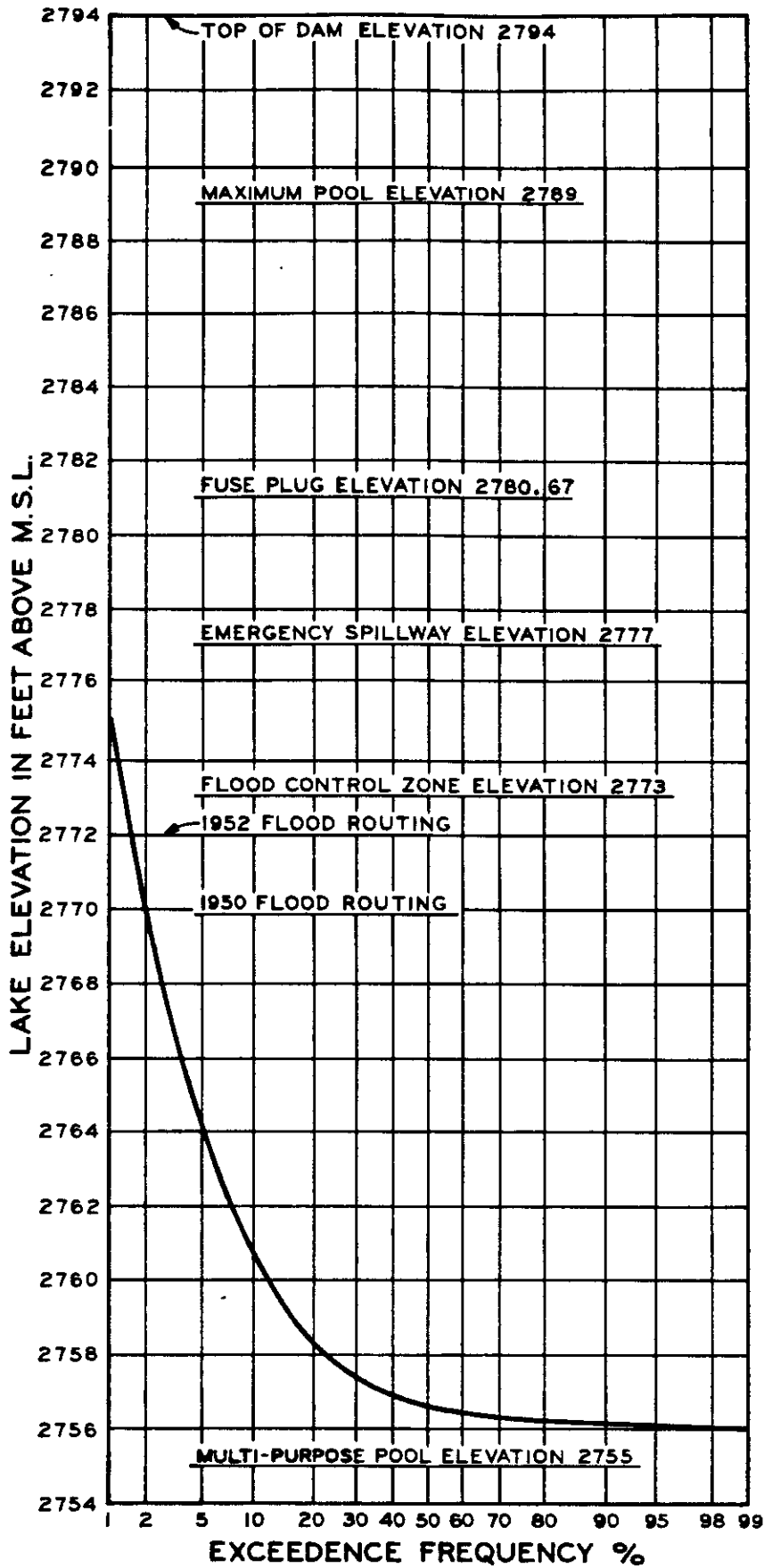
Nov. 1967

PLATE 26



BOWMAN-HALEY DAM AND RESERVOIR

RESERVOIR ROUTING  
 1952 FLOOD  
 JUNE 1974



NORTH FORK GRAND RIVER  
 NORTH DAKOTA  
**BOWMAN-HALEY LAKE**  
**MASTER PLAN**  
 LAKE ELEVATION FREQUENCY  
 IN PERCENT  
 U.S. ARMY ENGINEER DISTRICT, OMAHA  
 CORPS OF ENGINEERS OMAHA, NEBRASKA  
 MAY 1980