

BEAVERHEAD RIVER BASIN
CLARK CANYON DAM
AND RESERVOIR

MONTANA
BUREAU OF RECLAMATION

REPORT
ON
RESERVOIR REGULATIONS
FOR
FLOOD CONTROL



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

REPORT ON RESERVOIR REGULATIONS
FOR
FLOOD CONTROL
CLARK CANYON DAM AND RESERVOIR

Department of the Army
Corps of Engineers
Office of the District Engineer
Omaha District
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Bureau of Reclamation Photo

CLARK CANYON DAM AND RESERVOIR
(Reservoir length 5 miles)



Bureau of Reclamation Photo

CLARK CANYON DAM AND RESERVOIR
(18 miles southwest of Dillon, Montana)

REPORT ON RESERVOIR REGULATIONS
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PERTINENT DATA

Clark Canyon Dam and Reservoir

General

- Location of Project - Beaverhead County, Montana, on the Beaverhead River; immediately below the junction of Red Rock River and Horse Prairie Creek
- Purpose - Irrigation, flood control, fish and wildlife, water supply and recreation
- Authorized by - Flood Control Act approved 22 December 1944 (Public Law 534, 78th Congress, 2d Session)
- Date Complete - 1964, Water storage began 1964
- Drainage Areas - Beaverhead River above Clark Canyon Dam = 2,320 sq.mi.
- Streamflow - Average flow at Barretts, Mont. = 417 c.f.s.
- Average annual flow at Barretts, Mont. = 302,100 A.F.
- Peak flow at Barretts, Mont. = 3,720 c.f.s. (20 Jun 1908)
- Maximum April-June flow at Barretts, Mont. = 271,000 acre-feet (1917)
- Maximum monthly flow at Barretts, Mont. = 155,000 acre-feet (June 1908)
- Maximum monthly inflow Clark Canyon Reservoir = 88,300 acre-feet (June 1975)

Reservoir

<u>Item</u>	<u>Elev. Ft.MSL</u>	<u>Gross Area Acres</u>	<u>Gross Storage Acre-feet</u>	<u>Incremental Storage-AF</u>
Max. Water Surface	5571.9	6,600	328,979	
Top Flood Control Storage (Spillway) Crest, Uncontrolled	5560.4	5,903	257,152	71,827
Top of Joint Use Storage	5546.1	5,160	178,062	79,090 ^{1/}
Top of Active Con- servation Storage	5535.7	4,496	127,626	50,436
Top of Inactive Storage	5470.6	209	1,509	126,117
Top of Dead Storage (Invert of Outlet Works)	5455.0	23	61	1,448
Streambed at Dam Axis	5446.5	0	0	61

^{1/} Upper 22,615 A.F. (above elevation 5556.5 ft.) is reserved for local flood control only. Depending on season, the lower 56,475 A.F. is for both local flood control and replacement storage purposes. Storage in the joint use zone is also usable as replacement storage.

Dam

Type	Earth and rock fill
Crest elevation	= 5,578.0 ft.
Top Width	= 36 ft.
Height Above Streambed	= 131.5 ft.
Crest Length	= 2,900 ft.
Freeboard	= 6.1 ft.

Spillway

Location	Landward of left abutment
Type	Ungated ogee crest with concrete chute
Crest Elevation (Top Flood Control Pool)	= 5,560.4 ft.
Width of Crest	= 66 ft.
Length of Concrete (Start of inlet channel to end of stilling basin)	= 686 ft.
Discharge Capacity, (Max. Pool 5571.9)	= 9,530 c.f.s.

River Outlets

Location	Left abutment
Dimension of Outlet Conduit	= 9 ft. diam.
Length of Outlet Works (From inlet trashrack to downstream end of stilling basin)	= 908 ft.
Inlet Elevation	= 5455.0 ft.
Discharge Capacity, Top Conservation Pool (El. 5535.7)	= 2,160 c.f.s.
Discharge Capacity, Top Flood Control Pool (El. 5560.4)	= 2,500 c.f.s.

Stilling Basin

Width	
Spillway Basin	= 45.0 ft.
Outlet Works Basin	= 20.0 ft.
Bottom Elevation	= 5422.5 ft.

Barretts Diversion Dam (Eleven miles below Clark Canyon Dam)

Discharge Capacity	
East Bench Canal	= 440 c.f.s.
Canyon Canal	= 200 c.f.s.
Rebich Ditch	= 12.5 c.f.s.
Spillway	= 2,500 c.f.s.
Top of Dam	= 5,260.0 ft.
Max. T.W. Elevation	= 5,252.8 ft.

REPORT ON RESERVOIR REGULATIONS
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SECTION I - INTRODUCTION

1-01. Authority. This report has been prepared in compliance with instructions contained in ER 1110-2-240 and covers the pertinent topics of information specified in Chapter 6 of EM 1110-2-3600.

1-02. Scope. Clark Canyon Dam and Reservoir was constructed by the Bureau of Reclamation on the Beaverhead River for irrigation, flood control, water supply and recreational purposes. Locally the lake is called Hap Hawkins Lake. This report covers only the regulation of the reservoir for flood control purposes. Reservoir storage space will be regulated to provide a firm degree of flood protection to the Beaverhead River downstream from the dam. Additionally, storage space in Clark Canyon will be utilized in coordination with space in the Missouri River Main Stem Reservoir System to supplement the annual flood control and multiple use space in the downstream system. Detailed information on the regulation procedures and schedules for these flood control purposes are presented herein. This report is subject to future revision and updating as circumstances warrant.

SECTION II - BASIN AND RIVER DESCRIPTION

2-01. General. The Beaverhead River basin is located in the southwestern corner of Montana. It has a mountainous drainage area, ranging in elevation from 4,600 feet at its mouth and 5,500 feet where it is formed by the confluence of Red Rock River and Horse Prairie Creek to above 10,000 feet in the mountains. It is fed along its course mainly by Grasshopper and Black-tail Creeks and Ruby River. Five miles below the mouth of Ruby River near Twin Bridges, the Beaverhead River terminates as it joins the Big Hole River to form the Jefferson River. The city of Dillon located on the Beaverhead River about 22 miles below Clark Canyon Dam is the focal point of several ranching valleys with a 1970 census population of 4,548. Twin Bridges located about 48 miles below the dam has a 1970 census population of 631. Plates 1, 2 and 3 give respectively a general map of the area, a profile of the Beaverhead River and tributaries and a Beaverhead River Basin high elevation map. The average annual precipitation ranges from 10 to 17 inches, except in the higher elevations where it is much greater. Because of the low rainfall and short growing season livestock ranching is the main agricultural pursuit.

2-02. Streamflow. The high water period usually occurs in June when the maximum effect of melting snow in the mountains is combined with rain. Following is the 29 year average monthly runoff in c.f.s., for the period 1936 through 1964 (prior to Clark Canyon), at the Barretts, Montana stream gaging station which indicates the seasonal nature of the streamflow in this area.

October	331	February	287	June	685
November	360	March	347	July	413
December	327	April	410	August	312
January	278	May	442	September	296

2-03. Table 1 lists pertinent stream gaging stations giving mean and peak discharges corresponding to the number of years of record.

2-04. Table 2 gives a tabulation of the yearly March-April snowpack (average water content in inches of the 5 snow courses used in forecast given in Exhibit V) and the corresponding natural maximum monthly runoff (in thousand acre-feet) at Barretts during the snowmelt period. Flow at the Clark Canyon damsite is estimated as 72 percent of the Barretts flow for the April-June period.

2-05. Travel Time. The approximate bankfull or below bankfull travel times below Clark Canyon Dam are given below:

Clark Canyon Dam to Barretts	4 to 5 hours
Clark Canyon Dam to Dillon	10 to 12 hours
Clark Canyon Dam to Blaine	20 to 24 hours
Clark Canyon Dam to Twin Bridges	30 to 36 hours
Clark Canyon Dam to Canyon Ferry Dam	3 to 3.5 days

TABLE 1
PERTINENT STREAM GAGING STATIONS
(RECORD THROUGH 1973)

<u>Stream Gaging Station</u>	<u>Drainage Area(sq.mi.)</u>	<u>Years of Record</u>	<u>Discharge (c.f.s.)</u>		<u>Date of Peak</u>
			Mean	Peak	
Beaverhead River near Grant	2,322	11	388	2,110	Feb. 7, 1963
Beaverhead River at Barretts	2,737	66	417	3,720	June 20, 1908
Beaverhead River near Dillon	3,484	12	385	1,570	June 22, 1964
Beaverhead River near Twin Bridges	3,619	38	407	3,130	June 12, 1944
Ruby River below reservoir	596	10	220	1,610	June 10, 1970
Big Hole River near Melrose	2,476	50	1,137	14,300	June 10, 1972
Jefferson River at Silver Star	7,683	19	1,973	16,500	June 10, 1964
Missouri River at Toston	14,669	38	5,292	32,000	June 6, 1948

TABLE 2
SNOWPACK VERSUS MAXIMUM MONTHLY RUNOFF

Year	Snow Water Content** (inches)		Maximum Barretts Monthly Runoff* and Month (thousand acre-feet)
	<u>1 March</u>	<u>1 April</u>	
1948	7.6	11.1	80 June
1949	10.5	12.5	61 April
1950	8.9	10.8	63 April
1951	10.3	12.7	60 April
1952	12.0	12.6	69 May
1953	9.8	10.9	63 June
1954	8.1	9.5	36 April
1955	5.6	7.3	39 April
1956	10.6	12.7	45 April
1957	8.3	12.5	97 May
1958	7.5	11.7	52 April-May
1959	8.8	8.9	32 April
1960	7.2	7.5	48 April
1961	5.8	8.1	24 April
1962	10.0	11.7	60 April
1963	6.6	7.1	55 June
1964	7.4	9.9	108 June
1965	16.2	17.6	79 June
1966	7.1	7.9	42 April
1967	10.6	13.9	81 June
1968	10.8	12.0	51 June
1969	17.0	17.4	95 April
1970	6.7	11.6	86 May
1971	12.9	16.6	112 May
1972	13.7	14.9	58 June
1973	6.0	8.3	55 April
1974	8.9	14.7	54 April
1975	10.9	14.6	115 June
1948-75 Average	9.5	11.7	65

*Adjusted for change in Lima and Clark Canyon Reservoirs.

** Average at Goldstone, Lakeview Canyon, Lakeview Ridge, Lemhi Pass and Trail Creek.

2-06. Channel Capacity. During planning of the reservoir and up until the early or mid-1970's, the nondamaging channel capacity was estimated at a minimum of 1,500 c.f.s. between Clark Canyon Dam and the mouth of Beaverhead River near Twin Bridges. Currently the capacity is a minimum of 900 c.f.s., approximately 3 miles south of Dillon. Two other areas of low capacity are located near the north edge of Dillon where it is estimated about 1,200 c.f.s. and from Blaine to Twin Bridges where it is estimated about 950 c.f.s. These capacities were established following reports of high flows during 1975. Minor overbank flow at these three areas is anticipated to flood a commercial campground south of Dillon, a city park in Dillon, and pasture and crop lands from Blaine to Twin Bridges.

2-07. Stage-Discharge Relationship. Open water ratings are tabulated for the Beaverhead River near Grant, at Barretts, near Dillon and near Twin Bridges (formerly Blaine) on Plate 4. Similar ratings for other stations are on file in the Omaha District, Reservoir Regulation Section. The stage-discharge relationships given on Plate 4 may shift from time to time and are kept current with discharge measurements made by the U.S. Geological Survey. The larger shifts from these open water relationships will occur when ice forms on the streams.

2-08. Relationship of Clark Canyon Inflow to Fort Peck Inflow. The average annual flow of the Missouri River near Zortman, Montana, located just above Fort Peck Reservoir, is 6,160,000 acre-feet, while the average annual flow of the Beaverhead River at Barretts is 290,000 acre-feet. As a rule, when the seasonal snowmelt runoff above Fort Peck is high, the runoff above Clark Canyon is also high. Similarly, in years of low runoff above Fort Peck, low runoff generally occurs above Clark Canyon Dam. Plate 5 illustrates this relationship by comparing April-June streamflow on the Beaverhead River at Barretts to May-July Fort Peck inflow. In view of this relationship, a portion of the Clark Canyon Reservoir storage capacity is used to assist in flood control along the Missouri River main stem by withholding flood water from Fort Peck during high runoff years, as discussed in paragraphs 4-08 to 4-11.

2-09. Historical Floods. The greatest flood of record along the Beaverhead River occurred in June 1908 as a result of heavy rains during the June snowmelt runoff. A peak discharge of 3,720 c.f.s. occurred on 20 June at the Barretts stream gaging station during this flood. The greatest flood on the Beaverhead River of which there is a record of monetary losses occurred from snowmelt and rainfall runoff in June 1944 when flood damages of \$47,300 were sustained by railroads, highways and farms. A peak discharge of 3,060 c.f.s. occurred on 10 June 1944 at the Barretts stream gaging station during this flood. In June 1975, it was estimated that the runoff from snowmelt and rainfall would have caused a flood greater than in 1908 had it not been for the storage of the flood water by Clark Canyon Dam. The maximum natural daily peak flow at Barretts was estimated to be 3,900 c.f.s. Clark Canyon

was credited with preventing \$608,000 in flood damages. A description of these three floods and their causes is given in Section X. Other years in which rain and snowmelt floods occurred were in 1903, 1912, 1916, 1917, 1927, 1948 and 1964.

2-10. Ice jam floods occur frequently during the months of January and February, but are of a local nature. The jams are formed during cold periods. Slush ice forms in large quantities and masses together at constricted sections of the stream. This ice mass tends to block the natural flow of the water, although the ice doesn't freeze solidly enough to withstand the pressure exerted by a large body of water. Consequently, the flooding is relatively minor and of short duration. Ice jam floods were reported in 1882, 1910, 1928, 1936, 1937, 1940, 1942, 1949, 1951 and 1974. Flooding has occurred in other years but records are incomplete.

2-11. Discharge-Damage Relationships. The river downstream from Clark Canyon Dam has been divided into three reaches for computation of flood damages. Discharge-damage curves were determined for these reaches. They are shown on Plate 6.

SECTION III - WATER RESOURCE DEVELOPMENT

3-01. Reservoir Development. Lima Reservoir (capacity 84,050 A.F.) is the only significant reservoir upstream from Clark Canyon Reservoir. Its water is utilized primarily for irrigation in the Red Rock Valley. It is owned by the Water Users Irrigation Company and was completed in 1934. Downstream from Clark Canyon Dam, the only significant reservoir affecting flows on the Beaverhead River is Ruby River Reservoir (capacity 38,850 A.F.) located on the Ruby River. Its water is used primarily for irrigation along both the Ruby and Jefferson River Valleys. It is owned by the Montana Department of Natural Resources and Conservation and was completed in 1938. These reservoirs may have some effect in the reduction of spring runoff volume, however, the reservoirs are usually full before the peaks from large floods occur and offer little reduction in the higher peak flows. There are numerous natural lakes above Clark Canyon Dam which have the same effect on runoff.

3-02. Irrigation. Irrigation has been practiced in this area since about 1865 when the first water right filings were made. Agriculture in the area is dependent upon irrigation. The acreage of irrigated land has varied considerably over the years, depending upon the water supply available. Prior to Clark Canyon being built insufficient water storage prevented adequate irrigation of the Beaverhead Valley, as the water stored in Lima Reservoir was not enough to supply water for both the Red Rock and Beaverhead Valleys. Consequently, in years of low and erratic runoff, the water supply in the Beaverhead Valley was insufficient to irrigate hay and cash crops.

3-03. Water diverted from the Beaverhead River for irrigation has a definite effect on the flow along the Beaverhead River. At Barretts Diversion Dam, 11 miles below Clark Canyon Dam, 640 c.f.s. can be diverted along the East Bench (440 c.f.s.) and Canyon (200 c.f.s.) canals. This compares with the 66-year average flow at Barretts of 417 c.f.s. The average annual Beaverhead River irrigation diversion requirement is 175,500 acre-feet of which 15% is for May, 25% for June, 30% for July, 20% for August and 10% for September. During years of above normal runoff Clark Canyon release requirements necessary for irrigation may be considerably less than these average diversion requirements, while in periods of subnormal precipitation and runoff they may be greater.

3-04: Flood Control. Clark Canyon Dam and Reservoir is the only Federal flood control project in the Beaverhead and Jefferson River basin. It is understood some private levees exist in the basin below the dam although their location and size are obscure. Based on similar private levees in other areas, it is believed they are not adequate for complete control of floods along the Beaverhead. In determining releases from Clark Canyon Dam for flood control these levees are assumed as ineffective.

3-05. Fish and Wildlife Requirements. The Bureau of Sport Fisheries and Wildlife has recommended a minimum flow of 200 c.f.s. in the reach of the Beaverhead River between Clark Canyon Dam and Barretts Diversion Dam, and a minimum flow of 250 c.f.s. in the reach between Barretts Diversion Dam and the mouth of the Ruby River, at all times to maintain a satisfactory river fishery. However, it is impossible to release these flows at all times and still provide for the basic functions of irrigation and flood control. During filling of the reservoir and following the dry 1966 water year, minimum releases ranged from 80 to 100 c.f.s. except for short periods when releases were further reduced to facilitate measurement of streamflow accretions below the dam (November 1964 to May 1965 and October 1966 to May 1967). The effects on the fishery were carefully observed during these periods. No detrimental effects were apparent. Winter releases will drop as low as 25 c.f.s. during periods of extended drought.

3-06. Water Rights and Supplies. Most of the water rights on Beaverhead River have been adjudicated in three water-right decrees. Although a suit to adjudicate the entire river was filed some years ago, there seems to be no intention of bringing the suit to trial. There is an ample supply of domestic water throughout the basin.

SECTION IV - PROJECT HISTORY AND DESCRIPTION

4-01. History Prior to Water Storage. The original irrigation project, of which Clark Canyon Dam is now a part, was formed in 1922. The original plan proposed a diversion from the Beaverhead River near Dalys Spur (about 3 miles above Barretts) and storage on Grasshopper Creek for irrigation of 11,000 to 12,000 acres. In the fall of 1938 the Bureau of Reclamation, assisted by the Montana Power Company and the State Water Conservation Board, began an investigation of the Beaverhead River. The final report of these studies was published as a part of Senate Document 191. Following authorization by the Flood Control Act of 1944 detailed studies were begun and the Definite Plan Report was published in March 1956. The definite plan report proposed construction of the 261,000 acre-foot Clark Canyon Dam, supplemental service to 28,004 acres of valley lands, full service to 21,800 acres on East Bench, and construction of the Barretts Diversion Dam and East Bench Canal. Construction of Clark Canyon Dam began 7 November 1961. Diversion was made 6 February 1963 and initial storage began 28 August 1964.

4-02. Dam and Appurtenant Works. Clark Canyon Dam is a rolled earth and rock filled structure 133 feet above streambed and about 2,900 feet long and 36 feet wide on the crest. Water is released through the gated outlet works which has a capacity of 2,500 c.f.s. when the pool elevation is at the spillway crest. An ungated ogee concrete spillway crest is at the top of the flood control pool. It has a maximum capacity of 9,530 c.f.s. at maximum pool elevation. Refer to plates 7 to 11, inclusive, for general plan of dam, outlet works rating curve and spillway rating curve.

4-03. Reservoir. Clark Canyon Reservoir normally extends about 4 to 5 miles up both Red Rock River and Horse Prairie Creek. Area capacity curves are shown on Plate 12. A map of the reservoir is shown on Plate 13. Allocation of storage space has been made as follows:

TABLE 3
STORAGE ALLOCATION

<u>Reservoir Use</u>	<u>Elevation Limits</u>	<u>Capacity Acre-Feet</u>
Surcharge Storage	5560.4-5571.9	71,827
Exclusive Local Flood Control Storage	5556.5-5560.4	22,615
Replacement Local Flood Control Storage	5546.1-5556.5	56,475
Joint Use Storage ^{1/}	5535.7-5546.1	50,436
Active Conservation Storage	5470.6-5535.7	126,117
Inactive Storage	5455.0-5470.6	1,448
Dead Storage	5446.5-5455.0	61
Total (with Surcharge Zone)		328,979
Total (Without Surcharge Zone)		257,152

^{1/} Also usable as replacement flood control storage. These allocations are illustrated on page IV-5.

Storage space has been provided for 10,000 acre-feet of sediment, which it is estimated will be distributed 61 acre-feet in the dead storage pool, 1,248 acre-feet in the inactive storage pool, 8,317 acre-feet in the active conservation pool, and 374 acre-feet in the joint-use pool. It is estimated that this volume will be adequate to contain a 100-year accumulation of sediment.

4-04. Relocations. A highway, a county road, a railroad, and transmission and telephone lines were relocated. Property and buildings in the town of Armstead, Montana, were purchased to make way for Clark Canyon Dam and Reservoir.

4-05. Irrigation. The East Bench Unit is the principal irrigation development along the Beaverhead River. The principal features of this unit include Clark Canyon Dam and Reservoir, Barretts Diversion Dam, East Bench Canal and a system of laterals and drains. Water stored at Clark Canyon Reservoir is released into the Beaverhead River for downstream irrigation. About 11 miles downstream from Clark Canyon, the Barretts Diversion Dam diverts water from the river to the 44.2 mile long East Bench Canal (capacity 440 c.f.s.) and two private canals (Canyon Canal - capacity 200 c.f.s.; and Rebich Ditch - capacity 12.5 c.f.s.). This diversion dam is designed to release a flow of 2,500 c.f.s. down the river in addition to the diverted flow. This release is regulated by a 24 by 10 foot radial gate and/or a 8 by 10 foot radial gate. Further description of this unit is given on Plate 14.

4-06. Sedimentation. The streams above Clark Canyon Dam generally run clear except during rainstorms, at which time they show some turbidity. The Bureau of Reclamation estimates that about 100 acre-feet of sediment annually may be expected in the reservoir.

4-07. Recreation. The Montana State Fish and Game Department planned, manages and maintains the developed recreation areas located around the reservoir. The plans for the areas were approved by and built under supervision of the Bureau of Reclamation. They were financed primarily on a cost sharing basis between the State and Federal government with the greatest share from Federal funds. Some of the facilities are located within the allocated flood control zone. One of the shelters becomes inundated at elevation 5546.1. During regulation of the reservoir in 1975 for main stem replacement flood control, the peak pool level reached was 5556.87. Damages to the recreation facilities were estimated at \$5,000.

4-08. History Relating to Replacement Storage. The Missouri River Main Stem Reservoir System, located downstream from Clark Canyon Reservoir, was designed in the 1940's and construction of the system was essentially completed by the mid-1960's. This is a multi-purpose system serving both flood control and water supply functions. The flood control storage space provided in the system was developed on the basis that no upstream storage space was in existence, although it was recognized that as this upstream

space became operational a re-evaluation of the main stem system's space requirements would be necessary. Continuing analysis of inflows into the main system and into tributary reservoirs constructed upstream from the system has indicated that in certain instances, particularly when inflows are distinctly seasonal in nature, storage space provided in upstream reservoirs could effectively replace a portion of the annual flood control and multiple-use space initially provided in the main stem system. Effective operation would require a coordinated regulation of the upstream space with the space in the main stem system and would result in the most efficient overall utilization of the water resources of the basin. Such space provided in upstream reservoirs has been designated as "replacement flood control storage space."

4-09. In addition to regulating the flood control storage space provided in Clark Canyon Reservoir for local flood purposes, it has been determined that replacement type regulation is also feasible. The relatively good relationship between flood season flows near the Clark Canyon damsite and corresponding inflows into Fort Peck, the upstream project of the main stem system, was discussed in paragraph 2-08. With the maintenance of minimum releases necessary to sustain irrigation and fish and wildlife requirements, as discussed in paragraphs 3-03 and 3-05, there is an opportunity to store a substantial amount in Clark Canyon Reservoir in those years of well above-normal runoff when the flood control capabilities of the main stem system may be fully utilized. The flood control storage reservation diagram attached to the Flood Control Regulations (Exhibit I) provides for storage drawdown of at least the top 20,199 A.F. of the joint use pool before winter freeze-up. Therefore, this storage, plus the lower 56,475 A.F. of the flood control pool is firmly available for replacement use when needed. In addition examination of long-range operation studies of the main stem reservoir system in conjunction with observed flows and storage levels at Clark Canyon discloses that there is a reasonable assurance that at least 106,911 A.F. could be stored in Clark Canyon Reservoir during the March-July flood period of high runoff years. This includes the joint-use storage zone (50,436 A.F.) and the lower 56,475 A.F. of the flood control zone. Therefore, it has been concluded that this amount of space can be regulated in conjunction with the regulation of Fort Peck Reservoir and the remainder of the main stem system to replace a corresponding amount of annual flood control and multiple-use space in the downstream reservoirs.

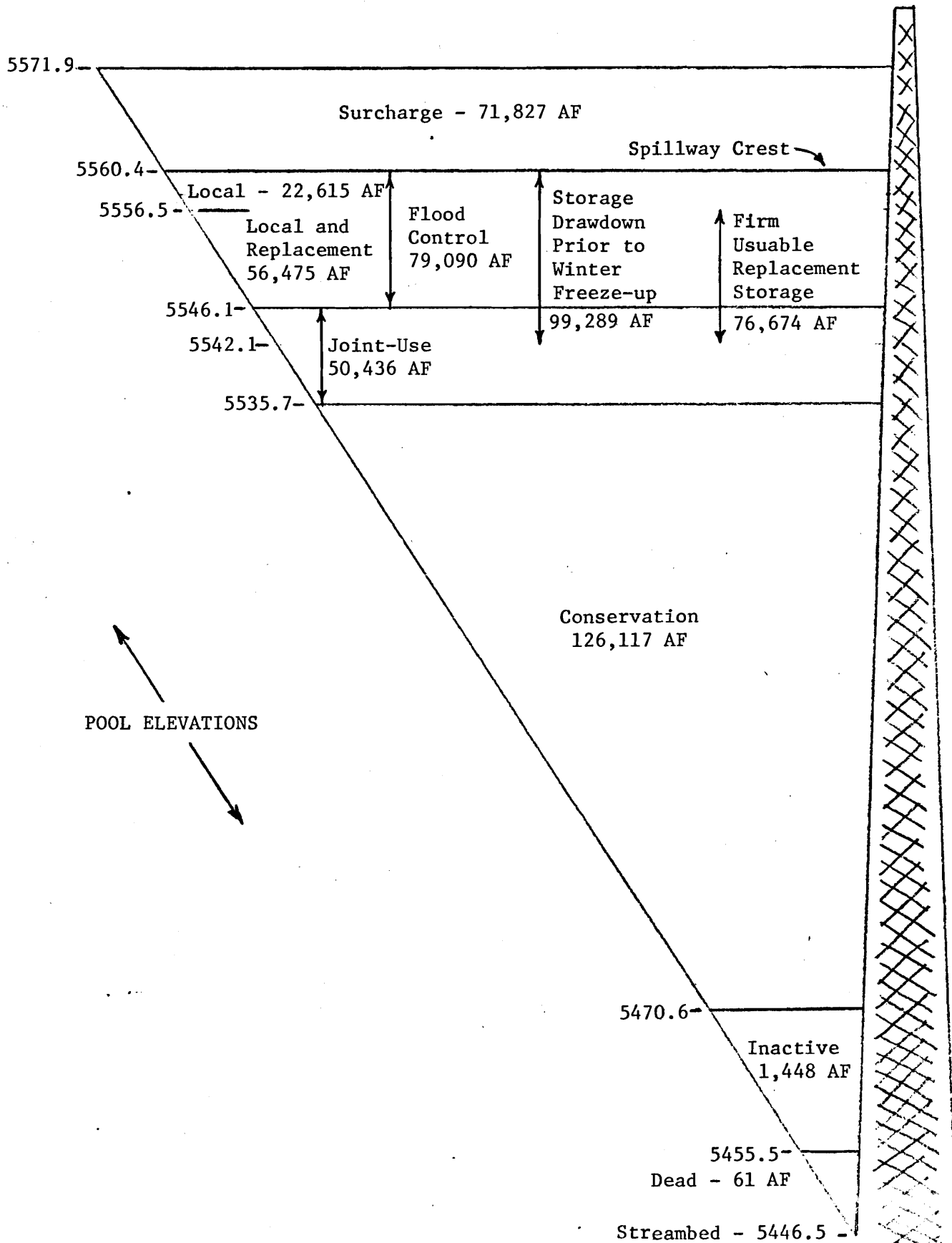
4-10. If conditions warrant, the entire joint-use storage zone of Clark Canyon Reservoir will be evacuated prior to March 1st to subsequently serve both local flood control and replacement storage purposes. Additionally, deliberate storage into the flood control storage zone up to elevation 5556.5 may be made for replacement as well as local flood control purposes. Storage space between elevations 5556.5 and 5560.4 will be utilized only for providing local flood control below the dam. Evacuation

of storage accumulated in Clark Canyon Reservoir, for replacement flood control purposes, at rates in excess of multiple-purpose requirements, will be based on storage conditions within the main stem system.

4-11. Operational History. Deliberate fill of Clark Canyon Reservoir began on 28 August 1964. Fill of the conservation storage was completed during the following seasonal (1965) runoff period. Since that time the allocation of the breakdown in flood control storage in the reservoir has been revised twice. These changes are reflected in revised Field Working Agreements dated 30 November 1967 and 5 October 1970. The original Field Working Agreement dated 9 November 1964 allocated about 99,300 A.F. between elevations 5560.4 and 5542.1 for exclusive flood control and about 30,200 A.F. between elevations 5542.1 and 5535.7 for joint use storage. The allocations were changed in 1967 because the 1964 agreement did not provide for regulation beneficial to main stem replacement storage. Main stem replacement storage benefits were included in determining average annual benefits in planning of the project. The 1967 agreement allocated about 22,600 A.F. for exclusive-local flood control, about 76,700 A.F. for replacement-local flood control and about 30,200 A.F. for joint-use storage. The agreement was again revised in 1970 following the final review by the Chief of Engineers. In the agreements up to that time (1970) the Bureau was permitted to store about 20,000 A.F. above the top of the joint use zone each year during the flood season and use it for conservation purposes until 30 September. The 1970 agreement raised the top of the joint use storage to include this 20,000 A.F. This agreement allocated about 22,600 A.F. for exclusive-local flood control, about 56,500 A.F. for replacement-local flood control and about 50,400 A.F. for joint-use storage (also usable for replacement purposes). These concepts are reflected in the Flood Control Storage Reservation Diagram currently in force (dated 14 October 1971).

4-12. Plate 15 presents pool elevations, reservoir monthly inflows and outflows and maximum annual daily reservoir inflows and outflows and maximum annual daily discharge at Barretts. The pool level exceeded elevation 5546.1 (the top of the joint use storage) in 1965, 1971 and 1975. Operation of Clark Canyon through 1975 has prevented \$2,920,200 in downstream flood damages.

CLARK CANYON RESERVOIR
STORAGE ZONES



SECTION VI - COLLECTION AND DISTRIBUTION OF BASIC HYDROLOGIC DATA

6-01. General. The State of Montana and various Federal agencies have established a system of stream and precipitation gages. The U. S. Geological Survey, National Weather Service, Bureau of Reclamation, Soil Conservation Service, Corps of Engineers and the State of Montana contribute personnel and/or funds to support the system. Meteorological and hydrological data from this system are received by the Reservoir Regulation Section on teletype receivers connected to the National Weather Service - Service C and RAWARC circuits and on a national facsimile network printer. Hydrologic data is also obtained from the Clark Canyon Dam Tender directly or via the Bureau's Reservoir Regulation Branch in Billings.

6-02. Reservoir Data. Clark Canyon Reservoir elevations are obtained and recorded on a standard water stage recorder. A digital indicator, connected to the gage, also records pool elevations at the dam tender's office in Dillon.

6-03. Precipitation and Stream Gaging Data. Precipitation and stream gaging stations judged most useful for regulation of Clark Canyon Reservoir are listed in Tables 4 and 5. Their locations are shown on Plate 1.

6-04. Snow Surveys. Monthly snow survey reports, needed to prepare forecast, are received by the Omaha District Reservoir Regulation Section via the RAWARC teletype circuit, by telephone (Soil Conservation Service Bozeman office 8-585-4270) and mail from 1 January through 15 June. The snow survey stations most useful to Clark Canyon Reservoir regulation are listed in Table 6. Their locations are shown on Plate 1. Daily snow depths from West Yellowstone and Helena, Montana are received in the office of the Omaha District Reservoir Regulation Section via a National Weather Facsimile network weatherfax machine.

TABLE 4
STREAM GAGING STATIONS
(Useful to Clark Canyon Reservoir Regulation)

<u>River</u>	<u>Station</u>	<u>Drainage Area-sq.mi.</u>	<u>Operating Agency & Type</u>
Beaverhead	nr. Grant	2,322	USGS - Recorder
Beaverhead	at Barretts	2,737	USGS - Recorder
Beaverhead	nr. Dillon	3,484	USGS - Recorder
Beaverhead	nr. Twin Bridges*	3,619	USGS - Recorder

*Prior to 1968, published as at Blaine.

TABLE 5
PRECIPITATION STATIONS
NATIONAL WEATHER SERVICE
(Useful to Clark Canyon Reservoir Regulation)

Dillon WMCE
Divide
Gallatin Gateway
Hebgen Dam
Helena (SM code - 72 772)
Lakeview
Lima
Logan
Melrose
Sappington
Virginia City

TABLE 6
SNOW SURVEY STATIONS
(Useful to Clark Canyon Reservoir Regulation)

Goldstone
Hebgen Dam
Lakeview Canyon
Lakeview Ridge
Lemhi Pass
Ten Mile Upper
Trail Creek
West Yellowstone

SECTION V - ORGANIZATION FOR RESERVOIR REGULATION

5-01. Corps of Engineers Organization. The Reservoir Regulation Section of the Omaha District Office prepares and issues instructions for regulation of flood control releases from the reservoir, collects basic hydrologic data, and makes advance estimates of streamflow for regulation purposes. Required reports to higher authority relative to flood control regulation activities are also prepared by the Reservoir Regulation Section. Section D of Exhibit III lists Corps of Engineers' personnel.

5-02. During flood emergencies the District organization as far as the regulation of Clark Canyon Reservoir is concerned will be essentially unchanged. Additional men may be borrowed from other sections as required but key men will be in their regular positions. In event that widespread flooding should develop and when regulation for main stem replacement purposes is occurring, the Reservoir Control Center of the Missouri River Division Office may temporarily specify flood control release schedules from Clark Canyon Dam.

5-03. Bureau of Reclamation Organization. General plans for regulation of Clark Canyon Dam and Reservoir are under the direction of the Reservoir Regulation Branch of the Upper Missouri Region office in Billings, Montana. Prior to January 1976, the Bureau's East Bench O&M Field Branch office located in Dillon, Montana operated the control works of both Clark Canyon and Barretts Diversion Dams. (Gate manipulation to regulate releases from these two dams is made remotely from the Dillon office.) The chief of this office was designated the dam tender. He was responsible for usage of irrigation water from Clark Canyon Reservoir. In January 1976, the Bureau turned the duties of the Dillon office over to the water users. The District Manager of the East Bench Irrigation District then became the designated dam tender. The dam tender's duties for flood control operation are outlined in Exhibit III. Section D of this exhibit gives Bureau and operating personnel.

5-04. Communications. Telephone facilities are available for communication between the dam tender, the District Reservoir Regulation Section and the Bureau of Reclamation offices. Reports of reservoir operating data are normally sent by post card from the dam tender to the Upper Missouri Region office and then forwarded to the Corps of Engineers Reservoir Regulation Section in Omaha. During flood periods the Reservoir Regulation Section will obtain operating data by telephone from either the dam tender or the Reservoir Regulation Branch in Billings or via National Weather Service transmission means.

5-05. Regulation Orders. Except for emergency conditions outlined in Exhibit III, issuance of regulation orders when the pool is in flood control zone is the function of the Reservoir Regulation Section of the Omaha District. Oral instructions issued by the District Engineer to the Regional Director or the dam tender shall be confirmed in writing under date of the day issued. A copy of this order will be furnished the MRD Reservoir Control Center. This copy will contain a brief statement giving the background and reasons for issuance of the order.

5-06. Coordination with Other Agencies. Daily project operating data and miscellaneous hydrologic information are exchanged between the Omaha District Reservoir Regulation Section, Bureau of Reclamation Upper Missouri Region office and the dam tender. Cooperation is also maintained with the National Weather Service, U. S. Geological Survey, and Soil Conservation Service relative to the collection and reporting of precipitation amounts, snow water content, stream stages and discharges.

SECTION VII - FORECASTS PERTINENT TO RESERVOIR REGULATION

7-01. Weather Forecasts. General weather forecasts furnished every 6 hours by the National Weather Service consist of weather conditions during the next 48 hours. A 3-day extended outlook (48 to 120 hours) of weather conditions is furnished once daily and a 30-day forecast of weather conditions is furnished on the 1st and 15th day of the month. These forecasts, together with the various weather maps on the National Facsimile Network and 6-hour weather analyses received on the National Weather Service "Circuit C" Teletype network are used by the Reservoir Regulation Section to obtain knowledge of impending hydrologic conditions related to the regulation of Clark Canyon Dam for flood control purposes.

7-02. Long-Range Runoff Volume Forecast. Except for runoff from intense rainfall, inflow to Clark Canyon Dam which might require storage in the flood control zone is essentially limited to the April through July snow-melt runoff period. A method of forecasting inflow during this period, utilizing snow course and precipitation reports given in Section VI, is presented in Exhibit IV.

7-03. Short-Range Runoff Forecast. Short-range rainfall-runoff forecasts are not made, since the Barretts, Dillon and Twin Bridges gages provide adequate control points for the river below. Also, because of the sparsity of precipitation stations and the fast peaking time on the tributaries, the data obtained would not be adequate to make an accurate forecast in time to control the releases by short-range forecasts.

7-04. Short-Range Stage and Discharge Forecast. Forecasts of discharge are made for Barretts by lagging the Clark Canyon outflow 4 or 5 hours and adding to this an estimated discharge for the runoff from the incremental area between Clark Canyon Dam and Barretts. The incremental area discharge can be estimated by careful observation of the discharge differences between these two stations. Forecasts of discharge are made for Dillon by lagging the Barretts discharge 5 or 6 hours and adding to this an estimated discharge for the runoff from the incremental area between Barretts and Dillon. This incremental area discharge can be estimated by observation of the discharge differences between the Barretts and Dillon gages. A more precise method of predicting local runoff above and below the dam could be made with the addition of more stream and precipitation gaging stations and stage readings. However, it is felt that the acquiring of additional data does not warrant the added cost.

SECTION VIII - MULTI-PURPOSE REGULATION

8-01. General. Since Clark Canyon Reservoir is the storage facility for the East Bench Irrigation Unit, irrigation is the primary conservation usage function of the reservoir. Recreation, industrial water supply and fish and wildlife are other conservation functions served by the reservoir. A municipal water supply can be furnished the city of Dillon should they ever require it. Flood control regulation is given in Section IX.

8-02. Conservation Regulation. Generally the conservation pool is kept as full as possible, consistent with downstream requirements. Water is normally stored in the conservation pool any time downstream senior rights are satisfied. The Water Commissioner for the Beaverhead River advises the Dam Tender to what extent inflows must be bypassed to satisfy downstream water rights. The Dam Tender determines the daily irrigation requirement for lands to be served from the reservoir. He will then coordinate the total requirements and have releases adjusted accordingly.

8-03. Flows of 200 c.f.s. at Clark Canyon Dam and 250 c.f.s. at Barretts are desirable flows for maintenance of the downstream fishery. However, these flows cannot be maintained in all years. During low flow years, 25 c.f.s. below Barretts is considered the minimum flow. The Reservoir Regulation Branch evaluates the available water supply and advises the Dam Tender of the minimum flow to be maintained. If necessary, the minimum release will be made when forecasts indicate insufficient inflows to reach 110,000 acre feet in storage (pool level 5531.7) by 1 March. The Dam Tender notifies the State Fish and Game Commission whenever releases are to be reduced to less than 100 c.f.s. Except for a few short periods, releases have not been reduced to less than 100 c.f.s. since 1967. There are no requirements to maintain specific reservoir elevations for recreation purposes.

8-04. Annual Operating Plan. Each year the Bureau of Reclamation publishes a report of reservoir operations during the preceding water year together with their planned operation of reservoirs during the coming year. The operation of Clark Canyon Reservoir is included in this report. The report is prepared by the U.S.B.R.'s Upper Missouri Region Reservoir Regulation Branch following the ending of the water year on 30 September.

SECTION IX - FLOOD CONTROL REGULATION

9-01. Objectives for Flood Control. Clark Canyon Reservoir will be regulated for flood control primarily to reduce flooding within the City of Dillon, Montana, and through the Beaverhead Valley downstream of the project. As feasible, the reservoir will also be regulated to assist in the reduction of flood damages on the Missouri River by withholding water from Fort Peck Reservoir during certain years.

9-02. Classification of Flood Control Regulation. In general, the developed method of flood control regulation of Clark Canyon Reservoir may be classified as Method C defined in EM 1110-2-3600. This represents a combination of the concept of reducing downstream damaging stages as much as possible during each flood with the currently available storage space, with consideration of control of floods of project design magnitude.

9-03. Proposed Plan of Regulation. The regulation plan for the objectives given above and as developed into the Flood Control Diagram are as follows:

a. Local Flood Control. Project releases will be made as necessary to prevent the discharge from exceeding 1,500 c.f.s. at the Barretts gage. (The only exception to this would be in the event of occurrence of high inflows in combination with pool elevations above 5556.5. The regulation schedule on plate 16 may indicate greater releases are required while still within the flood control zone to reduce the maximum release later on.) Travel time from Clark Canyon Dam to Barretts is about 4 or 5 hours. The flow at Barretts will be forecast as given in paragraph 7-04. If at any time the above Barretts control does not provide non-damaging flows at Dillon or along the entire Beaverhead River below Clark Canyon Dam, consideration will be given to reduction of project outflow to minimize the damages.

b. Replacement Flood Control. In the years when forecast and storage conditions for Fort Peck Reservoir, along with the main stem reservoir system, indicate that replacement regulation will be needed at Clark Canyon Reservoir, the release rates will be adjusted to store the required amount by 15 July if possible while also providing for conservation releases. As soon as it is determined that supplemental storage will be needed (to be determined by the Missouri River Division Reservoir Control Center usually between 1 January and 1 March except in years when runoff prospects generate later than this period) forecasts of Clark Canyon inflow for the April-June period will determine if evacuation of joint use storage space should be made for replacement - flood control purposes. As additional information becomes available additional forecasts of inflow will be made and release schedules modified as needed to fill the required space by 15 July. Normally, conservation releases of 12,000 acre-feet for April, 15,000 acre-feet for May and 25,000 acre-feet for June will be made; however, if necessary, releases may be modified to minimum conservation requirements in an effort to fill as much

Clark Canyon
Exceeded 5546.1

1965	1'	
1971	1.3'	(Jul 01)
1975	10.8'	(Jul 22)
1976	8.4	(Jun 25)
1977	.3	(May 03)
1978	1.4	(May 20)
1979	2.2	(May 22)
1980	2.2	(Jun 17)
1981	4.7	(Jun 11)
1982	3.5	(Jul 19)
1983	1.8	(Jul 19)
1984	18.6	(Jun 25)
1988	.5	(Apr 29)

Releases start mid-may

Our Apr. 1 forecast < 50% normal

Snowpack 60-70% normal

space as possible. When operating for supplemental storage in conjunction with the main stem reservoir system, water stored for this purpose will not be released in excess of conservation needs until after spill above Fort Peck powerplant capacity has ended or about 15 July unless drawdown of this storage is directed otherwise by the District Engineer. After this time water will be released as directed by the District Engineer. This drawdown will normally be accomplished in a rapid manner, while maintaining non-damaging flows below the dam. Normally, replacement regulation of Clark Canyon Reservoir and other tributary reservoirs contributing this type of storage space will be required in the years when a major amount of the annual flood control storage space in the six Missouri River main stem reservoirs is forecast to be used in storing flood inflows. The total space requirement will be dependent on the magnitude of expected inflows and anticipated storage needs to augment the annual flood control and multiple-use functions of the main stem systems.

c. Joint Use Storage. This space will normally be used for conservation purposes except when required for flood control and/or replacement purposes as indicated by the Flood Control Storage Reservation Diagram.

9-04. Regulation Schedule. Regulation curves on Plate 16 were developed by the methods described in paragraph 4-06 of EM 1110-2-3600. They will serve as a basis for regulation when other information may not be available. They are based on a flood hydrograph with a 15-day recession which is representative of a mountain snowmelt recession. They give the minimum releases for any combination of pool elevation and inflow to assure effective use of the flood control storage by (1) filling the flood control storage, (2) reducing the maximum flood releases, and (3) reducing the magnitude of changes in release rates. Inflows will be computed once daily except when inflow is above 3,000 c.f.s. or when the reservoir is above elevation 5556.5, then inflows will be computed at least twice daily. Suggested releases are determined, from Plate 16, by utilizing the mean inflow for the previous period (not less than 12 hours) and the current reservoir elevation.

9-05. Emergency Flood Control Regulation. Refer to Exhibit III, Section C, for emergency flood control regulations.

9-06. Regulation for Floods Exceeding Project Size. When it becomes apparent that the pool elevation will exceed the top of the flood control pool (elevation 5560.4) the Regional Director will be notified. Operation of the reservoir is the responsibility of the Bureau when the reservoir level is in the surcharge pool. A total of 11.5 feet of surcharge with a capacity of 71,800 acre-feet has been provided above the flood control pool. When the pool level is above the exclusive flood control pool, the District Engineer may make recommendations to the Regional Director for operation in interest of flood control, but such recommendations shall not be considered mandatory.

9-07. Further Consideration. Located in the reservoir between elevations 5546.1 and 5556.5 (the replacement storage zone) is a considerable amount of recreation development (picnic tables, latrines, wells, etc. reference Plate 13). One of the shelters becomes inundated at elevation 5546.1 and one of the latrines becomes inundated at elevation 5550.1. Consideration of effects of inundating these developments should be considered before storing water for replacement purposes. However, when the decision is made to store water for this purpose, local news media and the Montana State Fish and Game Department should be notified accordingly so that protective measures can be made in advance of water storage.

SECTION X - EXAMPLES OF FLOOD CONTROL REGULATION

10-01. Project Design Flood. The project design flood for flood control storage allocation purposes was derived for Barretts (90 percent of this was used as the flow at the Clark Canyon Damsite). This flood was derived by combining the 1917 snow accumulation using synthetic spring temperatures from 1934 to time runoff, and rainfall based on the storm of 9-15 June 1944. A peak flow of 5,800 c.f.s. and a 60-day volume of 250,000 acre-feet (85,000 A.F. over 1,500 c.f.s. release) resulted. Routing of this flood using regulation curves described in paragraph 9-04 is shown on Plate 17.

10-02. In this routing and the examples in paragraph 10-03 and 10-04 below, a release rate of 500 c.f.s. was used prior to the time higher rates are indicated by the regulation curves. This rate represents a reasonable conservation release and was selected in developing the regulation curves. In order to contain the project design flood in the flood control zone, while routing it using regulation curves based on a representative recession this initial release rate proved satisfactory.

10-03. Spillway Design Flood. The inflow design flood, as developed by the Bureau of Reclamation, has a peak discharge of 21,500 c.f.s. and a 15-day volume of 250,000 acre-feet. It is a combination of the largest snowmelt runoff augmented by rainfall as recorded at the Barretts gage (occurred in 1917 with a 15-day volume of 61,000 acre-feet) plus the runoff from a 24-hour rainfall of 5.58 inches over the 1,755 square miles above Clark Canyon damsite and below Lima Reservoir. Routing of this flood using the flood control regulation curves is shown on Plate 18.

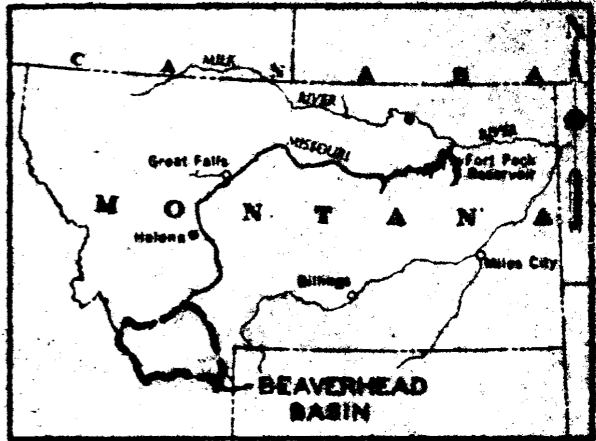
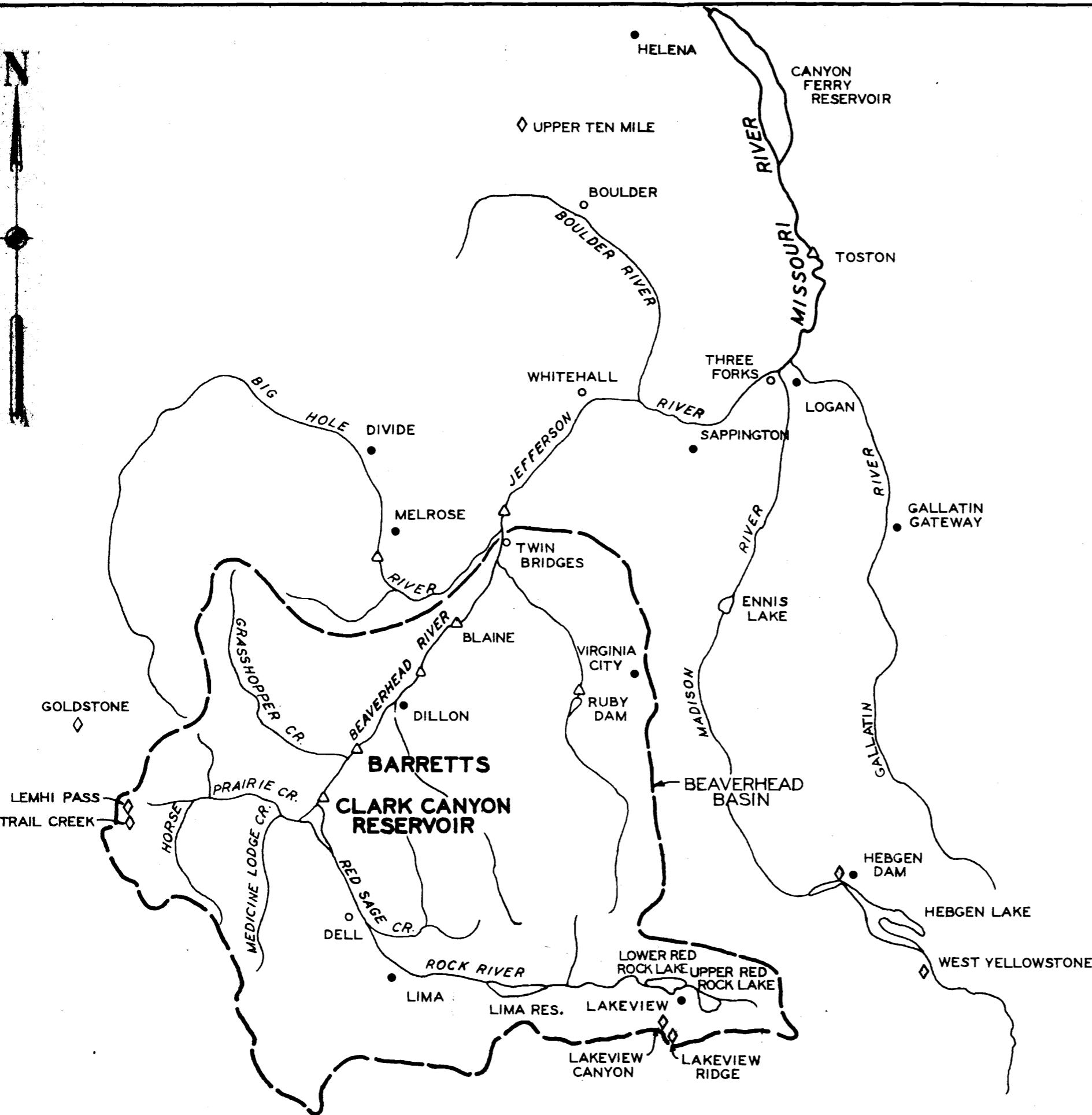
10-04. Flood of 1908. The greatest flood of record along the Beaverhead River occurred in June of 1908 as a result of rain combined with snowmelt. Dillon, Montana, reported 13.04 inches of precipitation for the April through June period (0.34 inches in April, 9.16 inches in May and 3.54 inches in June). At Barretts, this flood had a peak flow of 3,720 c.f.s. and an estimated 60-day volume of 220,000 acre-feet. Routing of this flood using regulation curves is shown on Plate 19.

10-05. Flood of 1944. The greatest flood on the Beaverhead River of which there is a record of monetary losses occurred in June 1944, also as a result of rain combined with snowmelt. Dillon, Montana, reported 9.51 inches of precipitation for the April through June period (0.46 inch in April, 2.14 inches in May and 6.91 inches in June). At Barretts, this flood had a peak flow of 3,060 c.f.s. and a 60-day volume of 151,000 acre-feet. A reservoir routing for this flood event is not presented herein inasmuch as inflow peaks and volumes were significantly less than during the 1908 flood described above.

10-06. Regulation During 1975. High runoff in 1975 also came as a result of rain combined with snowmelt. Dillon, Montana, reported 8.36 inches of precipitation for the April through June period (2.55 inches in April, 2.54 inches in May and 3.27 inches in June). Forecast of seasonal runoff indicated near normal runoff both above Clark Canyon and above Fort Peck until 1 April. Then the forecast of April-June natural runoff above Clark Canyon increased from 134% on 1 April, 162% on 1 May to 156% on 1 June. May-July forecast above Fort Peck increased from 110% on 1 April, 148% on 1 May, to 175% on 1 June. The increase in forecast resulted from the above average precipitation. This resulted in buildup of the mountain snowpack. Because of (1) the high Fort Peck pool level (2243 on 12 May), (2) the almost assured prospect of eventual spill past the Fort Peck powerplant and (3) the increasing runoff forecasts, the decision to regulate Clark Canyon for main stem replacement storage was made on 12 May. Releases from Clark Canyon were then set to the minimum conservation rate until the replacement storage space was filled the first week in July. On entering the exclusive flood control zone, releases were made up to downstream channel capacity levels in an effort to maintain the pool at this base. The maximum pool elevation achieved was 5556.87 feet on 11 July. About 2,100 of 22,615 acre-feet of exclusive flood control storage was utilized. Clark Canyon had a peak daily inflow of 2,800 c.f.s. on 20 June and a 60-day inflow volume of approximately 160,000 acre-feet. The peak inflow was the maximum since the project was completed in 1964. The maximum natural daily flow at Barretts was estimated at 3,900 c.f.s. This would have exceeded the previous 1908 peak flow. When it became evident that spill past the Fort Peck powerplant would cease, evacuation of the Clark Canyon replacement storage was initiated (28 July). Releases were made at downstream channel capacity levels. In October, when heavy rains occurred and major irrigation diversions ceased, high water occurred in the area of Blaine to Twin Bridges. Releases were then reduced and final evacuation of the lower portion of the flood pool was prolonged until the end of the year. Plate 20 illustrates the regulation during 1975.

10-07. During this year, use of the Flood Control Diagram did not require any spill above conservation release levels until the pool entered the exclusive flood control zone. The reason being that the pool level was at much below normal levels at the beginning of year and conservation releases were such that the pool level remained below the diagram forecast parameter values requiring spill for local flood control. The beginning of the year pool elevation was at its lowest level since 1967, primarily because of the low runoff and high irrigation demand during the previous year. The 1 January (1975) pool elevation was about 60,000 acre-feet below the top of the conservation pool level. Forecasts of remaining April-June Clark Canyon inflow (For Diagram Use) in percent of normal were 72 percent on 1 January, 88 percent on 1 February, 96 percent on 1 March, 122 percent on 1 April, 168 percent on 1 May and 97 percent on 1 June.

10-08. Past Regulation. Actual regulation from 1964 through 1975 is illustrated on Plate 15. In all years except 1975, regulation for flood control has resulted in only minor storage above the top of the joint use zone. When storage has been accumulated above this level, it has been evacuated as rapidly as downstream conditions permit.



LOCATION MAP

LEGEND:

- ◇ SNOW STATIONS
- △ STREAM GAGING STATIONS
- PRECIPITATION STATIONS
- OTHER PERTINENT PLACES

**BEAVERHEAD BASIN
CLARK CANYON RESERVOIR
BEAVERHEAD DRAINAGE AREA**

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

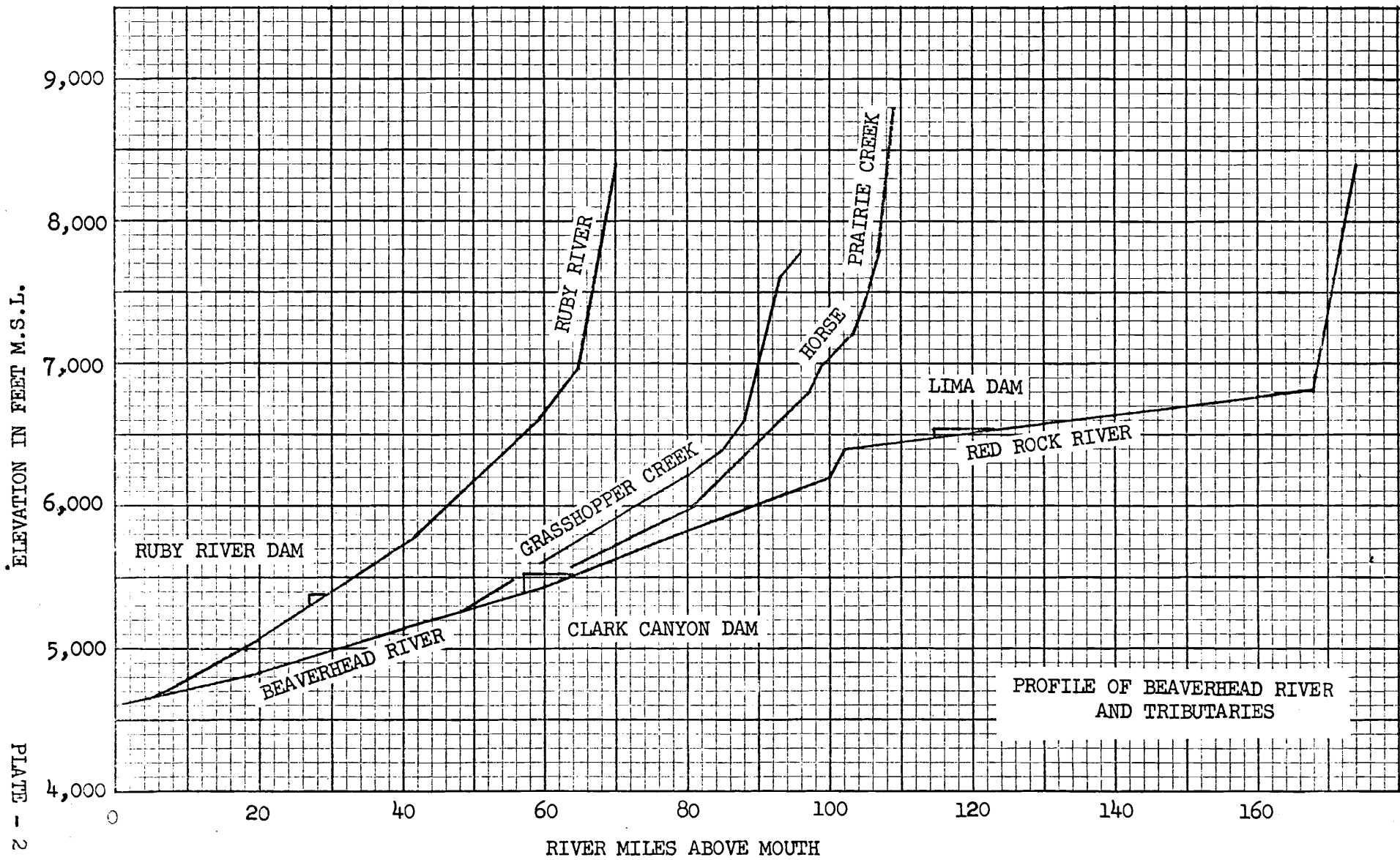
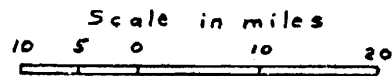
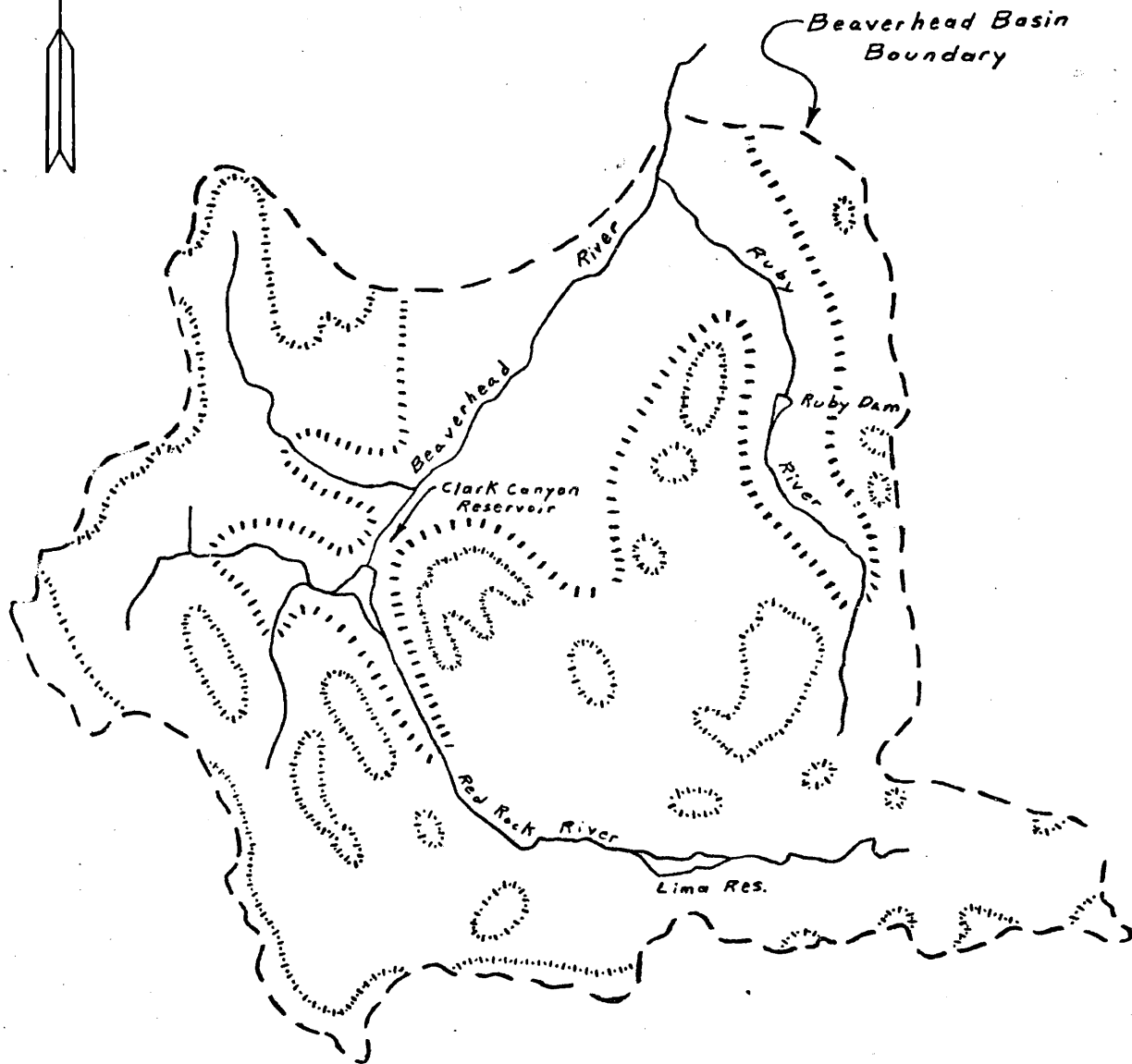


PLATE - 2

PROFILE OF BEAVERHEAD RIVER AND TRIBUTARIES



Contour	Elevation
	6,000 Feet
	8,000 "

CLARK CANYON RESERVOIR
BEAVERHEAD RIVER BASIN
HIGH ELEVATION AREAS

STREAM GAGE
STAGE DISCHARGE RATING

Beaverhead River Discharge in C.F.S.

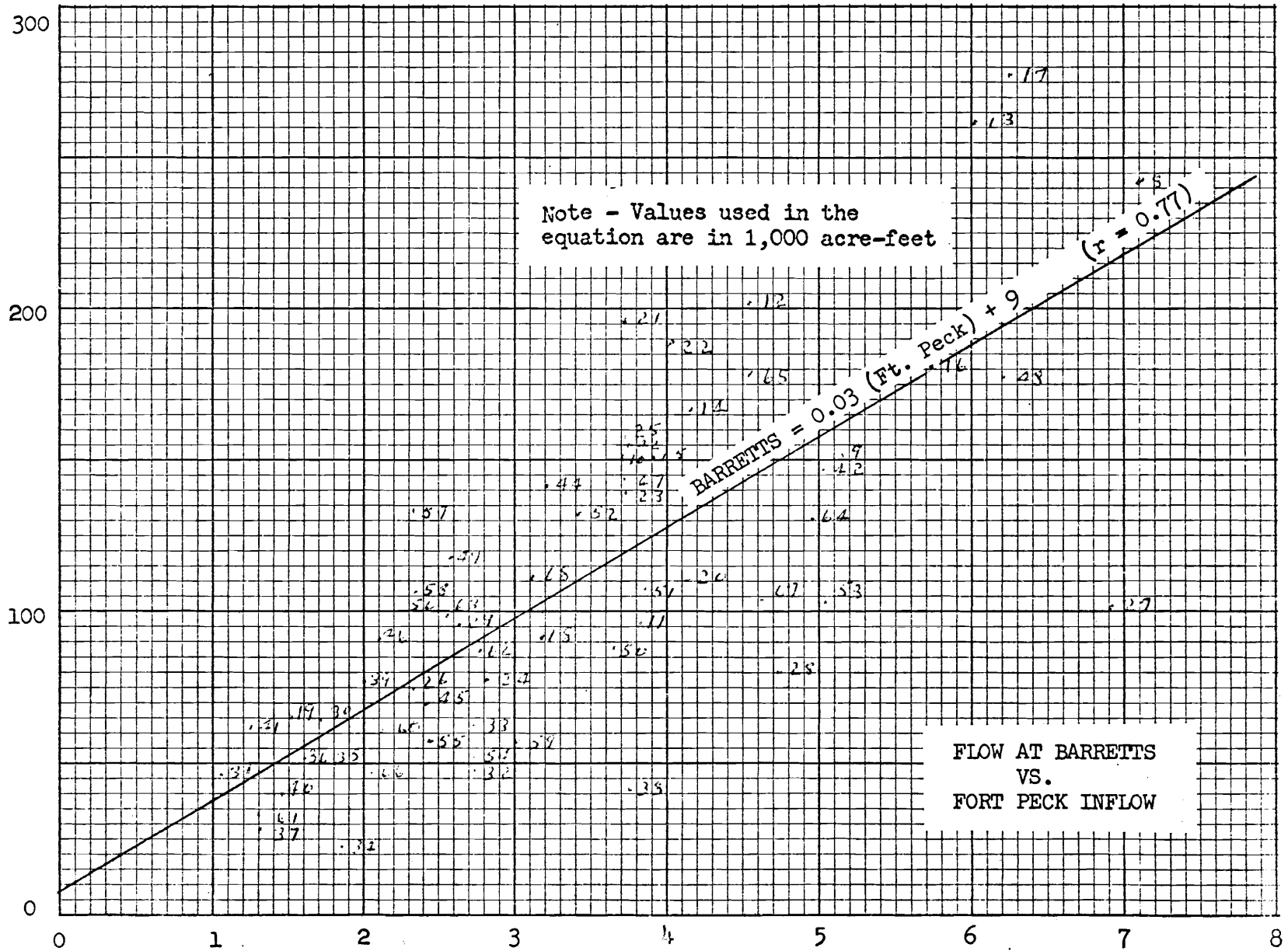
<u>Gage Ht.</u> <u>In Feet</u>	<u>Nr. Grant</u>	<u>At Barretts</u>	<u>Nr. Dillon</u>	<u>Nr. Twin Bridges</u>
0.5				
1.0		225		
1.5		440		
2.0		710		
2.5		1030		
3.0		1330	110	
3.5	50	1630	260	
4.0	190	1930	470	170
4.5	400		740	300
5.0	625		1020	440
5.5	890		1320	610
6.0	1150		1660	800
6.5	1430			1030
7.0	1700			

Flood Stages

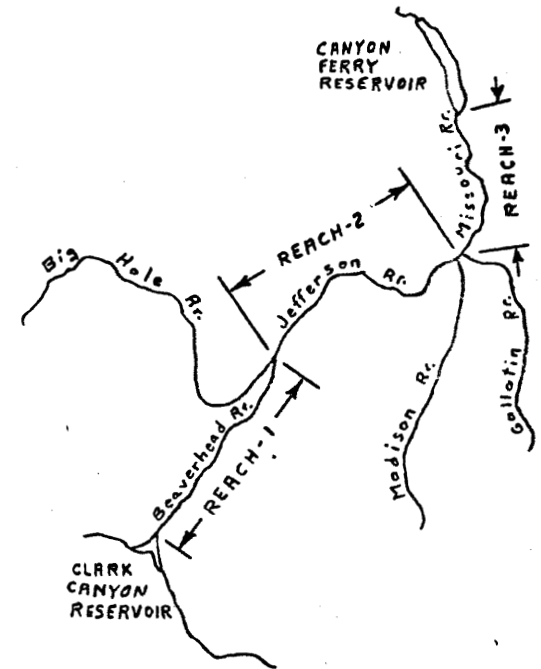
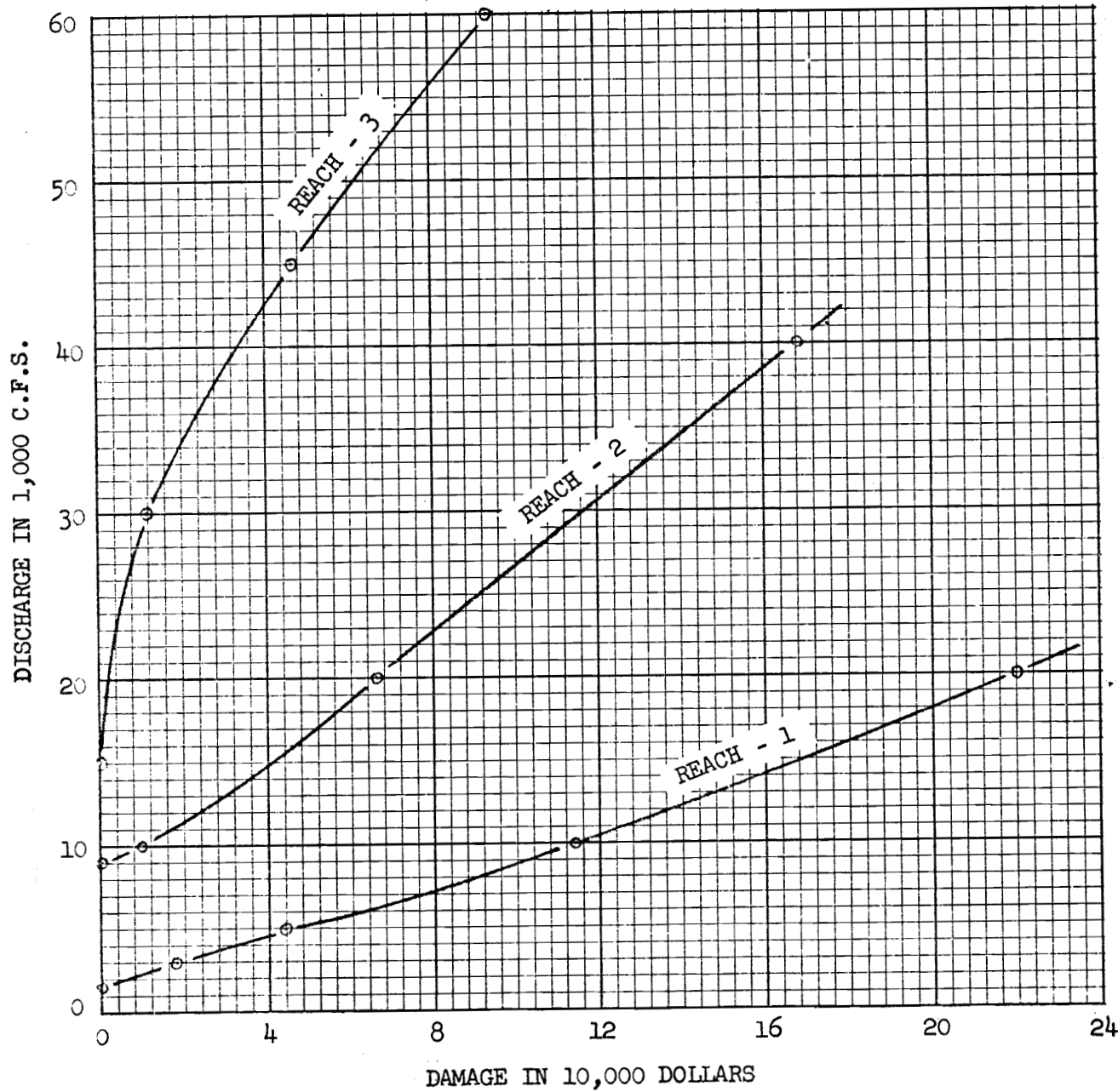
Nr. Grant - Unknown
 At Barretts - 3.3 Ft.
 Nr. Dillon - Unknown
 Nr. Twin Bridges - 6.2 Ft.

CLARK CANYON RESERVOIR
 STREAM GAGE
 STAGE DISCHARGE RATING

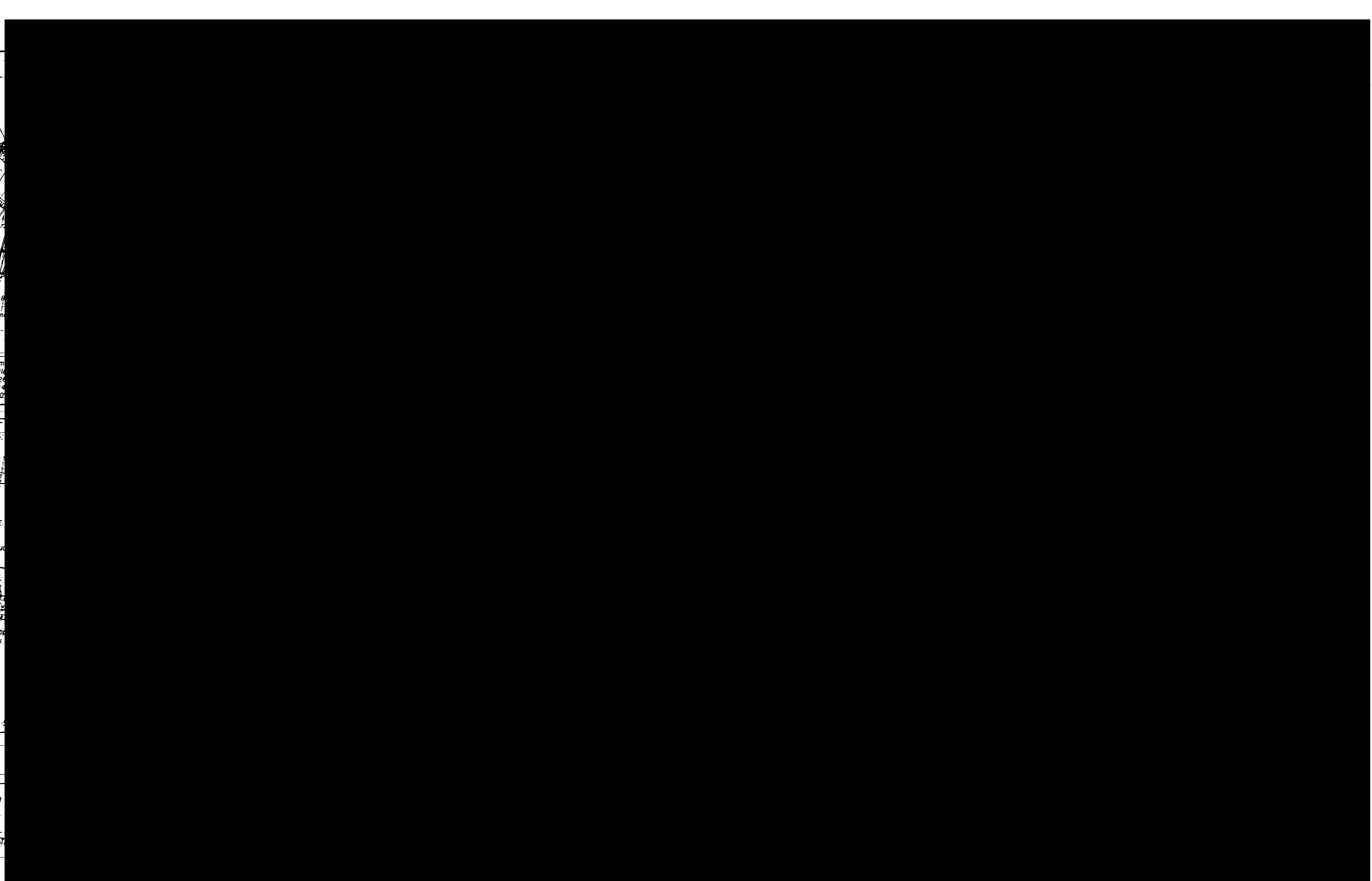
APRIL MAY JUNE FLOW IN THOUSAND ACRE-FEET

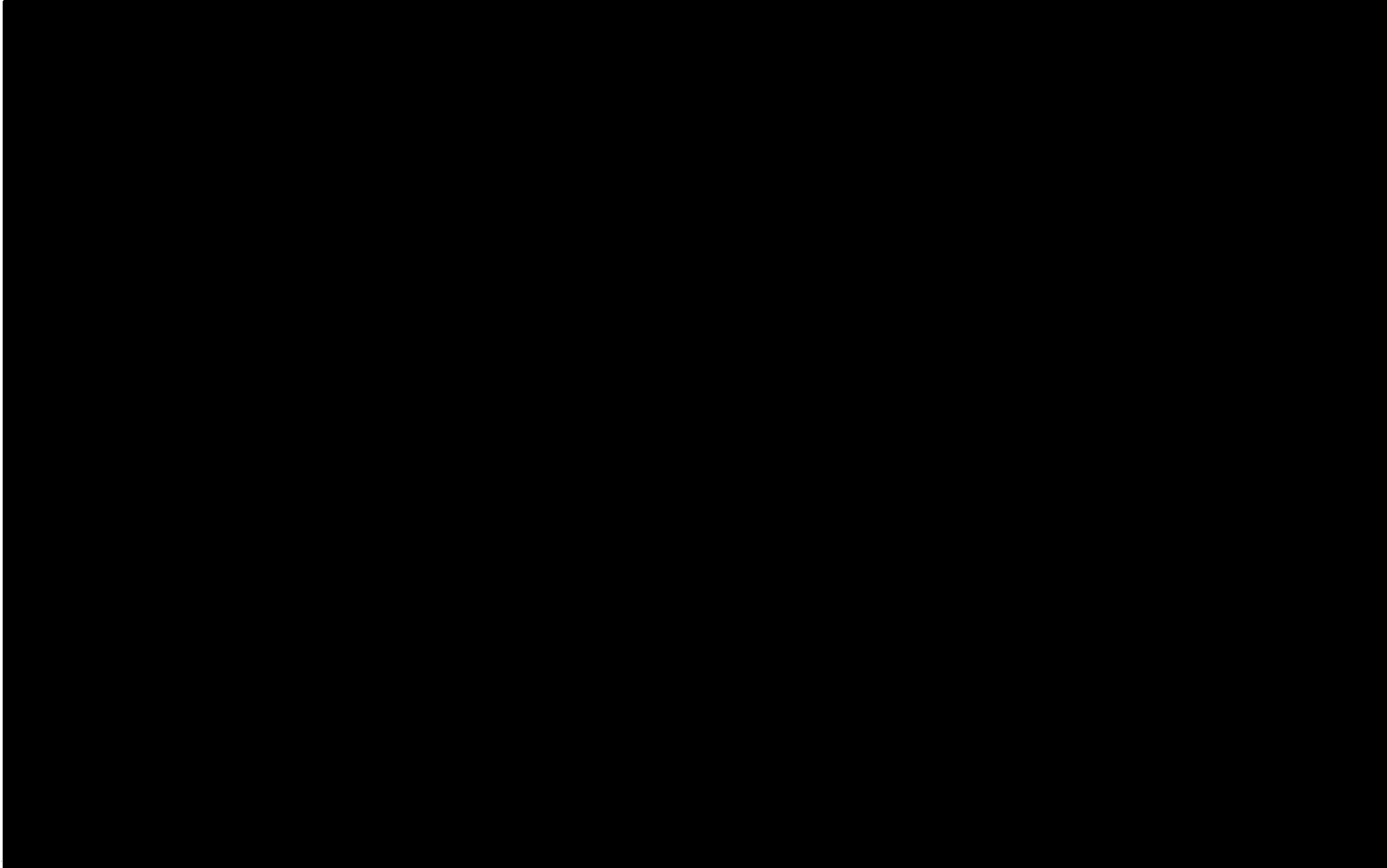


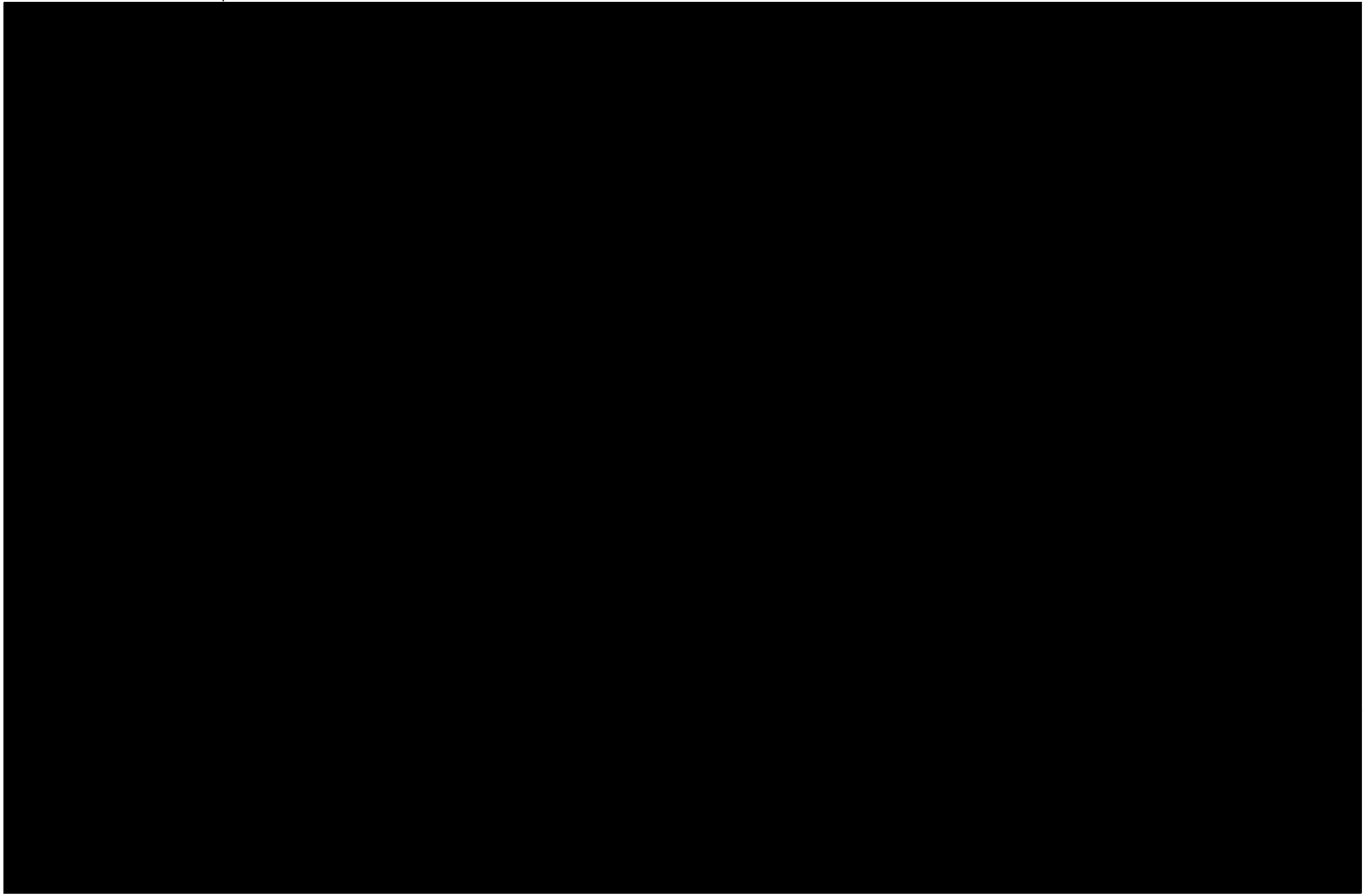
MAY JUNE JULY - FORT PECK INFLOW IN MILLION ACRE-FEET

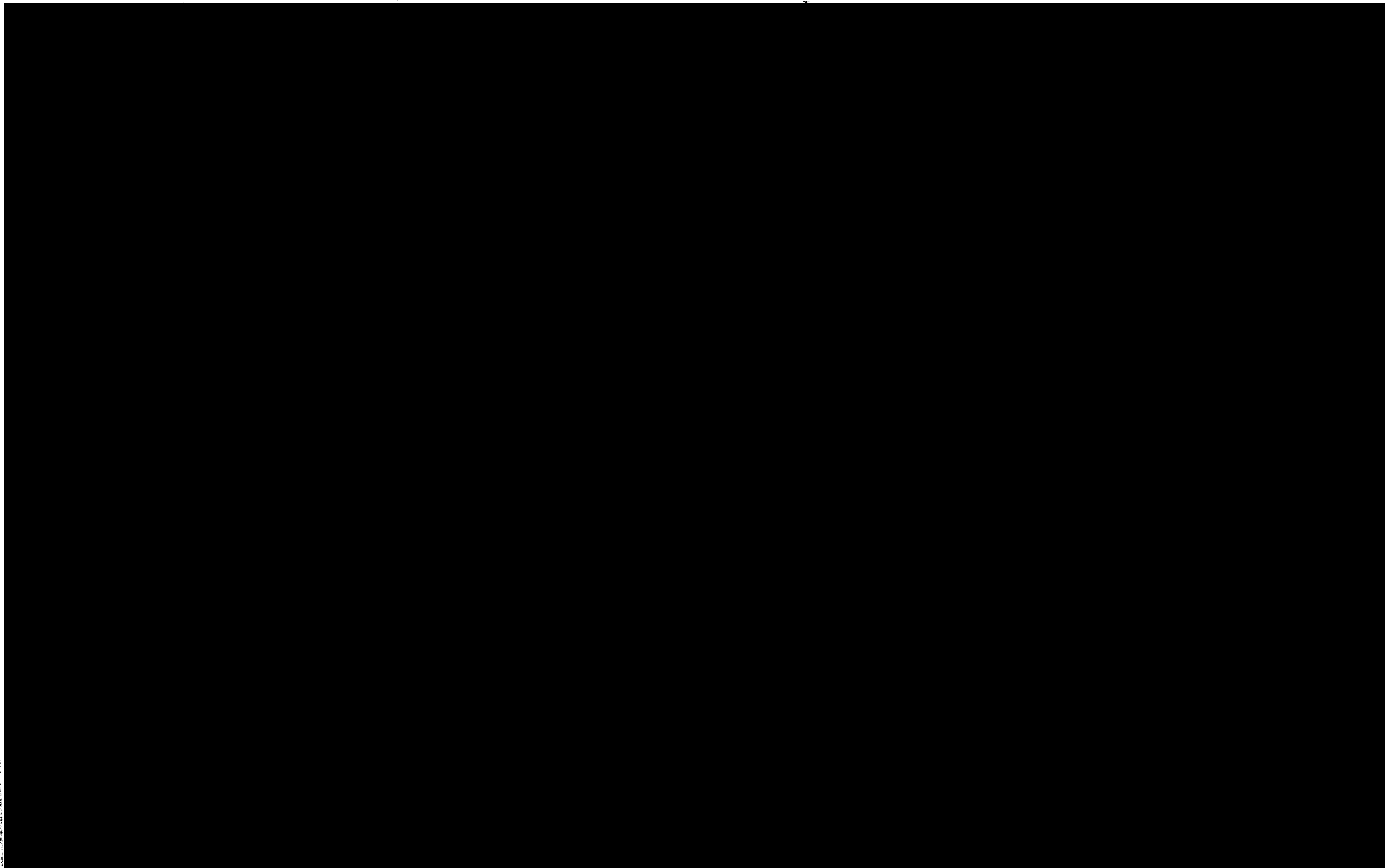


CLARK CANYON RESERVOIR
DISCHARGE-DAMAGE
1967 PRICE LEVELS









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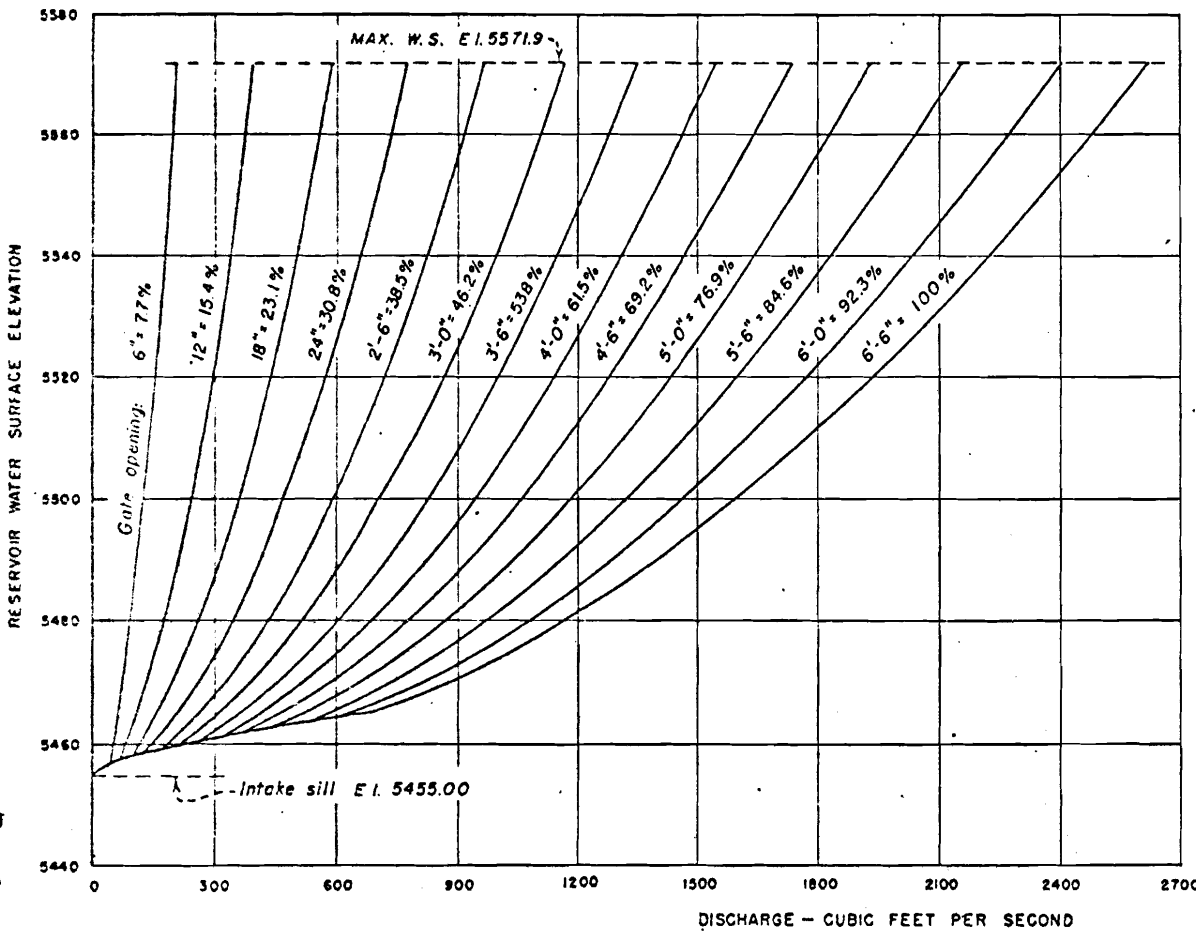
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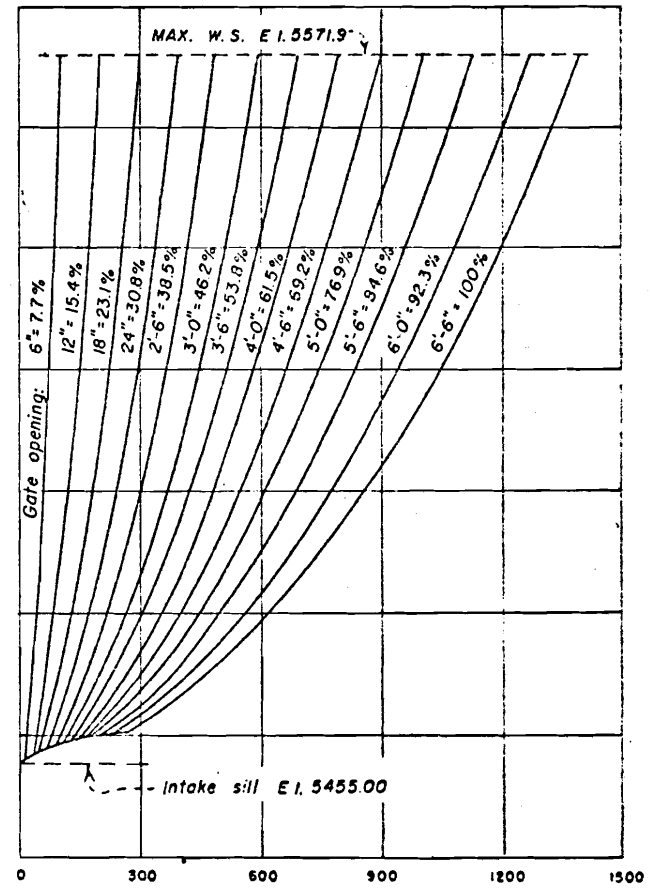
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PLATE-10

BOTH GATES OPERATING



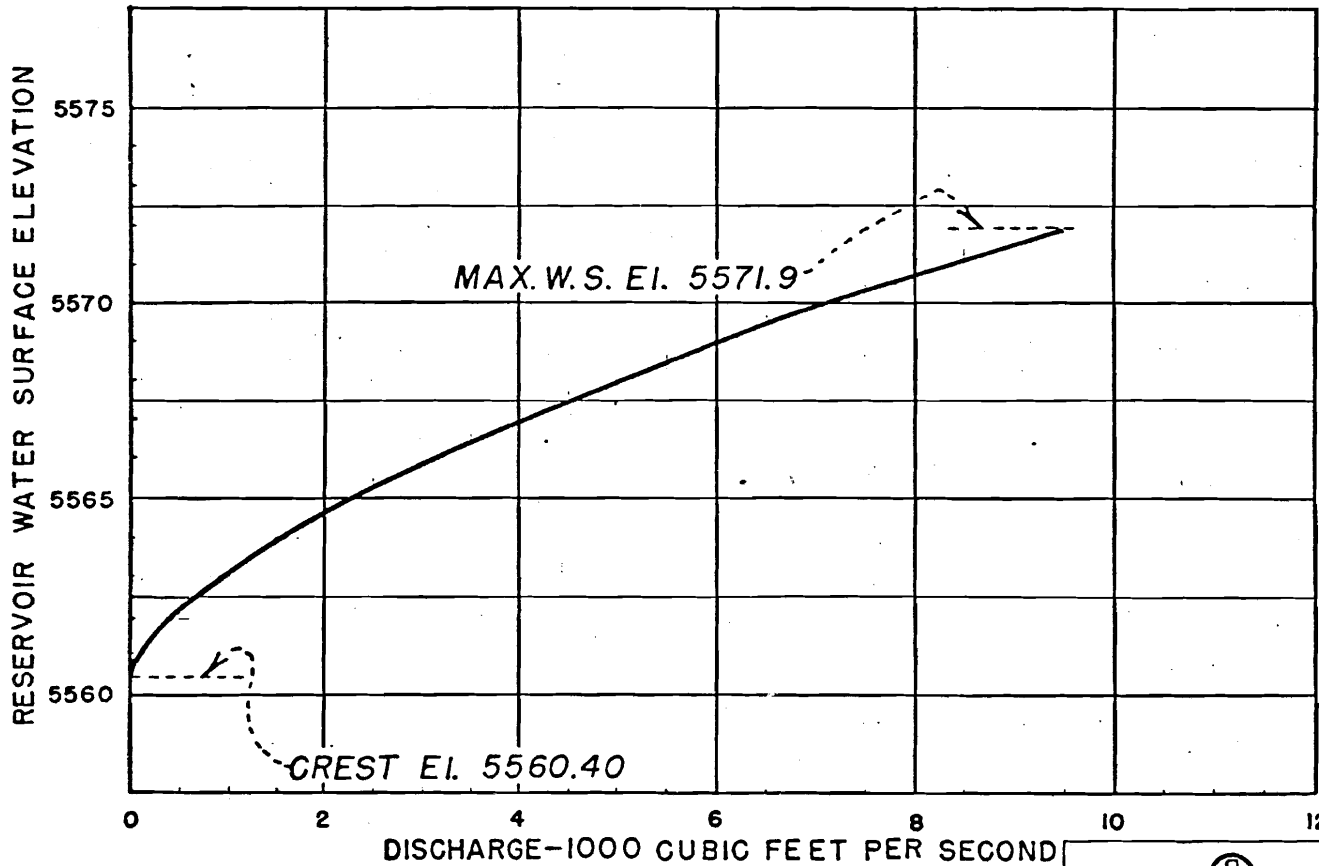
ONE GATE OPERATING



The two gates should be opened equal amounts to insure symmetrical flows in the downstream conduit. For conditions which involve gate openings of 2 inches or less, one gate only should be used.

NOTES
 Gates: 2- 3'-0" x 6'-6" H.P. regulating gates.
 Any variations in discharge from these curves as determined by flow measurements downstream of the outlet works should be reported to the Chief Engineer.

UNITED STATES
 DEPARTMENT OF RECLAMATION
 BUREAU OF RECLAMATION
 MISSOURI RIVER BASIN PROJECT
 THREE FORKS DIV.-EAST BENCH UNIT-MONTANA
CLARK CANYON DAM
 OUTLET WORKS-DISCHARGE CURVES
 DRAWN BY... SUBMITTED BY...
 TRACED, P.A.D., RECOMMENDED BY...
 CHECKED BY... APPROVED BY...



Any variations in discharge from this curve as determined by measurements of flow downstream from the spillway should be reported to the Chief Engineer.

 ALWAYS THINK SAFETY

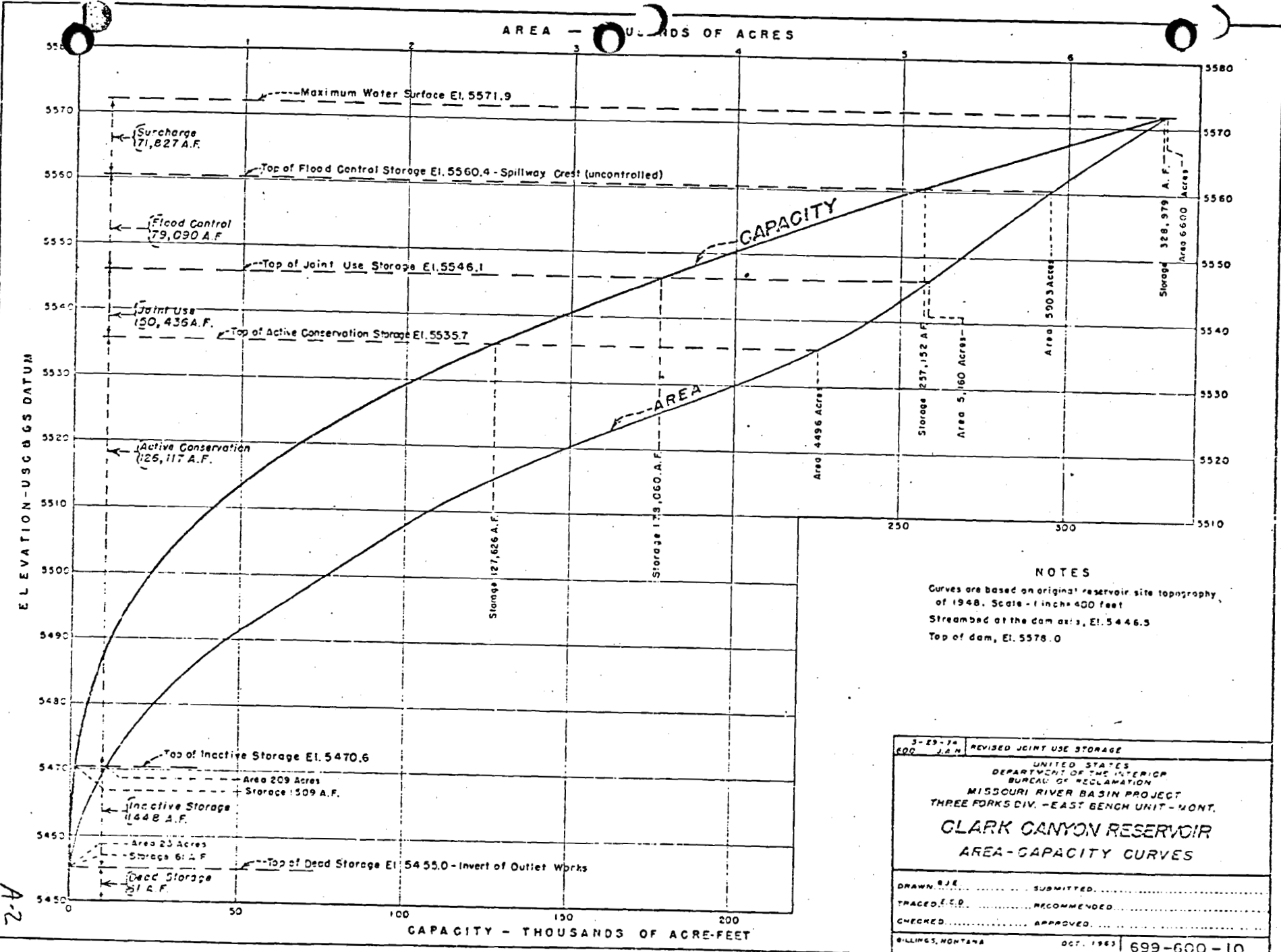
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
THREE FORKS DIV.-EAST BENCH UNIT-MONTANA

CLARK CANYON DAM
SPILLWAY-DISCHARGE CURVE

DRAWN J. I. B. SUBMITTED J. I. B.
TRACED J. M. W. RECOMMENDED J. I. B.
CHECKED C. C. R. APPROVED R. J. Laramie
CHIEF, DAMS BRANCH

DENVER, COLORADO FEB. 6, 1962

699-D-555



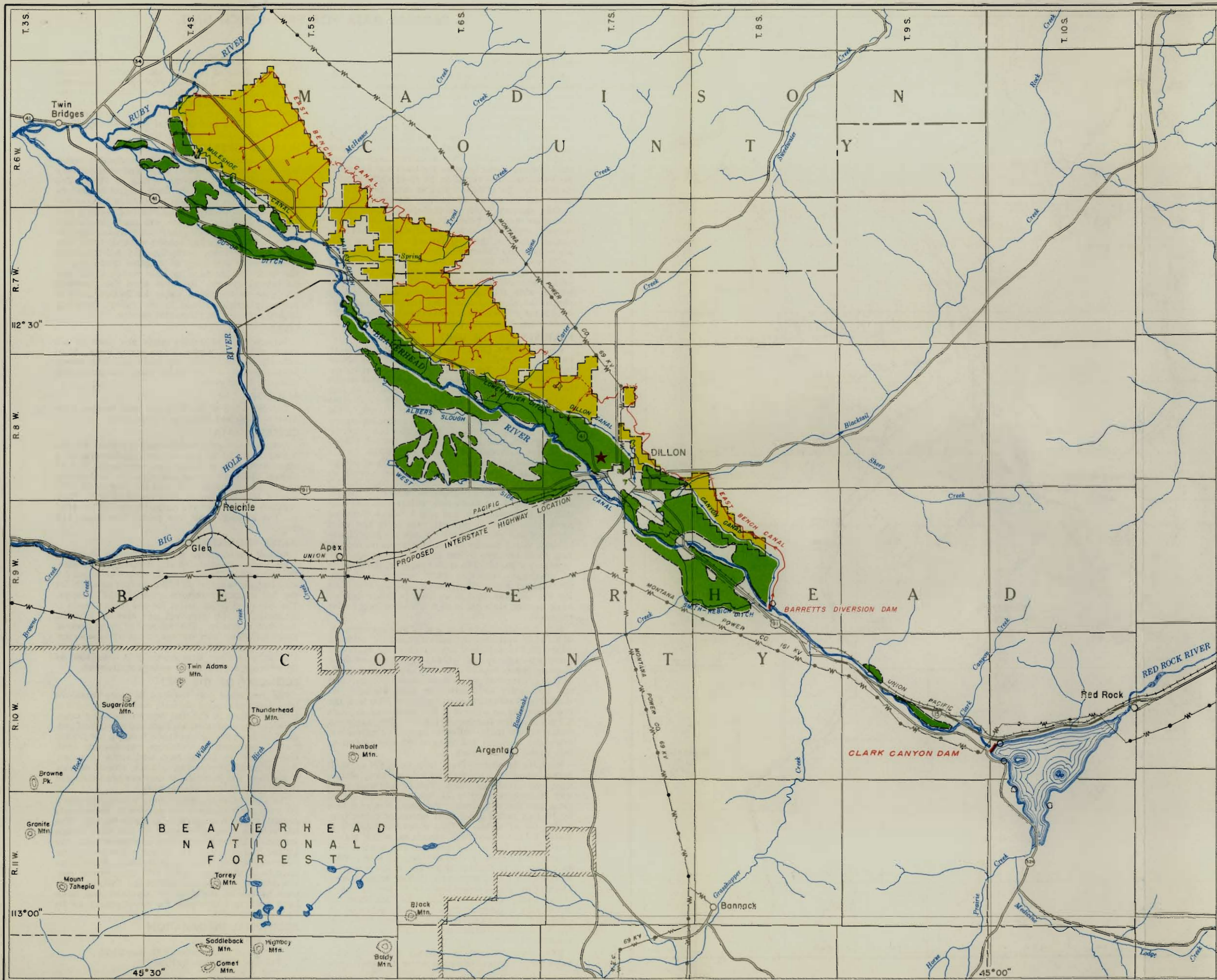
NOTES
 Curves are based on original reservoir site topography, of 1948. Scale - 1 inch = 400 feet
 Streambed at the dam axis, El. 5446.5
 Top of dam, El. 5578.0

3-23-74 600	REVISED JOINT USE STORAGE
UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION MISSOURI RIVER BASIN PROJECT THREE FORKS DIV. - EAST BENCH UNIT - MONT.	
CLARK CANYON RESERVOIR AREA-CAPACITY CURVES	
DRAWN R.J.E.	SUBMITTED.....
TRACED E.E.D.	RECOMMENDED.....
CHECKED.....	APPROVED.....
BILLINGS, MONTANA	OCT. 1963 699-600-10

PLATE - 12

A-2

A2

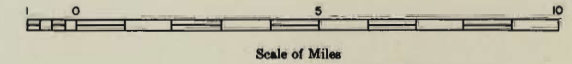


- EXPLANATION**
BUREAU OF RECLAMATION COMPLETED WORKS
- CANAL AND LATERALS
 - SIPHON
 - WASTEWAY
 - FULL IRRIGATION SERVICE AREA (EAST BENCH IRRIGATION DISTRICT)
 - SUPPLEMENTAL IRRIGATION SERVICE AREA (CLARK CANYON WATER SUPPLY COMPANY INC.)
 - PROJECT HEADQUARTERS
 - RECREATION FACILITY
 - STORAGE DAM (PROPOSED)



UNITED STATES
DEPARTMENT OF THE INTERIOR
ROGERS C.B. MORTON, SECRETARY
BUREAU OF RECLAMATION
ELLIS L. ARMSTRONG, COMMISSIONER
PICK-SLOAN MISSOURI BASIN PROGRAM
THREE FORKS DIVISION
EAST BENCH UNIT
MONTANA
(REGION 6)

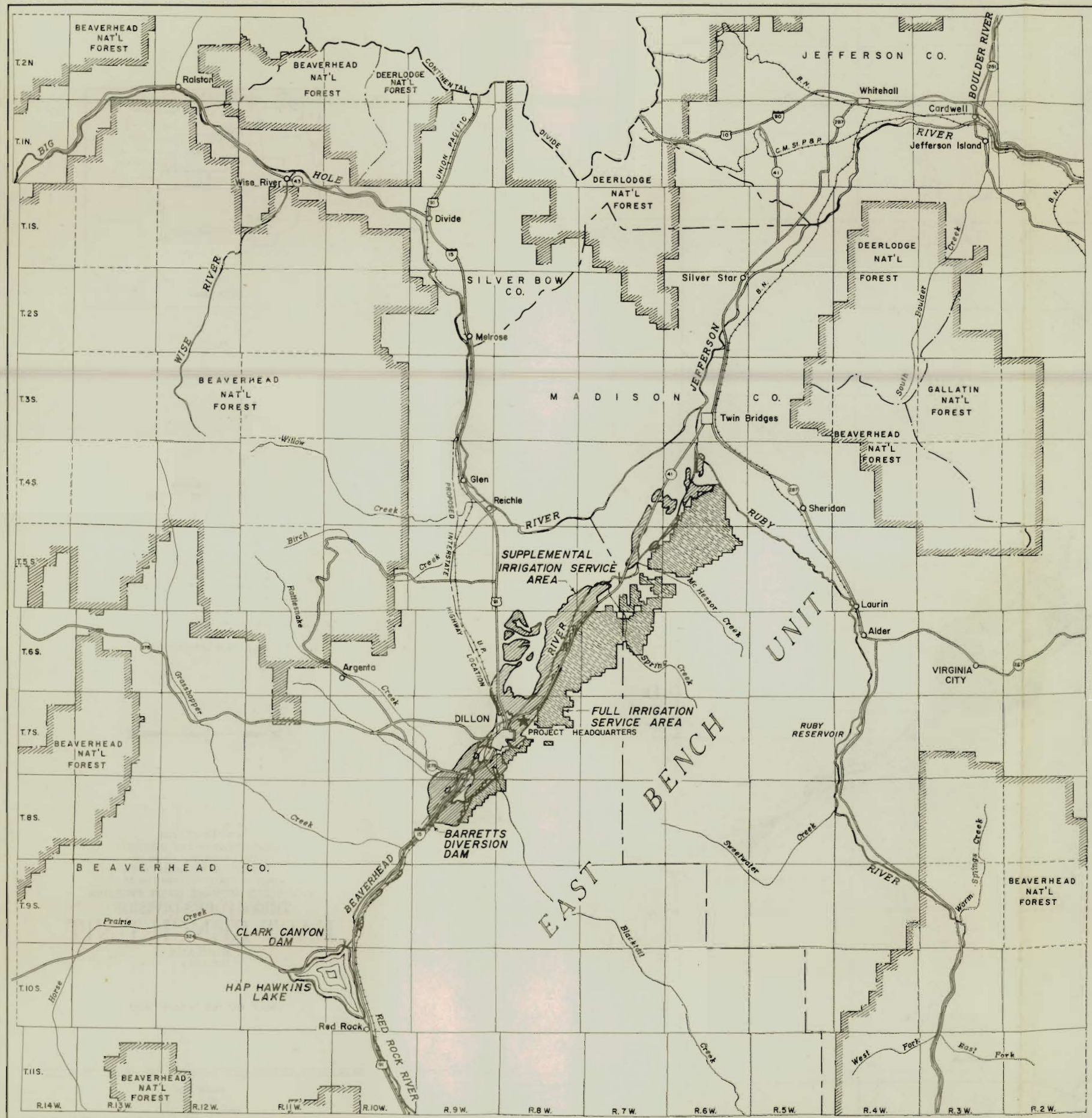
MAP NO. 699-604-800



Scale of Miles
REVISED JUNE 1972

SUPERSEDES MAP NO. 699-604-589

FACTUAL DATA FOR EAST BENCH UNIT



WATER SUPPLY

East Bench Unit, an irrigation development with other incidental benefits, makes maximum utilization of water of the Beaverhead River and tributaries. Stored water released from Hap Hawkins Lake (formerly Clark Canyon Reservoir) is controlled by Barretts Diversion Dam about 12 miles below the reservoir. The area of the watershed upstream of Clark Canyon Dam is approximately 2,315 square miles. An additional 422-square mile drainage area between the dam and diversion works contributes runoff to the river which supplements storage releases and is also available to meet downstream demands. Streamflows are mainly derived from precipitation within these drainage areas; however, many underground springs contribute to the water supply. Average annual runoff at the U.S. Geological Survey gage above Barretts Diversion Dam for the period 1927-1970 was 266,500 acre-feet, and the computed average above Clark Canyon Dam for the same period was 201,000 acre-feet. The total supply of water, with storage regulation, and including return flows, is adequate for irrigation demands except for a few critical years of extended drought when minor shortages may occur.

FEATURES OF THE UNIT

Clark Canyon Dam, the principal feature, is an earth and rockfill structure rising 132 feet above the streambed. The crest of the dam is at elevation 5578 feet above mean sea level. Crest length is 2,950 feet, and the width of the crest is 36 feet which provides a base for the Horse Prairie secondary highway to cross the river. Total volume of material in the dam, including riprap facing, is approximately 1,874,000 cubic yards. An ungated concrete spillway on the left (west) abutment with crest at elevation 5560.4 feet is surmounted by a concrete bridge. Spillway design capacity is 9,500 cfs (cubic feet per second) at maximum reservoir water surface elevation 5571.9 feet. The river outlet structure, also near the left abutment, is a cut-and-cover, 9-foot diameter conduit at the upstream end and a 9-foot diameter flatbottom conduit downstream from the gate chamber and access shaft. Within the gate chamber are two 3-foot by 6-foot high-pressure regulating gates and two 3-foot by 6-foot high-pressure emergency gates. The outlet capacity is 2,650 cfs at maximum reservoir water surface elevation, discharging into a stilling basin separate from that for the spillway, and flows from both are carried back to the river through a 675-foot long outlet channel.

Hap Hawkins Lake has a total storage capacity of 257,152 acre-feet at spillway crest elevation, of which 22,615 acre-feet are allocated as exclusive flood storage space, 46,475 replacement flood storage space, 50,436 acre-feet as joint-use space, 126,117 acre-feet as conservation storage, and the remainder as inactive or dead storage. At maximum water surface elevation, 5571.9 feet, the reservoir has an area of 6,600 acres and extends 6.4 miles up the Beaverhead River. The maximum width in the main valley is about 2.7 miles, but increases to about 4.3 miles at the arm extending into Horse Prairie Creek.

Barretts Diversion Dam is a compact earthfill embankment with concrete aprons, spillway, sluiceway, and canal headwork. The 24-foot wide spillway is equipped with a 24-foot by 10-foot radial gate, and the 8-foot wide sluiceway has an 8-foot by 10-foot radial gate; their combined capacity is 2,500 cfs at water surface elevation 5255 feet. Water to the headworks structure, which serves East Bench Canal and two private canals, first flows over a broad-crested weir topped with gravel, so designed to exclude fish. The outlet works to East Bench Canal have two 10-foot radial gates. The Canyon Canal outlet has one 10-foot by 8-foot radial gate. The Reich Ditch 24-inch diameter outlet pipe is controlled by two slide gates on an inlet box. Maximum capacities of these outlets in the headworks structure are 440, 200, and 12.5 cfs, respectively.

East Bench Canal, a contour alignment 44.2 miles long, carries irrigation water to benchlands

along the northeast side of Dillon Valley. About 31 miles of buried asphaltic and plastic membrane lining are installed in areas where porous materials are crossed. Inverted siphons constructed of concrete pipe are used for crossing most of the larger coulees and numerous other cross-drainage streams. Initial and terminal designed capacities are 440 and 51 cfs, respectively.

PLAN OF OPERATION

Construction of storage and distribution works was completed in 1964 in time for initial delivery of irrigation water in the spring of 1965. The reservoir is operated for flood control as well as irrigation. This operation maximizes the recreational use of picnicking, boating, fishing and camping. Winter releases are made to sustain fishery and to satisfy other downstream requirements. The irrigation season extends from May through September normally, and full irrigation service to 21,800 acres of irrigable land lying on the bench is provided by East Bench Canal and its lateral system. Releases from the reservoir also provide irrigation water for 28,004 acres of presently irrigated land in the valley, including 25,550 acres for supplemental service.

SOILS

Surface soils of arable lands are loam or silt loam, with local areas of fine sandy loam. Most subsoils are stratified silt loam and fine sandy loam deposited over gravelly loam, and grade into clean sand and gravel.

ALTITUDE

The elevation of the irrigable area ranges from 4700 to 5450 feet above mean sea level.

CLIMATIC DATA

Average annual precipitation reported for the period 1940-70 at the airport weather station 4 miles northeast of Dillon (on benchland) is 9.57 inches. Average annual temperature for January at the airport is 20.2°F. and for July is 66.5°F., with a May-September average of 58.8°F. Temperature extremes have ranged from -40° to 101° F. The average frost-free period has been 110 days.

WATER REQUIREMENTS

Annual consumptive use of irrigation water, in driest years, is estimated at 1.3 acre-feet per acre. The estimated diversion requirement is about 3.1 acre-feet per acre or 63,500 acre-feet annually for the full irrigation service area of 20,470 acres. The diversion requirement for the valley lands is estimated at 4.0 acre-feet per acre or 112,000 acre-feet annually. The amount of supplemental water furnished from storage varies with the water-right priorities of individual water users; however, 1.12 acre-feet per acre annually is estimated as the average supplemental water requirement.

ECONOMY OF THE UNIT

Full irrigation has resulted in more intensive land use and greater stability and improvement of farm operation in the unit and surrounding area. This was accomplished through improved feed production supporting livestock feeding programs, mostly beef cattle, and from increases in cash crops, such as grain, hay, and some potatoes. Agricultural processing plants, stores, service industries, and community services are sharing in the stability of irrigation farming.

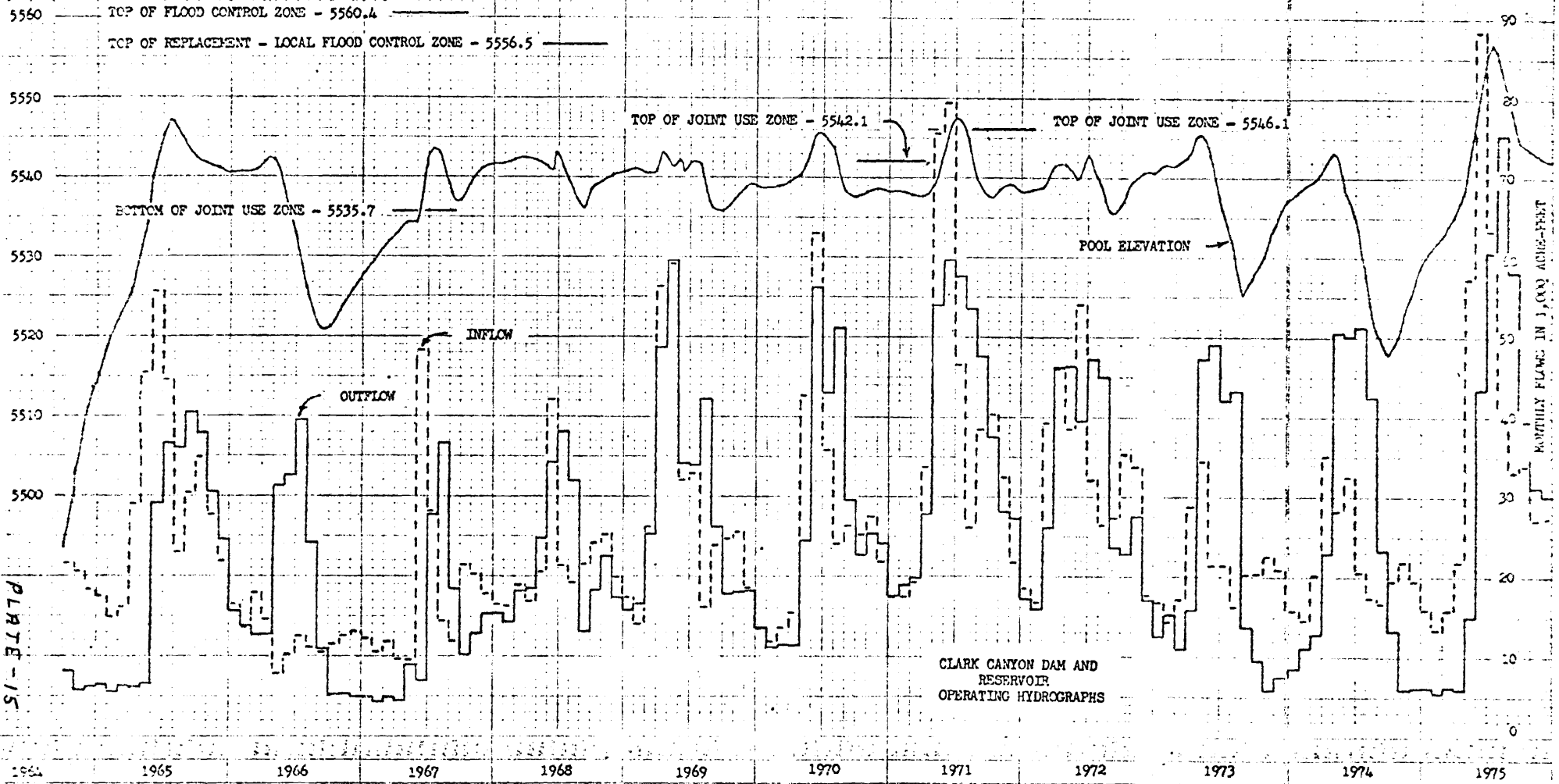
The Clark Canyon Water Supply Company has a 40-year contract for water service to those lands requiring only a supplemental water supply. The full service area is included in the East Bench Irrigation District which has contracted with the United States to repay a portion of the cost of the water supply and distribution facilities. Farm units have been planned largely with topographic considerations. Almost one-half of the District lands were owned by the State of Montana and have been sold to individuals for development as irrigated farm units.

ADDITIONAL INFORMATION

Address inquiries to:
Bureau of Reclamation, P.O. Box 2553,
Billings, Montana 59103.

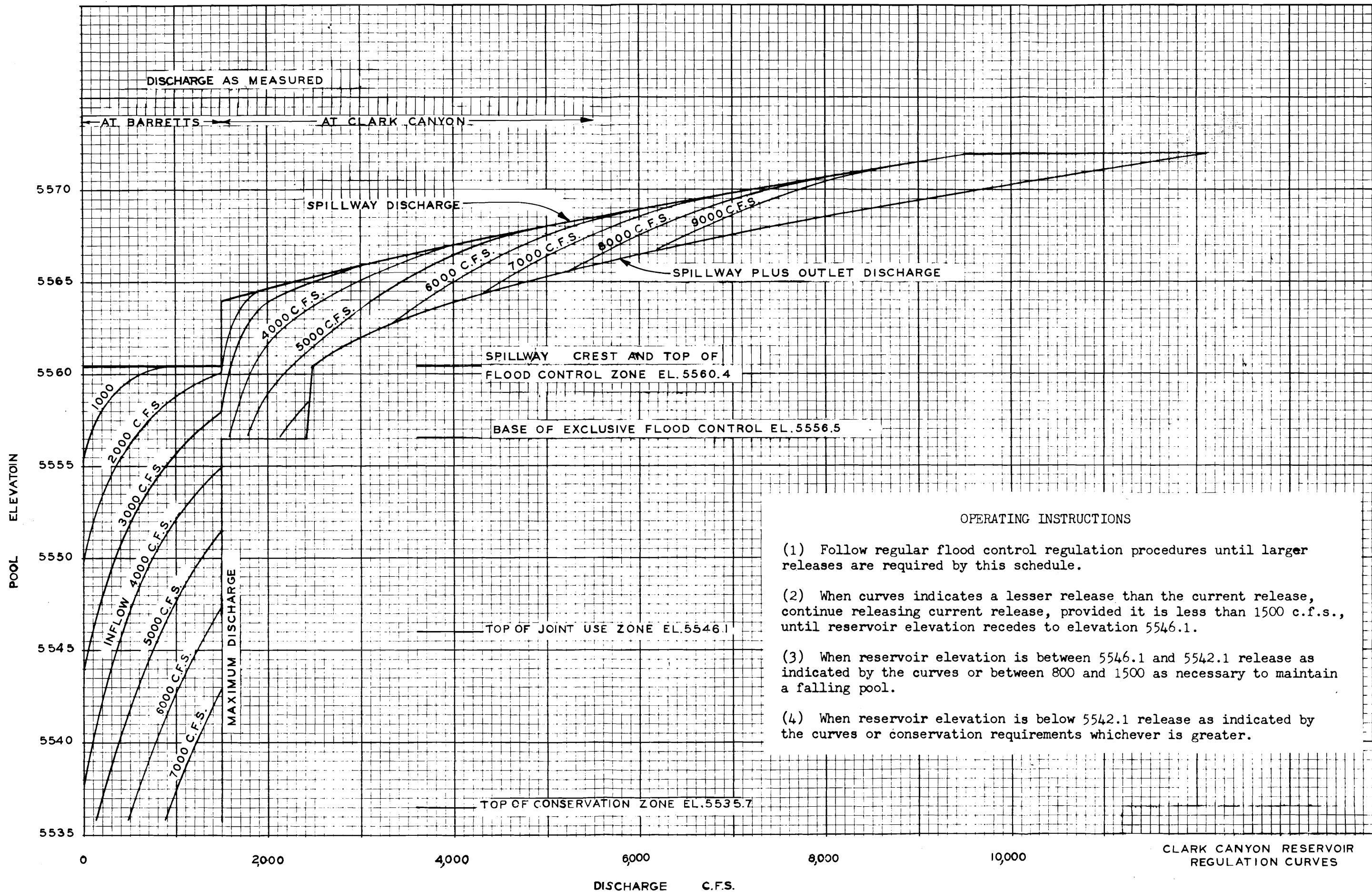
- (1) MAXIMUM ANNUAL DAILY INFLOW IN C.F.S.
- (2) MAXIMUM ANNUAL DAILY OUTFLOW IN C.F.S.
- (3) MAXIMUM ANNUAL DAILY DISCHARGE IN C.F.S. AT BARRETT'S

(1)	1,353 - JUN 17	547 - APR 2	1,511 - JUN 24	1,311 - JUN 10	2,208 - MAR 31	1,517 - JUN 14	2,189 - JUN 1	1,638 - JUN 9	807 - APR 29	883 - APR 19	2,800 - JUN 20
(2)	799 - SEP 18	1,054 - JUL 27	700 - AUG 16	841 - JUL 29	1,100 - APR 26	1,000 - MAY 27	1,000 - MAY 13	950 - JUL 19	1,100 - MAY 26	1,050 - JUN 26	1,239 - JUL 30
(3)	1,470 - JUN 18	1,020 - JUL 27	1,000 - JUL 14	996 - JUL 30	1,380 - MAY 21	1,490 - JUN 13	1,540 - JUN 2	1,220 - JUN 10	1,180 - MAY 27	1,210 - JUN 23	1,430 - JUN 16



CLARK CANYON DAM AND RESERVOIR OPERATING HYDROGRAPHS

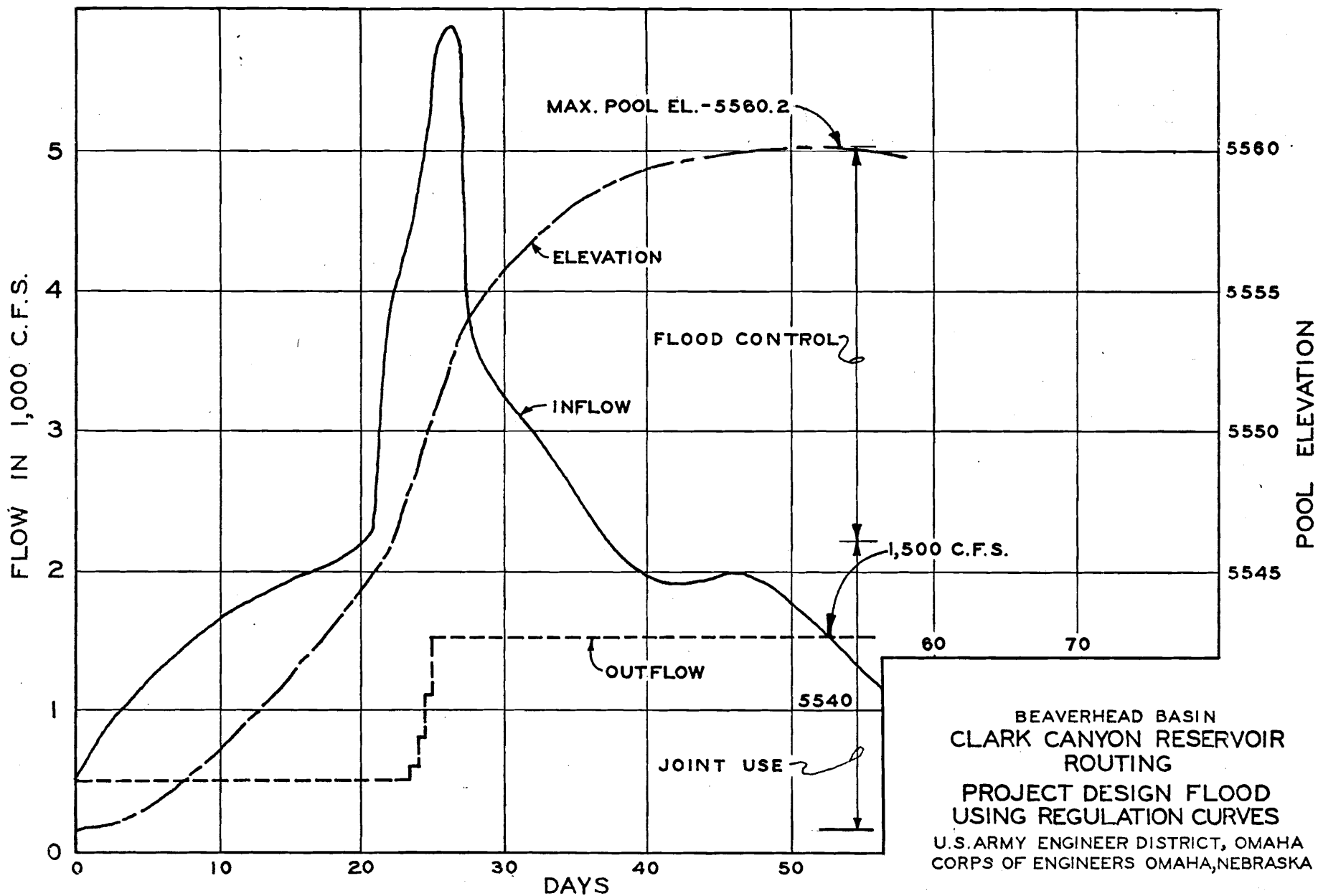
PLATE - 15



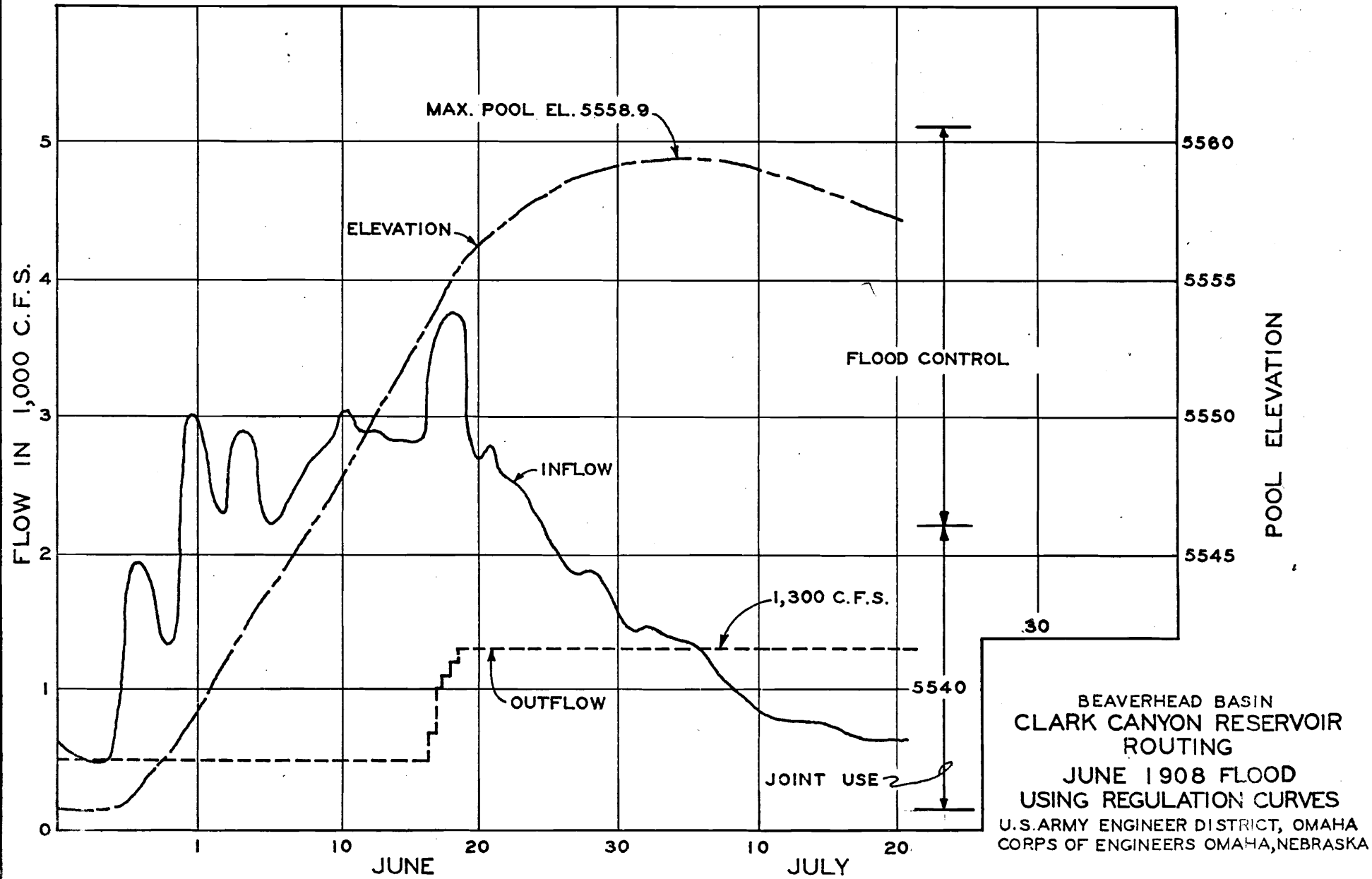
OPERATING INSTRUCTIONS

- (1) Follow regular flood control regulation procedures until larger releases are required by this schedule.
- (2) When curves indicates a lesser release than the current release, continue releasing current release, provided it is less than 1500 c.f.s., until reservoir elevation recedes to elevation 5546.1.
- (3) When reservoir elevation is between 5546.1 and 5542.1 release as indicated by the curves or between 800 and 1500 as necessary to maintain a falling pool.
- (4) When reservoir elevation is below 5542.1 release as indicated by the curves or conservation requirements whichever is greater.

CLARK CANYON RESERVOIR
REGULATION CURVES



BEAVERHEAD BASIN
CLARK CANYON RESERVOIR
ROUTING
PROJECT DESIGN FLOOD
USING REGULATION CURVES
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA



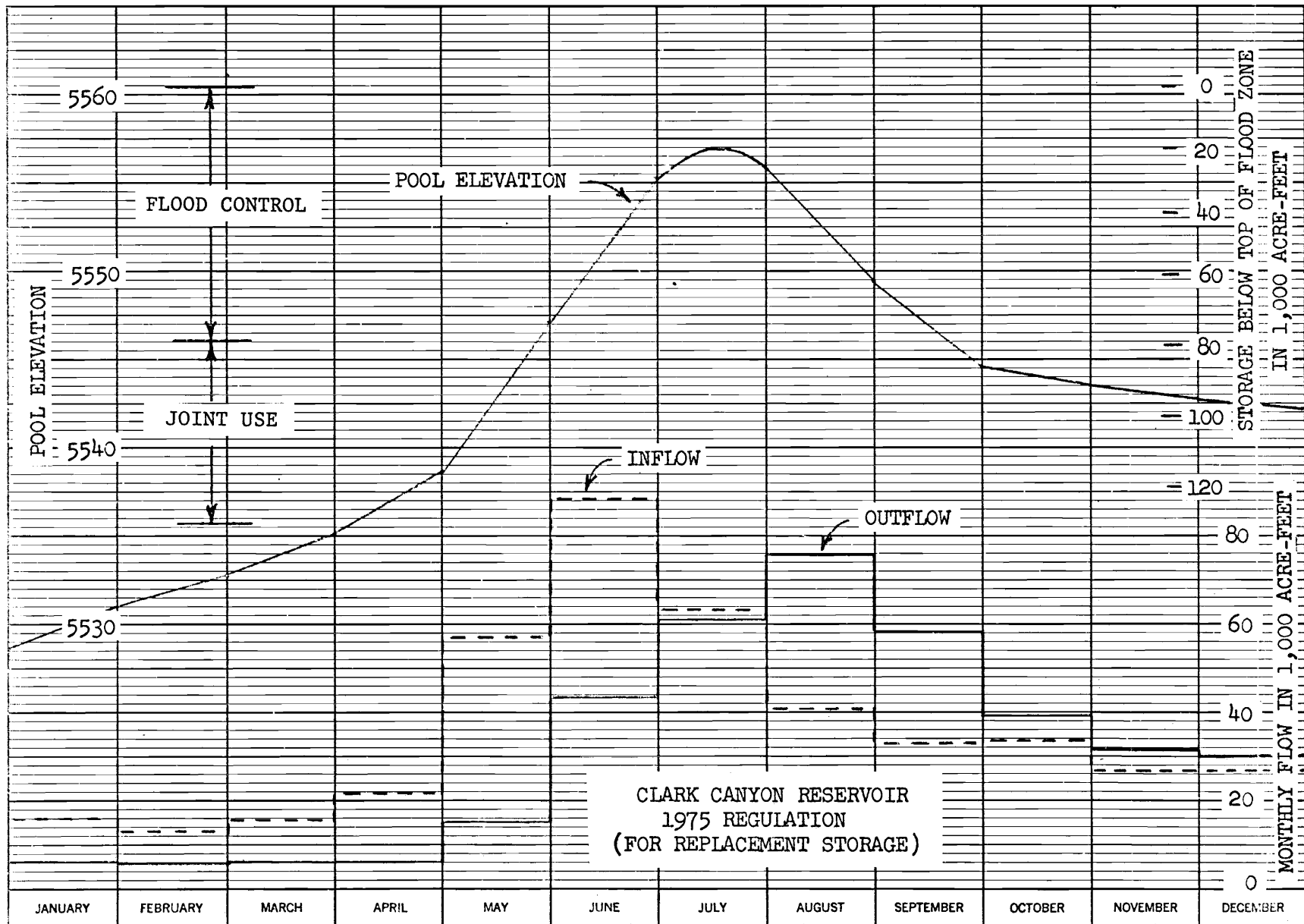


EXHIBIT I

FLOOD CONTROL REGULATIONS

Title 33—NAVIGATION AND NAVIGABLE WATERS

Chapter II—Corps of Engineers,
Department of the Army

PART 203—FLOOD CONTROL REGULATIONS

**Clark Canyon Dam and Reservoir,
Beaverhead River, Beaverhead
County, Mont.**

Pursuant to the applicable provisions of sections 7 and 9 of the Act of Congress approved December 22, 1944 (58 Stat. 890, 891; 33 U.S.C. 709), the following regulations are hereby prescribed to govern the use of storage capacity for flood control purposes in Clark Canyon Reservoir by the operation of Clark Canyon Dam on the Beaverhead River, Beaverhead County, Mont.

**§ 203.13 Clark Canyon Dam and Reservoir,
Beaverhead River, Beaverhead
County, Mont.**

The Bureau of Reclamation, Department of the Interior, represented by the Regional Director in charge of the locality, hereinafter referred to as the Regional Director, shall regulate Clark Canyon Dam and Reservoir in the interest of flood control in accordance with instructions furnished by the Department of the Army, represented by the District Engineer in charge of the locality, hereinafter referred to as the District Engineer, as follows:

(a) Releases will be made as necessary to achieve the following control:

(1) *Local flood control.* To restrict project releases to the amount which, in conjunction with incremental inflows below the dam, will not result in damaging discharges on the Beaverhead River.

(2) *Replacement flood control.* In years when the flood control and multiple-use storage space within the downstream Fort Peck Reservoir may be fully utilized, Clark Canyon Reservoir will assist in flood control along the Missouri River by withholding floodwater from Fort Peck Reservoir.

(b) To achieve the control specified in paragraph (a) of this section, storage space in Clark Canyon Reservoir shall be kept available in accordance with the Flood Control Storage Reservation Diagram currently in force. The Flood Control Storage Reservation Diagram in force as of the promulgation of this section is that dated October 14, 1971, and is on file in the Office of the Chief of Engineers, Department of the Army, Washington, D.C., and in the Office of the Commissioner of Reclamation, Washington, D.C. Revisions of the diagram may

be developed from time to time as necessary by the Corps of Engineers and the Bureau of Reclamation. Each such revision shall be effective upon the date specified in the approval thereof by the Chief of Engineers and the Commissioner of Reclamation and from that date until replaced shall be the Flood Control Storage Reservation Diagram for purposes of this section. Copies of the Flood Control Storage Reservation Diagram currently in force shall be kept on file in and may be obtained from the Office of the District Engineer, Corps of Engineers, and the Regional Director, Bureau of Reclamation, in charge of the locality.

(c) Any water temporarily stored in the space between elevation 5,500.4 (crest of spillway) and the elevation corresponding to the flood control allocation as indicated by the Flood Control Diagram, shall be released as rapidly as downstream conditions permit. The District Engineer will determine releases under these conditions.

(d) The discharge characteristics of the river regulation outlet works (having a capacity of 2,160 cubic feet per second with reservoir level at elevation 5,535.7) shall be maintained in accordance with the as-constructed drawings (Bureau of Reclamation Drawing No. 699-D-268 dated February 6, 1962).

(e) Proposed schedules of conservation releases and storage changes, if available, and current operating data shall be provided to the District Engineer by the Regional Director. Operating data shall be tabulated daily and furnished periodically as required and shall include such items as: Reservoir elevation, reservoir storage, inflow, discharge, and other pertinent available hydrologic data.

(f) Oral instructions issued by the District Engineer to the Regional Director shall be confirmed in writing under the date of the day issued.

(g) Nothing in this section shall be construed to require that releases shall be made at rates or in a manner inconsistent with requirements for protecting the dam and reservoir from major damage or inconsistent with the safe routing of the spillway design flood.

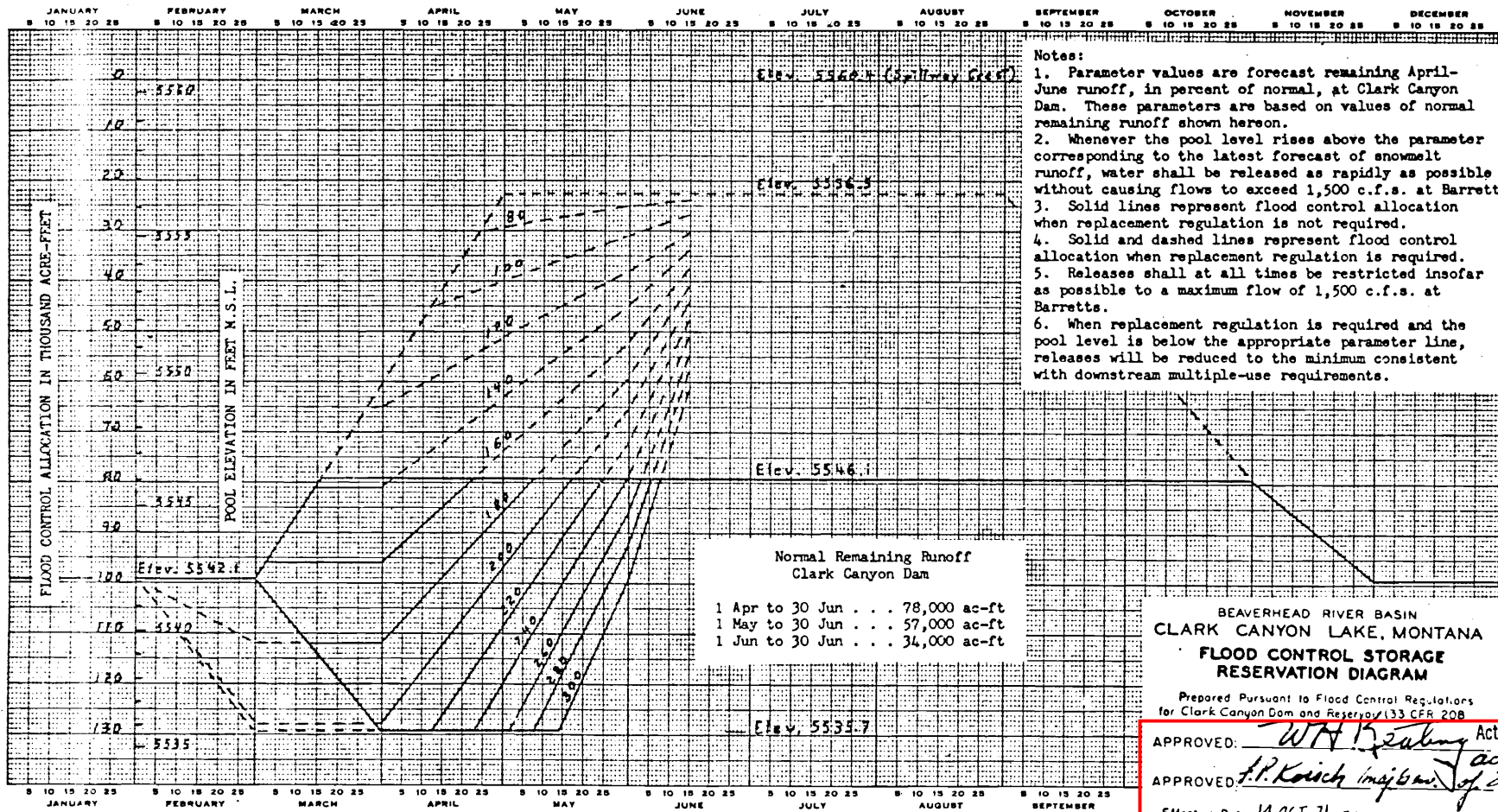
All elevations stated in this section are at the Clark Canyon Dam and are referred to a datum giving 5,500.4 as the elevation of the spillway crest.

[Regs., Oct. 14, 1971. DAEN-CWE-Y] Sections 7 and 9, 58 Stat. 890, 891; 33 U.S.C. 709]

For the Adjutant General.

R. B. BELNAP,
Special Advisor to TAG.

[FR Doc. 71-16045 Filed 11-3-71; 8:45 am]



- Notes:
1. Parameter values are forecast remaining April-June runoff, in percent of normal, at Clark Canyon Dam. These parameters are based on values of normal remaining runoff shown hereon.
 2. Whenever the pool level rises above the parameter corresponding to the latest forecast of snowmelt runoff, water shall be released as rapidly as possible without causing flows to exceed 1,500 c.f.s. at Barretts.
 3. Solid lines represent flood control allocation when replacement regulation is not required.
 4. Solid and dashed lines represent flood control allocation when replacement regulation is required.
 5. Releases shall at all times be restricted insofar as possible to a maximum flow of 1,500 c.f.s. at Barretts.
 6. When replacement regulation is required and the pool level is below the appropriate parameter line, releases will be reduced to the minimum consistent with downstream multiple-use requirements.

BEAVERHEAD RIVER BASIN
CLARK CANYON LAKE, MONTANA
FLOOD CONTROL STORAGE
RESERVATION DIAGRAM

Prepared Pursuant to Flood Control Regulations
for Clark Canyon Dam and Reservoir 133 CFR 208

APPROVED: *W.H. Zukow* Acting Commissioner
 APPROVED: *F.P. Koisch* *Imajbani* Acting Chief of Engineers
 Effective Date 14 OCT 71 File No _____

EXHIBIT II
FIELD WORKING AGREEMENT

19 November 1971

Regional Director
Region 6
Bureau of Reclamation
P. O. Box 2553
Billings, Montana 59101

Dear Sir:

Flood Control Regulations governing regulation of Clark Canyon Dam and Reservoir, Beaverhead River, Montana, having been completed and published in the Federal Register, at pages 21190 and 21191 Volume 36, No. 213, issue of November 4, 1971, it is agreed that the Clark Canyon Dam and Reservoir will be regulated in the interest of flood control under the following rules, unless and until such rules shall be modified by mutual agreement. This Field Working Agreement supersedes the previously signed interim agreement dated 5 October 1970.

a. Storage Capacity Allocations. The storage capacity allocations of Clark Canyon Reservoir, exclusive of surcharge storage capacity above elevation 5560.4, which is provided in combination with spillway and outlet capacity to insure safety of the structure, are defined in the following subparagraphs:

(1) Exclusive - Local Flood Control Storage. The exclusive-local flood control storage capacity shall include the storage capacity between elevations 5556.5 and 5560.4 (initially amounting to 22,615 acre-feet).

(2) Replacement - Local Flood Control Storage. The replacement-local flood control storage capacity shall include the storage capacity between elevations 5546.1 and 5556.5 (initially amounting to 56,475 acre-feet).

(3) Joint Use Storage. The joint use storage capacity shall include the storage capacity between elevations 5535.7 and 5546.1 (initially amounting to 50,436 acre-feet). This space shall normally be available for conservation usage, but will be used for local flood control and replacement storage purposes as per Flood Control Diagram in force.

(4) Conservation Storage. Conservation storage capacity allocation shall include the storage capacity between elevation 5470.6 and elevation 5535.7 (initially amounting to 126,117 acre-feet).

19 November 1971

(5) Inactive Storage. Inactive storage capacity allocation shall include the storage capacity between elevation 5455.0 and elevation 5470.6 (initially amounting to 1,448 acre-feet).

(6) Dead Storage. Dead storage capacity allocation shall include the storage capacity between streambed elevation and elevation 5455.0 (initially amounting to 61 acre-feet). This capacity is established by the elevation of the invert of the outlet works.

b. Storage Reallocations. The Regional Director shall at reasonable intervals make necessary field surveys and office studies to prepare estimates of the volume and location of sediment deposits in the reservoir. If the results of these studies show that the total storage available for flood control, joint use, or conservation (initially amounting to 79,090 acre-feet, 50,436 acre-feet, and 126,117 acre-feet respectively) is reduced by an amount exceeding 10 percent of the allocation for such purpose, the regulation plan described herein with respect to the elevation limits of the storage allocations shall be reviewed with the view of equitably distributing the loss of reservoir capacity between the primary reservoir uses. Any redistribution of storage capacity allocations is to be contingent on subparagraph f.

c. Plan of Regulation. The Regional Director shall regulate Clark Canyon Dam and Reservoir in the interest of flood control in accordance with the attached Part 208-Flood Control Regulations and Standing Instructions to Dam Tender, when the pool level is in the exclusive flood control zone or in that portion of the joint use zone required for flood control. When the reservoir level is in the surcharge or conservation storage zones or in that portion of the joint use storage zone which the Flood Control Storage Reservation Diagram indicates is not required for flood control, the District Engineer may make recommendations to the Regional Director for operation in the interests of flood control, but such recommendations shall not be considered mandatory, inasmuch as operation of such storage is the responsibility of the Regional Director. However, the Regional Director shall regulate to maintain nondamaging releases insofar as possible. Further regulation procedures are as follows:

(1) Estimates of flood season inflows into the Missouri River Main Stem System (made by the Corps of Engineers, Missouri River Division Reservoir Control Center, Omaha, Nebraska, normally between January 1 and March 1) along with main stem storage conditions will determine if replacement regulation is required. Forecasts of April-June inflow into Clark Canyon Reservoir (made by the District Engineer on January 1 and monthly thereafter) will determine if evacuation of joint use storage space for replacement and or local flood control purposes is required. The Regional Director shall schedule and coordinate in advance with the District Engineer releases from the joint use zone required to attain the necessary evacuation.

Regional Director

19 November 1971

(2) Forecasts referred to in (1) above are presented in Exhibit IV (Seasonal Forecast Procedure) of the current Preliminary Information Report on Flood Regulation for Clark Canyon Dam and Reservoir dated 1 October 1970. They will be exchanged with similar forecasts made by the Regional Director as soon after the first of each month as practicable.

(3) The replacement-local flood control storage space will be regulated as directed by the District Engineer, within the limits indicated by the Flood Control Storage Reservation Diagram.

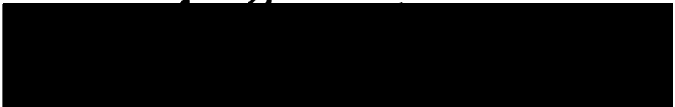
(4) Updating and/or revisions in the criteria pertinent to regulation of the joint use storage space may be made from time to time as changing circumstances or experience gained in the operation of the reservoir warrant.

d. Instructions issued by the District Engineer for local flood control regulation shall be issued simultaneously to the Regional Director and to operating personnel at the dam. The operating personnel at the dam shall act upon the order of the District Engineer after confirmation of the order by the Regional Director. In the absence of such confirmation, the operating personnel shall act upon the order not later than six hours after issuance.


e. Collection and Assembly of Hydrologic Data and Reporting Arrangements. Available reports from precipitation and streamflow stations pertinent to the flood control regulation of the Clark Canyon Reservoir which are collected by either the Regional Director or District Engineer will be relayed to the other by the most expeditious means of communication, under such detailed arrangements as may be made from time to time.

f. Design Limitations. It is recognized that any changes in the discharge characteristics of the spillway structures resulting from reallocation of storage capacities, or for any other reason, which otherwise are mutually acceptable to the Corps of Engineers and the Bureau of Reclamation, must be approved by the Director of Design and Construction of the Bureau of Reclamation.

Sincerely yours,



B. P. PENDERGRASS
Colonel, Corps of Engineers
District Engineer



U. S. Bureau of Reclamation

EXHIBIT III

INSTRUCTIONS TO DAM TENDER

FOR

FLOOD CONTROL OPERATION

INSTRUCTIONS TO DAM TENDER FOR
FLOOD CONTROL OPERATION OF CLARK CANYON DAM AND RESERVOIR

SECTION A
GENERAL

A-1. Purpose of Instructions. These instructions are issued for use as a guide to procedures to be used in reservoir regulation by the Dam Tender, both under normal and emergency flood control operation conditions. A copy of these instructions or an acceptable abbreviated version thereof should be posted by the Dam Tender in such a manner that it is readily accessible at all times. It will be the responsibility of the Dam Tender to make certain that any person temporarily charged with the operation of the reservoir is familiar with these instructions.

A-2. Agency Responsibility. The Corps of Engineers is responsible for regulation of the reservoir when storage is in the zone reserved exclusively for flood control (El. 5546.1 - 5560.4). The Corps of Engineers and Bureau of Reclamation are jointly responsible for regulation when storage is in the joint use pool (El. 5535.7 - 5546.1). The Corps of Engineers has the responsibility of the joint use storage space when it is required for local flood control and/or replacement-flood control as indicated by the Flood Control Diagram. The Bureau of Reclamation is solely responsible when storage is below elevation 5535.7 or above 5560.4. It is also responsible, regardless of pool elevation, whenever safety of the project is affected.

A-3. Routine Observations and Reports. Weekly reports of daily reservoir pertinent data (pool elevations, storage, discharge, precipitation, inflow, etc.) will be forwarded by the Dam Tender through the Regional Director's Office to the District Engineer.

SECTION B

NORMAL REGULATION FOR FLOOD CONTROL

B-1. Regulation Objectives. Clark Canyon Reservoir will be regulated to maintain non-damaging flows (currently estimated as less than 1,500 cfs at Barretts) on the River below Clark Canyon Dam to the maximum extent possible. In addition, regulation will be based on providing the maximum service to the other purposes for which the project was intended insofar as this regulation is consistent with the primary flood control function.

B-2. Definition of Normal Flood Control Regulation. For the purpose of these instructions, normal flood control regulation is defined to occur at all times when personnel of the District Engineer's office and/or Regional Director's office can be contacted within a reasonable time. The Dam Tender should arrange to report to the District Engineer's office and the Regional Reservoir Regulation Branch within 3 hours when any of the following conditions occur:

a. Whenever the pool rises into the storage space reserved by the Corps of Engineers for flood control as indicated by the Flood Control Diagram.

b. The pool is above elevation 5535.7 and a sudden increase in the rate of rise occurs, equal to or greater than 0.2 foot in 6 hours. (A rise in pool elevation which, in the opinion of the Dam Tender, exceeds the above limit only as a result of wind effects will not be used as a basis for notification).

c. Rainfall at the dam exceeds 1 inch in 6 hours and/or knowledge exists of heavy runoff downstream.

B-3. Personnel. Section D of these instructions lists offices and personnel to whom reports and questions related to flood control regulation may be directed.

SECTION C
EMERGENCY REGULATIONS FOR FLOOD CONTROL

C-1. Definition of Emergency Flood Control Regulation. For the purpose of these instructions an emergency is defined to begin with a failure in communications between the Dam Tender and the personnel of the District Engineer or the Regional Director listed in Section D at the time when a report from the Dam Tender is required by paragraph B-2. Emergency regulation procedures will be initiated only if communications cannot be established within 3 hours after such time that notification is required by paragraph B-2 and it has been determined that the communication outage may continue for an additional 12 hours. (Every possible effort will be made by the Dam Tender, while remaining at or near his post, to establish communication with the District Engineer's or the Regional Director's personnel, including use of any available Federal, commercial, or private means of communication media or use of a courier traveling by any available means of transportation to the nearest point where such rapid means of communication is available).

C-2. Emergency Procedures. Emergency flood control regulation instructions for Clark Canyon Reservoir are as follows:

a. Follow the last regulation instruction received for 6 hours after the conditions in paragraph B-2 occur (unless conditions under d below occur) before adjusting releases as provided below.

b. Pool elevations will be observed hourly but releases will not be adjusted more often than at 6-hour intervals.

c. With the pool above 5535.7, with no rain of consequence as defined in "d" below, and after the waiting period as described by "a" above, releases will be adjusted to the level given in the following schedule. However, releases will not be decreased to below the level specified by the latest available regulation order.

<u>Reservoir Elevation</u>	<u>Pool Rise (Feet) in a 6-Hour Period</u>	<u>Release Schedule</u>
5535.7-5542	--	Latest Regulation Order
5542 -5548	Less than 0.5	Latest Regulation Order
5542 -5548	Over 0.5	800 c.f.s.
5548 -5554	Less than 0.3	900 c.f.s.
5548 -5554	Over 0.3	1,000 c.f.s.
5554 -5560.4	Less than 0.2	1,200 c.f.s.
5554 -5560.4	Over 0.2	1,500 c.f.s.
5542.1-5546.1	Stationary or Falling Pool	Latest Regulation Order
5546.1-5560.4	Stationary or Falling Pool	Maintain Maximum Gate Opening attained until pool falls to elev. 5546.1

Schedule Continued

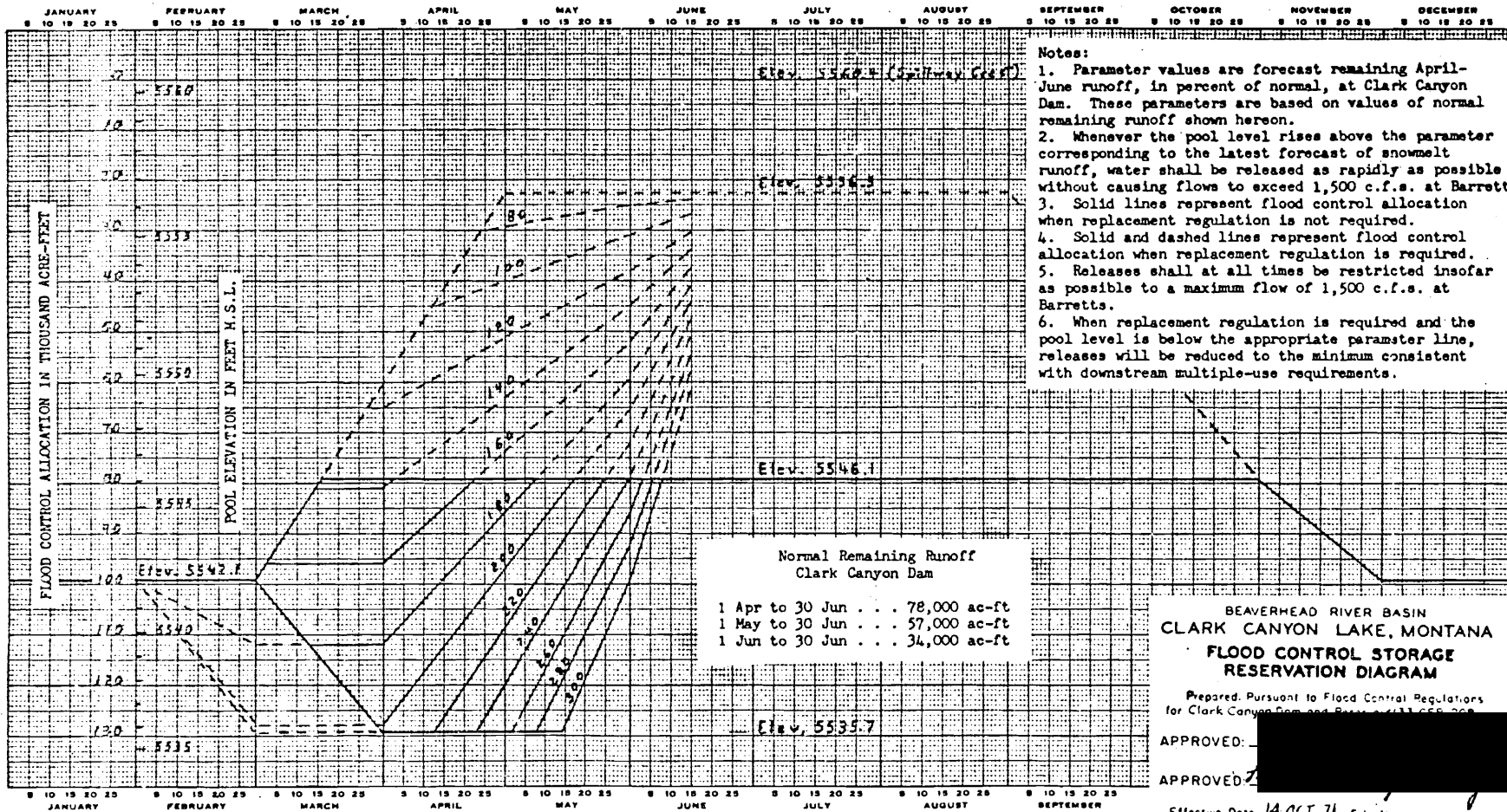
<u>Reservoir Elevation</u>	<u>Pool Rise (Feet) in a 6-Hour Period</u>	<u>Release Schedule</u>
*5560.4-5571.9	Stationary or Rising Pool	Open gates as necessary to pass inflow
*5560.4-5571.9	Falling Pool	Maintain maximum gate opening attained during rising pool

*Operation of the pool as directed by the Bureau of Reclamation.

d. In case of rain in excess of 1 inch in 6 hours at Clark Canyon Dam and/or knowledge exists of heavy runoff downstream reduce releases to conservation requirements if above that rate. Maintain this rate for 24 hours, then return to release based on above table.

C-3. Safety of Dam. The foregoing regulation procedures are not intended to restrict the Dam Tender from taking such additional measures as are necessary to insure the safety of the dam.

C-4. Report of Emergency Regulation. The Dam Tender shall report all emergency regulation to the District Engineer and/or Regional Director office personnel as promptly as practicable as communication facilities will permit.



- Notes:
1. Parameter values are forecast remaining April-June runoff, in percent of normal, at Clark Canyon Dam. These parameters are based on values of normal remaining runoff shown hereon.
 2. Whenever the pool level rises above the parameter corresponding to the latest forecast of snowmelt runoff, water shall be released as rapidly as possible without causing flows to exceed 1,500 c.f.s. at Barretts.
 3. Solid lines represent flood control allocation when replacement regulation is not required.
 4. Solid and dashed lines represent flood control allocation when replacement regulation is required.
 5. Releases shall at all times be restricted insofar as possible to a maximum flow of 1,500 c.f.s. at Barretts.
 6. When replacement regulation is required and the pool level is below the appropriate parameter line, releases will be reduced to the minimum consistent with downstream multiple-use requirements.

BEAVERHEAD RIVER BASIN
CLARK CANYON LAKE, MONTANA
FLOOD CONTROL STORAGE
RESERVATION DIAGRAM

Prepared Pursuant to Flood Control Regulations
for Clark Canyon Dam and Basin, 4/11/55, 200

APPROVED: [Redacted Signature]

APPROVED: [Redacted Signature]

Effective Date 14 OCT 71 File No. _____

CLARK CANYON DAM & RESERVOIR (FLOOD CONTROL REGULATION PERSONNEL)
(If more than one name shown, call in order listed)

CORPS OF ENGINEERS - OMAHA DISTRICT

RESERVOIR REGULATION SECTION - OMAHA

<u>PERSONNEL</u>	<u>OFFICE PHONE</u>	<u>HOME PHONE</u>	<u>MAILING ADDRESS</u>
R. F. Behrens	402-221-4608	402-451-6397	District Engineer
R. H. Williams	402-221-4606	402-553-7273	U.S. Army Engineer District
	FTS-Dial 864-Last 4 Digits		6014 U.S. Post Office and Courthouse Omaha, Nebraska 68102

FIELD OFFICE - FORT PECK AREA

Don Beckman, Area Engr.	406-526-3411	406-367-4381	Fort Peck Area, C.E.
	FTS- Dial 585-5011 Ask for Number		Fort Peck, Montana 59223

BUREAU OF RECLAMATION UPPER MISSOURI REGION

RESERVOIR REGULATION BRANCH - REGIONAL OFFICE

Bryan J. Edwards	406-245-6416	406-245-7771	Regional Director, Upper Missouri Region
Gordon Aycock	406-245-6516	406-245-3505	U.S. Bureau of Reclamation
	FTS-Dial 585-Last Four Digits		P. O. Box 2553 Billings, Montana 59103

CLARK DANYON DAM TENDER

Dick Kennedy	406-683-2307	406-683-5517	East Bench Irrigation District
	FTS-Dial 585-5011 Ask for Number		Dillon, Montana 59725

OTHER

Gary Wicks	406-449-3712		Montana Department of Natural Resources and Conservation
	FTS-Dial 585-Last Four Digits		Helena, Montana 59601

SECTION D
PERSONNEL

EXHIBIT IV

SEASONAL FORECAST PROCEDURE

SEASONAL FORECAST PROCEDURE

1. General. Since Clark Canyon Dam is located in a mountainous area, a major portion of its annual inflow normally occurs during the April-June period as a result of mountain snowmelt. In years when the snow accumulation is high it is necessary that reservoir storage space be made available in advance of the anticipated runoff. To determine the amount of space needed to control this runoff a seasonal volume forecast is developed.

2. Development of Forecast Procedure. Multiple correlation studies were made which related independent variables (antecedent runoff, fall and winter precipitation, winter or April temperature, spring and summer precipitation and snow water content) to the dependent variable (April through June runoff volume). Using a electronic computer different combinations of independent variables were correlated to the April-June runoff. After examination of the computer results the forecast formulas given below were selected as the most reliable.

Two basic formulas were developed, one to be used for forecast made before 1 March (1 February basic formula) and one for forecast made on and after 1 March (1 July basic formula). Two were developed, because prior to 1 March there are insufficient snow course measurements taken within the basin. Therefore, the basic 1 February formula was developed utilizing snow courses outside the basin. The snow courses used in the basic 1 July formula are all within or near the basin boundaries, however, most of them were not measured on 1 January and 1 February in the past. The 1 February formula is based on a correlation analysis for the 35-year period from 1941 through 1975. The 1 July formula is based on correlation analysis for the 28-year period from 1948 through 1975. Variables used in the analysis are given in Table III. It is felt the forecast equation should be updated using additional acquired data every five years.

3. Application of Basic Forecast Formula. The formulas are basically 1 February and 1 July forecast since all the data is not known until these dates. Before these times, observed values will be used to date of forecast with average values used for remainder of period. Average values are given in Tables I and II to aid in computing the forecasts at any time. Tables I and II also give the average value of variables used in the formula. This to enable the forecaster to determine what percent of average the current forecast and each of its variables may be.

As no past record of streamflow at the Clark Canyon damsite is available, the nearest stream gaging station, of sufficient record, was used to develop the runoff. The observed streamflow on Grasshopper Creek near Dillon was subtracted from the Beaverhead observed flow at Barretts. This difference along with the storage holdout from Lima was used as the dependent variable (X_1). Therefore, to obtain the forecasted actual flow at Clark Canyon Dam,

further adjustments need to be made to the value computed from the formula as follows:

$$\text{Actual Inflow} = 0.9 (X_1 - \Delta \text{Str Lima})$$

Actual Inflow = April through June estimated inflow to Clark Canyon Dam in 1,000 acre-feet.

X_1 = Flow of Beaverhead River at Barretts minus Grasshopper Creek near Dillon plus storage holdout of Lima Reservoir, from forecast equation in 1,000 acre-feet.

Δ Str Lima = Estimated storage holdout by Lima Reservoir during the April-June period in 1,000 acre-feet. (Example - Lima capacity of 84,000 A.F. minus estimated 1 April storage at that project).

For Forecast Prior to 1 March

$$\text{Basic Equation } X_1 = 0.548 X_2 + 9.92 X_3 - 1.64 \text{ (Corrected R Bar} = .51)$$

1 January Forecast

X_1 = April through June reference runoff in 1,000 acre-feet

X_2 = September through November runoff in 1,000 acre-feet (Represents same flow conditions as above and may be computed from actual runoff records or estimated from average streamflow conditions given in Table II)

X_3 = 1 January snow water content plus average gain of 3.3" to 1 February (Average of three stations Hebgen Dam, Ten Mile Upper and West Yellowstone).

1 February Forecast

X_1 = refer to 1 January forecast

X_2 = refer to 1 January forecast

X_3 = 1 February snow water content (Average of three stations used for January forecast).

TABLE I

Snow Station (Water Content)	January Ave. inches	February Ave. inches
Hebgen Dam	5.2	8.5
Tem Mile Upper	6.2	9.5
West Yellowstone	5.1	8.3
Average of 3 stations	5.5	8.8

Variable	Ave. Value
X_1	119.8
X_2	63.2
X_3	8.8

For Forecast on and After 1 March

Basic Equation $X_1 = 1.00 X_2 + 13.5 X_3 + 18.7 X_4 - 223$ (Corrected R Bar = .92)

1 March Forecast

- X_1 = refer to 1 January forecast
- X_2 = refer to 1 January forecast
- X_3 = 1 March snow water content plus average gain of 1.9" to 1 April (Average of five stations Goldstone, Lakeview Canyon, Lakeview Ridge, Lemhi Pass and Trail Creek)
- X_4 = 5.68 (April through June average precipitation)

1 April Forecast

- X_1 = refer to 1 January forecast
- X_2 = refer to 1 January forecast
- X_3 = 1 April snow water content (Average of five stations used for 1 March forecast)
- X_4 = 5.68 (refer to 1 March forecast)

1 May Forecast

- X_1 = refer to 1 January forecast
- X_2 = refer to 1 January forecast
- X_3 = refer to 1 April forecast
- X_4 = April precipitation plus average precipitation of 4.48" for May and June (Average of three stations Dillon WMCE, Lakeview and Lima)

1 June Forecast

- X_1 = refer to 1 January forecast
- X_2 = refer to 1 January forecast
- X_3 = refer to 1 April forecast
- X_4 = April-May precipitation plus average precipitation of 2.54" for June (Average of three stations used of 1 May forecast)

TABLE II

Precipitation Station	April Ave. inches	May Ave. inches	June Ave. inches
Dillon	1.12	1.83	2.25
Lakeview	.94	1.72	2.10
Lima	<u>1.53</u>	<u>2.27</u>	<u>3.27</u>
Average of 3 stations	1.20	1.94	2.54

Snow Station (Water Content)	March Ave. inches	April Ave. inches
Goldstone	15.5	18.9
Lakeview Canyon	10.7	13.1
Lakeview Ridge	9.3	11.3
Lemhi Pass	8.2	9.9
Trail Creek	<u>9.2</u>	<u>9.3</u>
Average of 5 Stations	10.6	12.5

Variable	Ave. Value
X ₁	117.3
X ₂	64.6
X ₃	12.5
X ₄	5.68

Average streamflow values:

For the April through June period the average contribution of flow at Barretts from areas above are:

- 72% - Area above Clark Canyon Dam
- 20% - Area above Grasshopper Creek near Dillon
- 8% - Incremental area between above two areas and Barretts Station

For the September through November period the average contribution of flow at Barretts from areas above are:

- 85% - Area above Clark Canyon Dam
- 10% - Area above Grasshopper Creek near Dillon
- 5% - Incremental area between above two areas and Barretts Station

4. Pertinent Data. Table III gives a tabulation of the values used to compute the forecast, along with the computed forecasts of runoff. This is then compared with the actual runoff. The difference between the two is also tabulated. This table is included mainly (1) to illustrate the accuracy of the forecast and (2) as a outline for continuation of computing future forecast.

TABLE III
 1 JANUARY APRIL-JUNE FORECAST
 $548(X2) + 9.92(X3) - 1.64 = X1$

YEAR	X2	X3	X4	X5	X6	X7	X8	X1	ACTUAL RUNOFF	DIFFERENCE
1941	45.	7.70						99.	68.	-31.
1942	70.	8.00						116.	172.	56.
1943	52.	12.50						151.	157.	6.
1944	51.	6.00						86.	147.	61.
1945	54.	6.80						95.	96.	1.
1946	59.	10.00						130.	105.	-25.
1947	73.	12.00						157.	164.	7.
1948	75.	10.10						140.	174.	34.
1949	69.	11.60						151.	124.	-27.
1950	80.	7.80						120.	109.	-11.
1951	76.	8.60						125.	96.	-29.
1952	58.	13.20						161.	146.	-15.
1953	62.	8.10						113.	116.	3.
1954	53.	8.20						109.	44.	-65.
1955	48.	5.80						82.	56.	-26.
1956	54.	11.90						146.	77.	-69.
1957	52.	9.10						117.	164.	47.
1958	65.	8.00						113.	116.	3.
1959	65.	7.80						111.	44.	-67.
1960	70.	6.20						98.	47.	-51.
1961	47.	7.70						100.	14.	-86.
1962	48.	9.60						120.	107.	-13.
1963	48.	6.40						88.	87.	-1.
1964	62.	7.40						106.	165.	59.
1965	77.	10.90						149.	203.	54.
1966	83.	5.30						96.	32.	-64.
1967	37.	9.20						110.	111.	1.
1968	50.	9.70						122.	110.	-12.
1969	79.	9.30						134.	180.	46.
1970	64.	6.80						101.	163.	62.
1971	68.	10.40						139.	237.	98.
1972	102.	10.90						162.	158.	-4.
1973	90.	7.70						124.	102.	-22.
1974	71.	9.40						131.	96.	-35.
1975	56.	7.40						102.	207.	105.

TABLE III (Cont'd)
 1 FEBRUARY APRIL-JUNE FORECAST
 $.548(X2) + 9.92(X3) - 1.64 = X1$

YEAR	X2	X3	X4	X5	X6	X7	X8	X1	ACTUAL RUNOFF	DIFFERENCE
1941	45.	6.00						83.	68.	-15.
1942	70.	7.00						106.	172.	66.
1943	52.	14.50						171.	157.	-14.
1944	51.	3.30						59.	147.	88.
1945	54.	5.20						80.	96.	16.
1946	59.	9.00						120.	105.	-15.
1947	73.	10.90						146.	164.	18.
1948	75.	9.60						135.	174.	39.
1949	69.	10.60						141.	124.	-17.
1950	80.	8.60						128.	109.	-19.
1951	76.	8.00						119.	96.	-23.
1952	58.	12.90						158.	146.	-12.
1953	62.	7.60						108.	116.	8.
1954	53.	8.70						114.	44.	-70.
1955	48.	5.60						80.	56.	-24.
1956	54.	11.80						145.	77.	-68.
1957	52.	9.00						116.	164.	48.
1958	65.	6.10						94.	116.	22.
1959	65.	7.40						107.	44.	-63.
1960	70.	5.40						90.	47.	-43.
1961	47.	5.20						76.	14.	-62.
1962	48.	9.50						119.	107.	-12.
1963	48.	6.30						87.	87.	-
1964	62.	8.20						114.	165.	51.
1965	77.	13.20						171.	203.	32.
1966	83.	5.30						96.	32.	-64.
1967	37.	10.70						125.	111.	-14.
1968	50.	10.30						128.	110.	-18.
1969	79.	13.20						173.	180.	7.
1970	64.	8.60						119.	163.	44.
1971	68.	11.20						147.	237.	90.
1972	102.	12.10						174.	158.	-16.
1973	90.	6.70						114.	102.	-12.
1974	71.	10.10						137.	96.	-41.
1975	56.	8.60						114.	207.	93.

TABLE III (Cont'd)
 1 MARCH APRIL-JUNE FORECAST
 $1.00(x2) + 13.5(x3) + 18.7(x4) - 223. = x1$

YEAR	X2	X3	X4	X5	X6	X7	X8	X1	ACTUAL RUNOFF	DIFFERENCE
1948	75.	11.40	5.68					112.	174.	62.
1949	69.	14.10	5.68					143.	124.	-19.
1950	80.	13.10	5.68					140.	109.	-31.
1951	76.	13.20	5.68					137.	96.	-41.
1952	58.	15.90	5.68					156.	146.	-10.
1953	62.	12.90	5.68					119.	116.	-3.
1954	53.	11.90	5.68					97.	44.	-53.
1955	48.	9.10	5.68					54.	56.	2.
1956	54.	14.60	5.68					134.	77.	-57.
1957	52.	11.60	5.68					92.	164.	72.
1958	65.	10.70	5.68					93.	116.	23.
1959	65.	11.30	5.68					101.	44.	-57.
1960	70.	9.70	5.68					84.	47.	-37.
1961	47.	8.60	5.68					46.	14.	-32.
1962	48.	12.60	5.68					101.	107.	6.
1963	48.	9.00	5.68					53.	87.	34.
1964	62.	10.20	5.68					83.	165.	82.
1965	77.	18.90	5.68					215.	203.	-12.
1966	83.	9.50	5.68					94.	32.	-62.
1967	37.	13.30	5.68					100.	111.	11.
1968	50.	13.30	5.68					113.	110.	-3.
1969	79.	19.60	5.68					227.	180.	-47.
1970	64.	9.80	5.68					80.	163.	83.
1971	68.	15.80	5.68					165.	237.	72.
1972	102.	16.00	5.68					201.	158.	-43.
1973	90.	8.50	5.68					88.	102.	14.
1974	71.	11.90	5.68					115.	96.	-19.
1975	56.	13.20	5.68					117.	207.	90.

TABLE III (Cont'd)
 $1,00(X_2) + 13.5(X_3) + 18.7(X_4) - 223 = X_1$
 1 APRIL APRIL-JUNE FORCAST

YEAR	X2	X3	X4	X5	X6	X7	X8	X1	ACTUAL RUNOFF	DIFFERENCE
1948	75,	12.30	5.68					124.	174.	50.
1949	69,	13.30	5.68					132.	124.	-8.
1950	80,	13.10	5.68					140.	109.	-31.
1951	76,	14.00	5.68					148.	96.	-52.
1952	58,	15.50	5.68					150.	146.	-4.
1953	62,	11.90	5.68					106.	116.	10.
1954	53,	11.60	5.68					93.	44.	-49.
1955	48,	9.30	5.68					57.	56.	-1.
1956	54,	13.50	5.68					119.	77.	-42.
1957	52,	12.90	5.68					109.	164.	55.
1958	65,	12.60	5.68					118.	116.	-2.
1959	65,	10.00	5.68					83.	44.	-39.
1960	70,	8.10	5.68					63.	47.	-16.
1961	47,	8.30	5.68					42.	14.	-28.
1962	48,	11.80	5.68					91.	107.	16.
1963	48,	7.60	5.68					34.	87.	53.
1964	62,	10.40	5.68					86.	165.	79.
1965	77,	17.90	5.68					202.	203.	1.
1966	83,	8.30	5.68					78.	32.	-46.
1967	37,	14.30	5.68					113.	111.	-2.
1968	50,	12.40	5.68					101.	110.	9.
1969	79,	17.80	5.68					203.	180.	-23.
1970	64,	12.10	5.68					111.	163.	52.
1971	68,	17.10	5.68					182.	237.	55.
1972	102,	15.30	5.68					192.	158.	-34.
1973	90,	8.70	5.68					91.	102.	11.
1974	71,	15.10	5.68					158.	96.	-62.
1975	56,	15.00	5.68					142.	207.	65.

TABLE III (Cont'd)
 1 MAY APRIL-JUNE FORECAST
 $1.00(X2) + 13.5(X3) + 18.7(X4) - 223. = X1$

YEAR	X2	X3	X4	X5	X6	X7	X8	X1	ACTUAL RUNOFF	DIFFERENCE
1948	75.	12.30	6.04					131.	174.	43.
1949	69.	13.30	5.43					127.	124.	-3.
1950	80.	13.10	5.35					134.	109.	-25.
1951	76.	14.00	5.44					144.	96.	-48.
1952	58.	15.50	5.06					139.	146.	7.
1953	62.	11.90	5.89					110.	116.	6.
1954	53.	11.60	5.13					83.	44.	-39.
1955	48.	9.30	6.12					65.	56.	-9.
1956	54.	13.50	5.82					122.	77.	-45.
1957	52.	12.90	5.93					114.	164.	50.
1958	65.	12.60	5.56					116.	116.	0.
1959	65.	10.00	4.84					68.	44.	-24.
1960	70.	8.10	5.95					68.	47.	-21.
1961	47.	8.30	5.00					30.	14.	-16.
1962	48.	11.80	5.08					79.	107.	28.
1963	48.	7.60	6.39					47.	87.	40.
1964	62.	10.40	6.23					96.	165.	69.
1965	77.	17.90	5.85					205.	203.	-2.
1966	83.	8.30	5.08					67.	32.	-35.
1967	37.	14.30	6.71					133.	111.	-22.
1968	50.	12.40	5.40					95.	110.	15.
1969	79.	17.80	5.58					201.	180.	-21.
1970	64.	12.10	5.68					111.	163.	52.
1971	68.	17.10	6.18					191.	237.	46.
1972	102.	15.30	5.37					186.	158.	-28.
1973	90.	8.70	5.58					89.	102.	13.
1974	71.	15.10	4.76					141.	96.	-45.
1975	56.	15.00	7.42					174.	207.	33.

TABLE III (Cont'd)
 1 JUNE APRIL-JUNE FORECAST
 $1.00(X2) + 13.5(X3) + 18.7(X4) - 223. = X1$

YEAR	X2	X3	X4	X5	X6	X7	X8	X1	ACTUAL RUNOFF	DIFFERENCE
1948	75.	12.30	7.12					151.	174.	23.
1949	69.	13.30	7.04					157.	124.	-33.
1950	80.	13.10	4.23					113.	109.	-4.
1951	76.	14.00	4.73					130.	96.	-34.
1952	58.	15.50	5.06					139.	146.	7.
1953	62.	11.90	6.64					124.	116.	-8.
1954	53.	11.60	4.19					65.	44.	-21.
1955	48.	9.30	6.59					74.	56.	-18.
1956	54.	13.50	5.79					122.	77.	-45.
1957	52.	12.90	8.16					156.	164.	8.
1958	65.	12.60	5.13					108.	116.	8.
1959	65.	10.00	5.66					83.	44.	-39.
1960	70.	8.10	5.53					60.	47.	-13.
1961	47.	8.30	5.01					30.	14.	-16.
1962	48.	11.80	5.87					94.	107.	13.
1963	48.	7.60	6.77					54.	87.	33.
1964	62.	10.40	6.06					93.	165.	72.
1965	77.	17.90	6.40					215.	203.	-12.
1966	83.	8.30	4.02					47.	32.	-15.
1967	37.	14.30	6.38					126.	111.	-15.
1968	50.	12.40	5.08					89.	110.	21.
1969	79.	17.80	4.45					180.	180.	0.
1970	64.	12.10	6.50					126.	163.	37.
1971	68.	17.10	5.86					185.	237.	52.
1972	102.	15.30	4.98					179.	158.	-21.
1973	90.	8.70	4.45					68.	102.	34.
1974	71.	15.10	4.02					127.	96.	-31.
1975	56.	15.00	7.14					169.	207.	38.

TABLE III (Cont'd)
 1 JULY APRIL-JUNE FORECAST
 $1.00(X2) + 13.5(X3) + 18.7(X4) - 223. = X1$

YEAR	X2	X3	X4	X5	X6	X7	X8	X1	ACTUAL RUNOFF	DIFFERENCE
1948	75.	12.30	8.53					178.	174.	-4.
1949	69.	13.30	5.64					131.	124.	-7.
1950	80.	13.10	4.09					110.	109.	-1.
1951	76.	14.00	3.11					100.	96.	-4.
1952	58.	15.50	5.41					145.	146.	1.
1953	62.	11.90	5.87					109.	116.	7.
1954	53.	11.60	4.65					74.	44.	-30.
1955	48.	9.30	6.49					72.	56.	-16.
1956	54.	13.50	4.06					89.	77.	-12.
1957	52.	12.90	7.98					152.	164.	12.
1958	65.	12.60	6.07					126.	116.	-10.
1959	65.	10.00	6.01					89.	44.	-45.
1960	70.	8.10	4.12					33.	47.	14.
1961	47.	8.30	3.54					2.	14.	12.
1962	48.	11.80	5.46					86.	107.	21.
1963	48.	7.60	9.44					104.	87.	-17.
1964	62.	10.40	8.60					140.	165.	25.
1965	77.	17.90	6.96					226.	203.	-23.
1966	83.	8.30	3.01					28.	32.	4.
1967	37.	14.30	7.17					141.	111.	-30.
1968	50.	12.40	5.37					95.	110.	15.
1969	79.	17.80	5.01					190.	180.	-10.
1970	64.	12.10	6.88					133.	163.	30.
1971	68.	17.10	5.98					188.	237.	49.
1972	102.	15.30	5.10					181.	158.	-23.
1973	90.	8.70	5.16					81.	102.	21.
1974	71.	15.10	1.88					87.	96.	9.
1975	56.	15.00	7.38					174.	207.	33.

NOTE - VALUES OF X2, X1, ACTUAL RUNOFF AND
 DIFFERENCE ARE THOUSAND ACRE-FEET OF FLOW.
 VALUES OF X3, ARE INCHES OF SNOW WATER CONTENT.
 VALUES OF X4 ARE INCHES OF PRECIPITATION. SEE
 EXPLANATION OF FORECAST EQUATION FOR FURTHER
 DETAILS.

EXHIBIT V

STORAGE RESERVATION DIAGRAM

STORAGE RESERVATION DIAGRAM

1. General. Corps of Engineers Reservoir Regulation policy promotes the use of a diagram, mutually signed by the Commissioner of Reclamation and the Chief of Engineers, as the official instrument designating flood control storage allocations in Bureau of Reclamation projects built with a seasonal flood control purpose. Flood control benefits were used in the feasibility study of Clark Canyon Dam. These benefits resulted from replacement of Missouri River main stem dam storage as well as the prevention of local downstream flooding. The Flood Control Diagram was constructed to realize these two objectives. See diagram attached to Flood Control Regulations, Exhibit I.
2. Replacement Regulation. To achieve replacement benefits the diagram was constructed to have 76,674 acre-feet of space vacant below elevation 5556.5 (or 99,289 acre-feet of space vacant below the spillway crest) prior to winter river freeze up each year. Then if replacement storage is needed at least this amount of space (76,674 acre-feet) will be available for fill. In addition, more detailed studies of regulation of the main stem reservoir system in conjunction with the tributary reservoirs have shown that there is a reasonable assurance that the entire joint use zone (50,436 acre-feet) plus the lower 56,475 acre-feet of the flood control zone (below the local flood control only zone) will be available as replacement storage. Once the decision is made for the need of replacement regulation (to be determined by the Missouri River Division Reservoir Control Center normally sometime between 1 August and 1 March) fill of as much of this space as possible, after March, is required. However, fill of this space must not exceed the limits, as referred to below, necessary for local downstream flood protection. If joint use storage is required for local downstream flood control, it must be vacated by 1 March (as constructed in the diagram) when replacement regulation is required.
3. Local Flood Control Regulation. To provide for local downstream flood control the amount of storage needed to store excess runoff or control an anticipated flood is determined as the difference between inflow and normal conservation releases. In developing the diagram this difference is subtracted from the storage at elevation 5556.5 (this being the target elevation to fill to during years replacement is needed) to determine the minimum flood control allocation. The points of minimum flood control allocation are then labeled as the corresponding inflow, only in percentage of normal.
4. To develop the parameter lines, average inflow distribution was assumed as 100% for April-June, 73% for May-June, and 43% for June. These values were developed from the runoff records at the Barretts stream gaging station. Corresponding outflow (normal conservation release) distribution was assumed as 52,000 acre-feet for April-June, 40,000 acre-feet for May-June and 25,000 acre-feet for June. Values of 78,000 acre-feet for April-June, 57,000 acre-feet for May-June, and 34,000 acre-feet for June were

assumed as the actual normal runoff into Clark Canyon after analysis of (1) the forecast equation, (2) past Lima Reservoir April-June water storage holdouts and (3) the converting of flow at Barretts to the Clark Canyon damsite. An example of determining the storage allocations for an inflow of 160% of normal is as follows: 160% of 78,000 acre-feet gives a April-June inflow of 125,000 acre-feet, with the corresponding 3 month outflow of 52,000 acre-feet, the storage allocation is then 73,000 acre-feet of space below the target elevation of 5556.5 or 96,000 acre-feet below elevation 5560.4 for 1 April. To determine the 1 May allocation May-June inflow is 73% of 125,000 acre-feet or 160% of 57,000 acre-feet or 91,000 acre-feet, outflow is 40,000 acre-feet, storage required is then 51,000 acre-feet below elevation 5556.5 or 74,000 acre-feet below elevation 5560.4. To determine the 1 June allocation, June inflow is 43% of 125,000 acre-feet or 160% of 34,000 acre-feet or 54,000 acre-feet, outflow is 25,000 acre-feet, storage required is then 29,000 acre-feet below elevation 5556.5 or 52,000 acre-feet below elevation 5560.4. Straight lines drawn connecting these values represent the flood control storage allocation for a anticipated inflow of 160% of normal at the damsite. The parameter lines were drawn horizontal from 1 April to 1 March to satisfy replacement criteria and to provide for orderly evacuation of storage. A minimum reservation line was arbitrarily drawn from 1 March to 1 May and from 1 September to 1 December.

5. Operating criteria with Bureau specifies that space jointly used for flood control and conservation be assured of fill prior to the end of the runoff season. At Clark Canyon since the joint use space lies 56,475 acre-feet below the targeted fill elevation of 5556.5, this provides ample assurance of refill (against the forecast error) of the joint use space. In other words, the positive forecast error (when actual runoff is less than forecast) is not sufficient to warrant regulation using an assured runoff forecast (most probable forecast less forecast error allowance). It is noted on the other hand, in preparation of years when negative forecast errors (when actual runoff is more than forecast) may occur, fill of space must be limited (as developed in the diagram) to prevent against too rapid a fill, which could impair the flood control function of the reservoir. To offset the negative forecast error when fill is targeted to elevation 5556.5 for replacement regulation, the difference between normal conservation release (52,000 acre-feet for April-June) as used in constructing the parameter lines and the permissible flood release (controlled to 1,500 c.f.s. at Barretts) provides sufficient allowance.