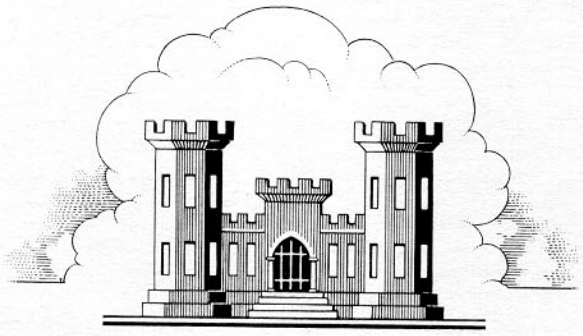
LADM 1130-2-44

VIRGIN RIVER AND TRIBUTARIES, NEVADA, ARIZONA, AND UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA

RESERVOIR REGULATION MANUAL

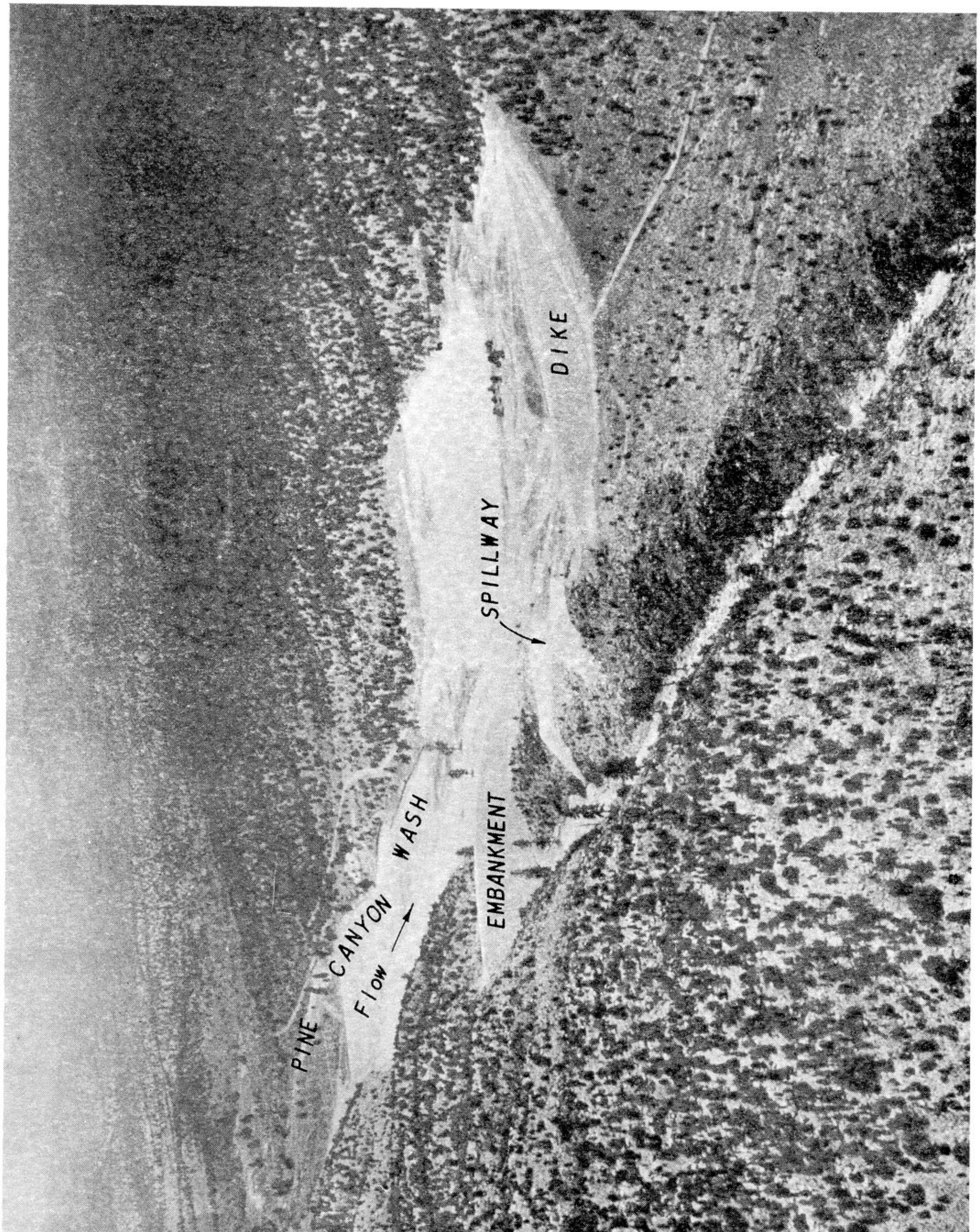
FOR

PINE CANYON DAM



U. S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS

OCTOBER 1974



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VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
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PINE CANYON DAM

VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & Utah
MEADOW VALLEY WASH & TRIBUTARIES, NEVADA

PERTINENT DATA

Drainage Area	sq. miles.	45
Reservoir:		
Elevation -		
Flood-control pool	ft., m.s.l.	5,675
Spillway design surcharge level	ft., m.s.l.	5,685.1
Area -		
Spillway crest	acres	254
Spillway design surcharge level	acres	322
Tope of dam	acres	367
Capacity, gross -		
Allowance for sediment	ac.-ft.	1,400
Spillway crest	ac.-ft.	7,840
Spillway design surcharge level	ac.-ft.	10,725
Top of dam	ac.-ft.	12,460
Embankment:		
Type		Earthfill
Top elevation	ft., m.s.l.	5,690
Height above original streambed	ft.	92
Top lenth	ft.	884
Top width	ft.	20
Freeboard	ft.	4.9
Dike:		
Type		Earthfill
Tope Elevation	ft., m.s.l.	5,690
Height above saddle	ft.	40
Top length	ft.	893
Freeboard	ft.	4.9
Spillway:		
Type		Crest-block
Crest length	ft.	330
Crest elevation	ft., m.s.l.	5,675
Design surcharge	ft.	10.1
Discharge at design surcharge	c.f.s.	31,700
Outlet Conduit:		
Invert elevation	ft., m.s.l.	5,604
Diameter	ft.	3.5
Length	ft.	479
Maximum capacity at spillway crest	c.f.s.	322
Outlet Channel (unlined):		
Length	ft.	150
Capacity	c.f.s.	340

PERTINENT DATA–Continued

Reservoir design flood:		
Duration	hours	60
Total volume	ac.-ft.	7,300
Inflow peak	c.f.s.	10,500
Outflow peak	c.f.s.	321
Reduction in peak	c.f.s.	10,179
Spillway design flood: (Type “A”)		
Duration	hours	20
Total volume	ac.-ft.	15,800
Inflow peak	c.f.s.	38,000
Outflow peak	c.f.s.	31,700
Reduction in peak	c.f.s.	6,300

R E S E R V O I R R E G U L A T I O N M A N U A L

FOR

PINE CANYON DAM

VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & Utah
MEADOW VALLEY WASH & TRIBUTARIES, NEVADA

AUTHORITY

1. The authority for preparation of this manual is contained in ER 1110-2-240. Detailed instructions pertaining to the contents of the manual are contained in EM 1110-2-3600.

SCOPE

2. This manual contains (a) descriptive information pertaining to the project and its drainage area, (b) a description of the plan of operation, and (c) the basis of design for the project, including the reservoir design and spillway design flood routings.

BASIN INFORMATION

3. PINE CANYON BASIN. Pine canyon Dam is located within Pine Canyon, in Lincoln County, Nevada. The site is 18 miles southeast of Caliente, Nevada, and 100 miles northeast of Las Vegas, Nevada. The drainage area behind the dam totals 45 square miles, and consists mostly of rolling hills and narrow valleys. The elevations in the drainage area vary from about 5,598 feet above sea level at the dam to 7,500 feet at the highest peak. The longest water course in the drainage area extends 11 miles above the dam and has an average streambed gradient of 135 feet per mile. Project location and topography are shown on Plate 1.

4. MUDDY RIVER BASIN. Clover Creek, which receives the drainage from Pine Canyon at a point approximately 4 miles downstream (northwest) from the dam, flows northwestward nearly 14 miles to Caliente, where it empties into Meadow Valley Wash. Meadow Valley Wash flows southward to its confluence with the Muddy River near Glendale, 70 miles downstream from Caliente. Downstream from Glendale, the Muddy River flows for a distance of 12 miles to the point where it empties into Lake Mead. Plate 2 illustrates the Muddy River Basin. Prior to the formation of Lake Mead behind Hoover Dam, the Muddy River flowed into the Virgin River. Lake Mead now submerges the confluence of these two rivers.

5. SOILS AND VEGETAL COVER. The mountainous drainage area is covered with shallow soils and large areas of bare rock. In the canyons, soils are deep. Soils throughout the drainage area are volcanic in origin, and have a low organic content. The lower valleys have sparse vegetation, with a few meadows. The higher elevations have a good cover of junipers and scattered large-diameter conifers.

6. ECONOMIC DEVELOPMENT. Pine Canyon Dam, together with Mathews Canyon Dam, provide partial protection to the downstream overflow areas along Clover Creek, Meadow Valley Wash, and lower Muddy River. These overflow areas comprise approximately 13,280 acres and include residential, business, public, and agricultural properties; irrigation and drainage works; flood-control improvements; and highways, roads, railroads, and utilities. Based on a 1955 price index, the value of the property subject to damage was estimated at $11,840,000. The economic analysis of the project found in "Design Memorandum No. 3, General Design for Pine Canyon Dam," dated July 1956 indicates that Pine Canyon Dam is a justified project with a benefit-cost ratio of 1.5 to 1.

7. EXISTING STRUCTURE AFFECTING RUNOFF. There are no structures in the drainage area above Pine Canyon Dam that significantly affect runoff.

8. CLIMATOLOGY. The climate of the drainage area is semiarid. The summers are long and hot and the winters are short and mild. Most precipitation in the drainage area results from general winter storms that are associated with extratropical cyclones of north Pacific origin. Storm rainfall is usually of low intensity, and its distribution reflects orographic influence. The duration of the most intense, flood-producing rain rarely exceeds 6 hours, although the storm itself may last several days. Storms occurring during the summer are of two types: "general summer storms" and "local summer storms." The latter, which are frequent, may result in heavy rain over small areas, but their duration rarely exceeds 3 hours. The general summer storms, which are infrequent, cover comparatively large areas. The duration of these storms may be 24 hours or more. They sometimes include cells of high intensity rainfall of short duration.

9. PRECIPITATION. Precipitation records are available for 4 precipitation stations in or near the drainage area. The longest is for Caliente, which has 50 complete years of record during the period of 1903-1973. The mean annul precipitation ranges from about 10 inches at the dam to 20 inches in the higher mountains. Climatic conditions in the Pine Canyon Basin generally vary with elevation. The months of May and June are somewhat drier that the other months. Snow is common during winter storms, especially at the higher elevations. According to statements by local residents, the maximum snow accumulation in the mountains probably does not exceed 3 or 4 feet. In the lower valleys, snow never remains on the ground for more than a few days. The effect of snow on runoff is generally slight. Precipitation data for four selected precipitation stations (Caliente, Pine Canyon, Mathews Canyon, and Acoma) are given in Tables 1 and 2. The locations are shown on Plate 1.

10. RUNOFF CHARACTERISTICS. Streamflow is negligible except immediately after heavy rains. Climatic conditions are not conducive to continuos runoff. However, high-intensity rainfall in combination with the effects of steep gradients results in intense debris-laden floods. Due to the limited size of the drainage area, the greatest peak discharges would occur from thunderstorms.

11. FLOODS. Flood history in the Muddy River Basin dates back to 1905. Numerous floods causing severe property damage in the basin occurred prior to the construction of Pine Canyon Dam. Once or more floods occurred in the basin in each of the following years: 1906, 1907, 1908, 1910, 1911, 1912, 1913, 1914, 1919, 1922, 1923, 1924, 1925, 1926, 1928, 1934, 1935, 1937, 1938, 1939, 1941, 1945, and 1946. Quantitative records are few; therefore, most of the information on these floods was collected from historical accounts, records of the Union Pacific Railroad Company, reports by local, State and Federal agencies, and statements of local residents. The floods of 1910, 1924, 1938, 1941, and 1946 were outstanding and representative of major floods within the basin. More recently, heavy rainfall occurred in 1965, 1966 and 1969; however, runoff from these storms was reduced considerably due to the protection of Pine Canyon Dam and Mathews Canyon Dam. Brief descriptions of the 27 February 1969 storms and floods are given in the following paragraphs.

12. STORM AND FLOOD OF 27 FEBRUARY - 3 MARCH 1938. The storm of February - March 1938 produced large floods over much of southern California, Arizona, southern Nevada, and southern Utah. The flood was the largest general flood of record in the Muddy River Basin. Low rainfall loss rates and unusually heavy rainfall on 2 March caused high rates of runoff, especially in the mountains. At Caliente the peak discharge on Meadow Valley Wash below Clover Creek was estimated at 15,000 cubic feet per second. This storm produced an estimated peak discharge of 9,000 cubic feet per second at the mouth of Pine Canyon. Snowmelt was a significant contribution to runoff during the storm.

13. STORM AND FLOOD OF 27 - 30 OCTOBER 1946. The general winter storm of 27 - 30 October 1946 deposited up to 10 inches of rainfall in the mountains near Clover Creek. Autographic rain gages in the genera region, operated by the U.S. Bureau of Reclamation, recorded the severity of rainfall. Isohyets of the total storm precipitation are shown on Plate 3. Estimated peak discharges were 3,000 cubic feet per second for Meadow Valley Wash below Caliente, 700 cubic feet per second for Meadow Valley Wash near Panaca, and 8,400 cubic feet per second for Muddy River below Glendale. No data was available for the flow at the mouth of Pine Canyon.

14. STORM AND FLOODS OF JANUARY AND FEBRUARY 1969. General winter storms produced widespread precipitation throughout the state. No significant damages were reported along the reaches both upstream and downstream of Pine Canyon Dam. However, losses in property and crops in other parts of the state totaled about $600,000. Total precipitation at the Pine canyon Dam was 5.43 inches during January and 4.91 inches during February. Runoff was negligible during February because most of the precipitation fell as snow. Inflow to the reservoir resulted in a record maximum water surface elevation of 5,622 feet above mean sea level on 26 January and a computed peak mean hourly inflow of 1,305 cfs on 21 January.

15. FLOOD DAMAGES. The flood of January 1910 caused direct damages estimated at $831,000, including damages of $714,000 to property of the Union Pacific Railroad. Railroad service was interrupted for more than six months. The March 1938 flood caused direct damages estimated at $318,000, including damages of $188,000 to the railroad. Rail traffic was interrupted for two weeks, and basements in Caliente were filled with water and debris. The 1946 flood caused direct damages estimated at $280,000, including damages of $226,000 to the railroad. These values have not been converted to current prices.

16. DOWNSTREAM CHANNEL. Flow from the outlet conduit discharges into a short unlined channel, excavated in sound rock. From the toe of the dam, the channel extends downstream about 150 feet to the natural streambed. The outlet channel has a discharge capacity of 340 cubic feet per second. The reaches extending downstream from Pine Canyon Dam to Lake Mead are predominantly natural streams. The nondamaging channel flow capacities were evaluated by the Corps of Engineers for their “Report on Survey, Flood Control, Virgin River and Tributaries in Nevada, Arizona and Utah” dated June 20, 1942 and are presented on Plate 2.

PROJECT INFORMATION

17. AUTHORIZATION. Pine Canyon Dam was authorized by act of Congress, Flood Control Act of 1950, Public Law 516, Eighty-first Congress, second session, approved 17 May 1950, in accordance with the recommendations of the Chief of Engineers in his report as contained in House Document Number 530, Eighty-first Congress.

18. CONSTRUCTION HISTORY. Construction of the dam began on 18 March 1957 and work was completed on 16 December 1957. Pine Canyon Dam and Mathews Canyon Dam were coordinate improvements under the overall plan of improvement for flood control. The total cost of the two projects (excluding maintenance and operation expenditures) through December 1957, was $1,401,000.

19. PURPOSE. The Purpose of Pine Canyon Dam, in conjunction with Mathews Canyon Dam, is to provide partial protection from floods to area comprising about 13,280 acres, which include about 80 miles of the Union Pacific Railroad mainline, many miles of county roads, the City of Caliente, and about 3,500 acres of irrigated land.

20. RELATIONSHIP TO COORDINATED PLAN OF DEVELOPMENT FOR THE BASIN. Pine canyon and Mathews Canyon Dams are the components of a coordinated flood control plan. Both units are essential for reducing flood peaks on Clover Creek, Meadow Valley Wash and lower Muddy River. These two structures provide partial protection to much of the downstream area, which is also subject to flooding from other sources. Ungated outlets at both dams provide automatic regulation of the reservoirs. Therefore, coordination of flood release from Pine Canyon Dam with other projects in the Muddy River Basin are not possible. Other projects existing within the Muddy River Basin include various small dams and weirs, constructed for purposes of flood control, erosion control, irrigation are recreation. None of these structures significantly effect large floods.

21. DESCRIPTION. A general plan of the project is shown on Plate 4 and a detailed description is contained in the following paragraphs.

22. EMBANKMENT AND DIKE. The embankment is a zoned earthfill structure with a crest length of 884 feet and crest width of 20 feet. The maximum height above the streambed is 92 feet. The upstream and downstream slopes are 1 vertical on 2.50 horizontal. The foundation is bedrock for the entire length of the embankment. The dike is an earthfill structure, 40 feet high and 893 feet long, and is identical in section and composition to the embankment. Slope protection for the embankment and dike is provided by stone blankets on upstream and downstream slopes. Typical sections of both the embankment and the dike are shown on Plate 5. The plan and profile for the embankment and dike are shown on Plate 6.

23. OUTLET WORKS. The outlet works is located in the right abutment and consists of an intake structure, an ungated outlet conduit, and an unlined outlet channel excavated in rock. The plan, profile, and sections of the outlet works are shown on Plate 7 and the outlet discharge curve is shown on Plate 8. A general description of the outlet works is contained in the following paragraphs.

a. Intake Structure. The intake structure is a rectangular concrete tower, 19 feet high and 8.5 feet square, perforated by a series of intake ports 1.5 feet wide 2 feet high, and includes a bell-mouth conduit entrance.

b. Conduit. The conduit, an ungated structure of reinforced concrete, is 3.5 feet in diameter and 499 feet in length. Elevations of the conduit's invert are 5604.00 at the upstream end, and 5594.62 at the downstream end. The entire conduit has been set into sound rock. Flow from the conduit discharges into the outlet channel which extends from the end of the conduit to the natural streambed. The maximum capacities of the conduit with the water surface at spillway crest (elevation 5,675.0) and top of the dam (elevation 5,690.0) are 322 and 352 cubic feet per second, respectively.

24. SPILLWAY. The spillway consists of a trapezoidal channel excavated in hard rock along the left wall of Pine Canyon. The channel has a 330 foot base and side slopes of 1 horizontal to 2 vertical. The spillway is not paved; however, a 2 foot wide and 5 foot deep concrete sill forms a control section extending the full length of the crest. The sill is fully entrenched in rock such that its top is flush with the spillway's profile at elevation 5,675. Spillway flow returns to the natural channel about 450 feet downstream of the crest. Plan, profile and details of the spillway are shown on Plate 9. The spillway discharge curve is shown on Plate 10.

25. RESERVOIR. The reservoir, formed by Pine Canyon Dam, has an area and gross capacity at spillway crest (elevation 5,675) of 254 acres and 7,840 acre-feet, respectively. At the top of the dam (elevation 5,690), the area is 367 acres and the gross capacity is 12,460 acre-feet, which includes a 1,400 acre-foot allowance for sedimentation and debris below spillway crest. Area and capacity curves are shown on Plate 11. A tabulation of areas and capacities is given in Table 3.

26. BASIS FOR DESIGN. The Pine Canyon Dam and appurtenances were designed to control the reservoir design flood; effectively pass the spillway design flood without endangering the dam; and provide storage for sediment carried into the reservoir from the tributary drainage area. Development of the design floods is described in the Corps of Engineers' report titled "Design Memorandum No. 1, Hydrology for Pine Canyon and Mathews Canyon Dams, Meadow Valley Wash and Lower Muddy River Basins, Nevada" dated April 1955. Establishment of the spillway crest and top of dam elevations and sediment volume is described in the report titled "Design Memorandum No. 3, General Design for Pine Canyon Dam, Meadow Valley Wash and Lower Muddy River Basins, Nevada" dated July 1956. The design criteria are briefly described below.

a. Reservoir Design Flood. The reservoir design flood is expected to occur from the most severe combination of meteorologic and hydrologic conditions that are reasonably characteristic of the geographic area. A synthetic general winter type storm, based on previous events, especially the storms of 1938 and 1946, was established for design. The duration of the synthetic storm was 24 hours, including 6 hours of intense rainfall. Ground conditions reasonably conducive to runoff were established by assuming the intense rainfall to occur 17 hours after the start of the storm. Rainfall over the entire drainage area during the 24-hour storm resulted in a total average depth of 8 inches, of which 4.5 inches occurred during the 6 hour period of intense rainfall. Infiltration loss rates varied with time. The average loss rate for the period of intense rainfall was .25 inches per hour. Runoff from snowmelt was considered to constitute a minor contribution to the flood flows and was therefore neglected. The storm produced a reservoir design flood having a peak discharge of 10,500 cfs and a volume of 7,300 acre-feet.

b. Sediment Volume. The allotted sediment-storage volume of 1,400 acre-feet in the reservoir was determined from a study of silt accumulation rates in existing reservoirs in the southwest United States. From this study, the silting rate was established at 28 States. From this study, the silting rate was established at 28 acre-feet per year, or .62 acre-feet per square mile per year.

c. Spillway Design Flood. The spillway design flood represents a discharge that may be expected from the most severe combinations of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Two types of floods were analyzed to determine which was most critical. The type "A" flood, which produced peak discharges, was based on the maximum possible thunderstorm; the type "B" flood, which produced peak volume was based on the maximum possible general storm with accretion to storm runoff from snowmelt. Type "A" flood was determined to be the most critical for the Pine Canyon Dam, and was used as the maximum probable flood. The thunderstorm was expected to have a 6 hour duration and produce an average rainfall depth over the entire basin of 8.2 inches. The resultant peak discharge was 38.000 cfs and the volume of runoff was 15,800 acre-feet for the flood.

d. Reservoir Design Flood Routing. The spillway crest elevation was determined by routing the reservoir design flood through the reservoir assuming the space allocated to sediment storage had silted in, i.e., net storage was used. A maximum water surface elevation of 5,674.6 feet was calculated and the peak inflow of 10,500 cfs was reduced to the peak outflow of 321 cfs. Spillway crest elevation was set 0.4 feet higher at elevation 5,675 feet above mean sea level. See Plate 12 for the reservoir design flood routing.

e. Spillway Design Flood Routing. The spillway design flood was routed through the reservoir assuming the ungated outlet blocked and the reservoir full to spillway crest at the beginning of the flood. A maximum water surface elevation of 5,685.1 feet was calculated and the peak inflow of 38,000 cfs was reduced to a peak outflow of 31,700 cfs over the spillway. A 4.9 foot freeboard to prevent waves from overtopping the dam was added to the maximum water surface elevation. Thus, the elevation of the top of the dam was established at 5,690 feet above mean sea level. See Plate 13 for the spillway design flood routing.

OPERATION

27. RESPONSIBILITY FOR THE OPERATION. The operation and maintenance of Pine Canyon Dam is the responsibility of the Chief, Construction-Operation Division. He has delegated authority for these functions through the Chief, Operations Branch, to the Chief, Reservoir Regulation Section, and Chief, Engineering Evaluation and Maintenance Section. Plates 14 through 17 indicate the organization and key personnel for normal and flood emergency operations.

28. FLOOD CONTROL OPERATION PLAN. Floods of magnitude up to and including the reservoir design flood would be controlled by the project such that peak outflows from the reservoir would be safely carried in downstream reaches. Flood waters would be released through a 3.5-foot-diameter conduit. The outlet works does not include any mechanical equipment that would permit adjustment to reservoir outflows.

29. REPORTING CRITERIA. Lincoln County Flood Control District, has agreed to report to the Corps of Engineers when any of the following conditions occur: rainfall of ½ inch in 2 hours at Caliente; rainfall of 1 to 2 inches in 2 hours at the dam or mountain area; and a reservoir water surface elevation of 5,644.0 feet.

30. EMERGENCY WARNING. There are no permanent attendants, telephones or radios located at Pine Canyon Dam. Access to the dam from Caliente is by an unpaved road which is subject to washouts during large storms. Thus the reporting of conditions of unusually high outflows from Pine Canyon Dam to downstream areas would be difficult if not impossible. Lincoln County Flood Control District is responsible for such reportings.

31. OPERATION RECORD. A condensed operation record including inflow, outflow and storage since the project was constructed is shown on Plates 18 through 21. The reservoir is normally dry and periods of more than 2 years without stream flow have occurred.

COLLECTION OF HYDROLOGIC DATA

32. HYDROLOGIC FACILITIES. Hydrologic facilities include: (a) fifteen staff gages, (b) an automatic water surface recorder, (c) an outflow gaging station with automatic water-stage recorder, and(d) three precipitation gages.

a. Staff Gages. There are fifteen 5-foot-adjustable staff gages located on the upstream slope of the dam. The staff gage system indicates water surface elevations in the range from 5,610 to 5,685.

b. Water Surface Recorder. Reservoir water surface elevations measured in the float well are recorded by an instrument located in the recorder house atop the dam embankment.

c. Stream Gages. The U.S. Geological Survey operates the “Pine Canyon Wash near Caliente” stream gaging station, located about 100 feet downstream from the dams’ outlet (see Plate 1). A concrete sill extending across the streambed provides control for stream flow measurements. Continuous stage recording equipment is installed at the station. Plate 22 is a rating curve for stream flow at this station.

d. Precipitation Gages. There are three precipitation gages in Pine Canyon Basin. On automatic recording gage is located at the Pine Canyon Wash gaging station and is serviced by the U.S. Geological Survey. The other two gages which are of the storage type are located in the upper reaches of the drainage area and are serviced by the Corps of Engineers (see Plate 1 for gage locations).

33. SEDIMENTATION. The allotted sediment storage space for the reservoir is 1,400 acre-feet. There are no sedimentation ranges in the reservoir.

COORDINATION WITH OTHER AGENCIES

34. A list of agencies together with a brief explanation of their functions related to reservoir operations is give in the following subparagraphs.

a. Lincoln County Flood Control District. Lincoln County Flood Control District is the agency responsible for local cooperation. This agency has agreed with the Corps of Engineers to keep the downstream channels free from man-made encroachment, report storm and flood conditions and to be responsible for any actions relating downstream water rights to the dam's operation.

b. National Weather Service. The Airport Station of the National Weather Service at Las Vegas, Nevada, provides this office, upon request, with weather forecasts and climatological reports for the Meadow Valley Wash and Muddy River Basins.

c. U.S. Geological Survey. The Corps of Engineers and the U.S. Geological Survey have agreed that the latter organization will service the outflow gaging station below Pine Canyon Dam and will make discharge measurements. Outflow records are published in U.S. Geological Survey water reports.

d. Soil Conservation Service. Data on existing snow cover in the Pine Canyon Basin are available from the Soil Conservation Service office in Reno, Nevada.

35. RECREATION DEVELOPMENT OF RESERVOIR AREA. Currently, there are no definite plans for any recreational development in the reservoir area.

Table 1

CLIMATOLOGICAL DATA AT CALIENTE, NEVADA*

Month	Temperature			Precipitation			Snowfall
	Mean monthly	Record highest	Record lowest	Mean monthly	Maximum monthly	Minimum monthly	Mean monthly
	Degrees Fahrenheit	Degrees Fahrenheit	Degrees Fahrenheit	Inches	Inches	Inches	Inches
Jan.	31.6	71	-31	.81	3.25	0	2.1
Feb.	37.3	76	-18	.86	3.70	0	2.2
Mar.	44.1	90	2	.81	2.98	0	1.1
Apr.	51.6	89	15	.67	3.71	0	.2
May	60.2	98	22	.46	1.91	0	0
Jun.	68.5	109	33	.31	1.95	0	0
Jul.	75.8	110	40	.69	2.25	0	0
Aug.	74.1	108	36	.83	4.18	0	0
Sep.	65.5	106	24	.52	3.14	0	0
Oct.	53.8	94	10	.72	4.29	0	.1
Nov.	42.0	80	0	.61	3.08	0	.6
Dec.	33.7	69	-17	.72	3.76	0	3.0
Period of record	**53.2	110	-31	**8.01	4.29	0	** 9.3

*Latitude 37°37'N; longitude 114°31'W; elevation 4,402 feet above mean sea level (see pl. 1 for location).

**Mean annual.

NOTE: Period of record for temperature 49 years (September 1904 to December 1973). Period of record for precipitation 50 years (April 1903 to December 1973). Period of record for snowfall 50 years (September 1903 to December 1973). All values based on number of full months or years of record available.

Table 2

PRECIPITATION DATA

Month	Pine Canyon, Nev. (1)			Mathews Canyon, Nev. (2)			Acoma, Nev. (3)		
	Mean monthly	Maximum monthly	Minimum monthly	Mean monthly	Maximum monthly	Minimum monthly	Mean monthly	Maximum monthly	Minimum monthly
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
Jan...	.94	5.43	0	.79	3.09	0	1.04	2.08	0.10
Feb...	1.34	4.91	0	1.47	5.69		.56	1.17	0
Mar...	.84	2.21	0	.76	1.87	0	.89	2.89	0
Apr...	.83	3.23	0	.76	4.08	0	.88	2.79	.03
May...	.61	1.52	0	.35	1.27	0	.56	2.36	0
Jun...	.30	.78	0	.37	1.45	0	.29	1.06	0
Jul...	.78	2.38	0	.85	2.12	0	1.18	1.81	.25
Aug...	.93	2.37	0	1.16	2.81	.02	1.11	4.43	0
Sep...	.82	4.07	0	.90	4.13	0	.44	1.00	0
Oct...	.78	3.45	0	.73	3.58	0	.63	3.07	0
Nov...	1.01	2.60	0	.93	2.64	0	.64	1.33	0
Dec...	.95	3.88	0	.99	3.64	0	.61	1.65	0
Period of record	10.13 *	5.43	0	10.06 *	5.69	0	8.83 *	4.43	0

* Mean annual

(1) Latitude 37°29'N; longitude 114°19'W; elevation 5,600 feet m.s.l. Period of record is discontinuous and extends from December 1949 to December 1973. Data is from Corps of Engrs records.

(2) Latitude 37°31'N; longitude 114°13'W; elevation 5,400 feet m.s.l. Period of record is discontinuous and extends from July 1958 to July 1973. Data is from Corps of Engrs records.

(3) Latitude 37°31'N; longitude 114°10'W; elevation 5,521 feet m.s.l. Period of record 9 years (December 1949-December 1958). Station discontinued 31 Dec 1958. Data is from "Climatological Data, Nevada," National Oceanic and Atmospheric Administration.

NOTE: All values based on number of full months or years of record available (see pl. 1 for locations).

Table 3

AREA AND GROSS CAPACITY - PINE CANYON DAM

Elevation	Capacity	Area	Elevation	Capacity	Area
Feet above mean sea level	Acre-feet	Acres	Feet above mean sea level	Acre-feet	Acres
5,604	0	0	5,639	1,700	97.5
5,605	5	3.0	5,640	1,800	101.5
5,606	10	5.0	5,641	1,900	105.0
5,607	20	7.9	5,642	2,000	108.0
5,608	40	10.0	5,643	2,100	112.5
5,609	50	12.0	5,644	2,200	116.0
5,610	70	14.6	5,645	2,350	120.0
5,611	90	17.0	5,646	2,450	123.5
5,612	100	19.0	5,647	2,575	128.0
5,613	120	21.5	5,648	2,725	131.5
5,614	150	24.0	5,649	2,850	135.0
5,615	180	26.5	5,650	3,000	139.0
5,616	210	29.0	5,651	3,125	143.0
5,617	230	31.5	5,652	3,275	147.0
5,618	260	34.0	5,653	3,450	150.0
5,619	280	37.0	5,654	3,600	154.0
5,620	340	39.5	5,655	3,750	159.0
5,621	390	42.0	5,656	3,900	163.0
5,622	420	45.0	5,657	4,050	167.0
5,623	475	48.0	5,658	4,250	171.0
5,624	510	51.0	5,659	4,400	176.0
5,625	575	54.0	5,660	4,550	180.5
5,626	625	57.0	5,661	4,750	185.0
5,627	690	59.5	5,662	4,950	189.5
5,628	750	62.5	5,663	5,150	194.0
5,629	850	65.0	5,664	5,350	199.5
5,630	925	69.0	5,665	5,550	204.0
5,631	1,000	71.0	5,666	5,750	209.0
5,632	1,090	74.0	5,667	5,975	213.5
5,633	1,175	77.0	5,668	6,200	219.0
5,634	1,250	80.0	5,669	6,400	223.5
5,635	1,350	84.0	5,670	6,650	229.0
5,636	1,425	87.0	5,671	6,900	233.5
5,637	1,500	90.0	5,672	7,100	238.0
5,638	1,600	93.5	5,673	7,350	243.5

Table 3 -- Continued

AREA AND GROSS CAPACITY - PINE CANYON DAM

Elevation	Capacity	Area	Elevation	Capacity	Area
Feet above mean sea level	Acre-feet	Acres	Feet above mean sea level	Acre-feet	Acres
5,674	7,625	249.0	5,683	10,050	304.0
#5,675	7,840	254.0	5,684	10,400	312.0
5,676	8,100	260.0	5,685	10,725	321.8
5,677	8,400	266.0	5,686	11,060	330.0
5,678	8,650	271.5	5,687	11,400	339.0
5,679	8,900	277.0	5,688	11,750	348.0
5,680	9,200	284.0	5,689	12,100	357.0
5,681	9,500	290.0	##5,690	12,460	367.0
5,682	9,800	297.0			

NOTE: Area and Capacity are based on survey of October 1941.

Spillway crest
Top of dam

114°30'
CALIENTE
114°20'
114°10'
ACOMA
37°30'
37°20'
5000
5500
6000
6500
7000
Clover Creek
UP RR
PINE CANYON DAM
BARCLAY
MATHEWS CANYON DAM
PINE CANYON
MATHEWS CANYON
N
NV.
UT.
AZ.
CA.
PIOCHE
CALIENTE
ST. GEORGE
LAS VEGAS
LAKE MEAD
NEEDLES
VICINITY MAP
SCALE 0 50 100 MILES
AREA COVERED BY MAP
LEGEND
BOUNDARY OF DRAINAGE AREA
EXISTING FLOOD CONTROL DAM
CLIMATOLOGICAL STATION
PRECIPITATION STATION
STREAM-GAGING STATION
DATUM IS MEAN SEA LEVEL
SCALE 1 0 1 2 MILES
VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL
PINE CANYON DAM
PROJECT LOCATION, TOPOGRAPHY, DRAINAGE AREA AND HYDROLOGIC MAP
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 1

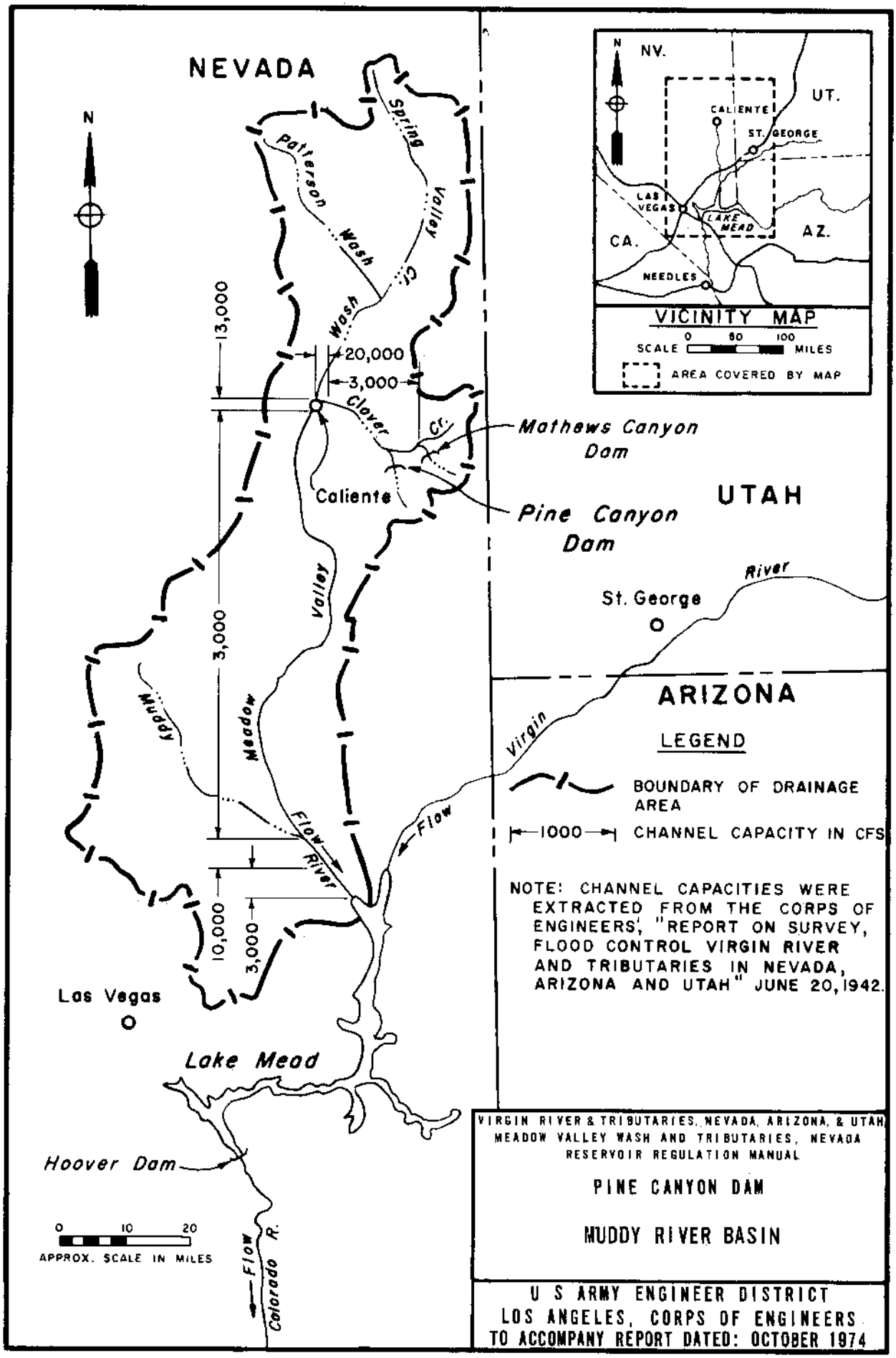

NEVADA
N
Spring Valley
Patterson Wash
Wash
Cr.
13,000
20,000
3,000
Clover
Cr.
Mathews Canyon Dam
Caliente
Pine Canyon Dam
UTAH
St. George
River
Virgin
3,000
Valley
Muddy
Meadow
Flow
River
Flow
10,000
3,000
Las Vegas
Lake Mead
Hoover Dam
0 10 20
APPROX. SCALE IN MILES
Flow
Colorado R.
N
NV.
UT.
CALIENTE
ST. GEORGE
LAS VEGAS
LAKE MEAD
CA.
AZ.
NEEDLES
VICINITY MAP
0 50 100
SCALE MILES
AREA COVERED BY MAP
ARIZONA
LEGEND
BOUNDARY OF DRAINAGE AREA
1000 CHANNEL CAPACITY IN CFS
NOTE: CHANNEL CAPACITIES WERE EXTRACTED FROM THE CORPS OF ENGINEERS', "REPORT ON SURVEY, FLOOD CONTROL VIRGIN RIVER AND TRIBUTARIES IN NEVADA, ARIZONA AND UTAH" JUNE 20, 1942.
VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL
PINE CANYON DAM
MUDDY RIVER BASIN
U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 2

UTAH

ARIZONA

NEVADA

2 3 4 5 6 7 8 9

MATHEWS CANYON DAM

PINE CANYON DAM

Panaca

Pioche

Caliente

Spring Valley Creek

Spring Valley Wash

Patterson Wash

Meadow Valley Wash

Clover Creek

Union Wash

Virgin River

Flow

Lake Mead

Overton

Glendale

Pacific Flow RR

Kane Spring Wash

Muddy River

California Wash

Las Vegas

93

91

N

Z

VICINITY MAP

NV. UT. CA. AZ.

PIOCHE CALIENTE ST. GEORGE LAS VEGAS LAKE MEAD NEEDLES

0 50 100 MILES

AREA COVERED BY MAP

LEGEND

3 — ISOHYET: LINE OF EQUAL RAINFALL IN INCHES.

DRAINAGE BOUNDARY

5 0 5 10

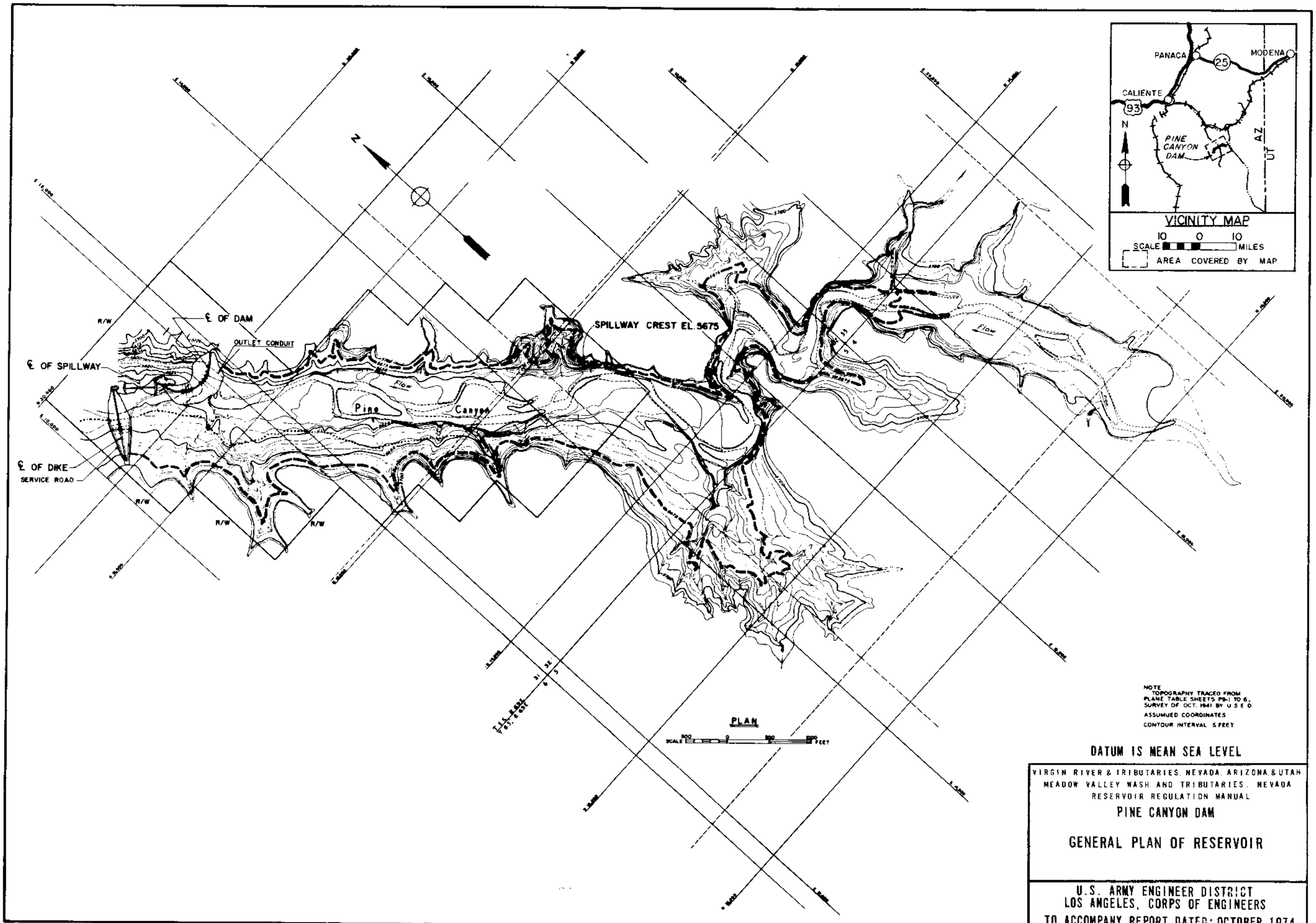
APPROX. SCALE IN MILES

VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM
ISOHYETS
TOTAL STORM PRECIPITATION
27-30 OCTOBER 1946

U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 3



VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM

GENERAL PLAN OF RESERVOIR

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 4

The Plate you are attempting to access is not currently available.

For additional information, please contact the Los Angeles District Public Affairs Office at (213) 452-3908.

The Plate you are attempting to access is not currently available.

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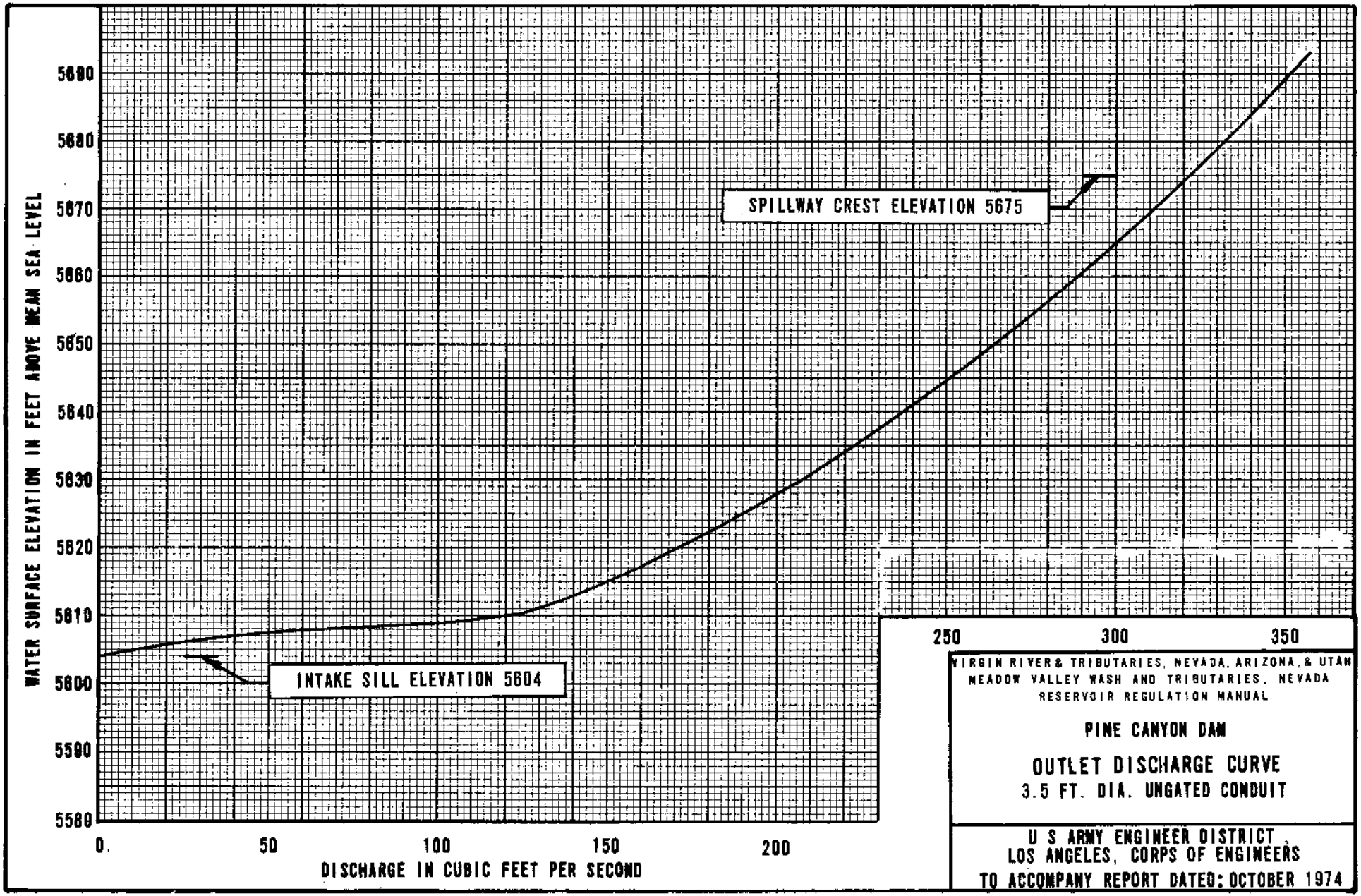


VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM

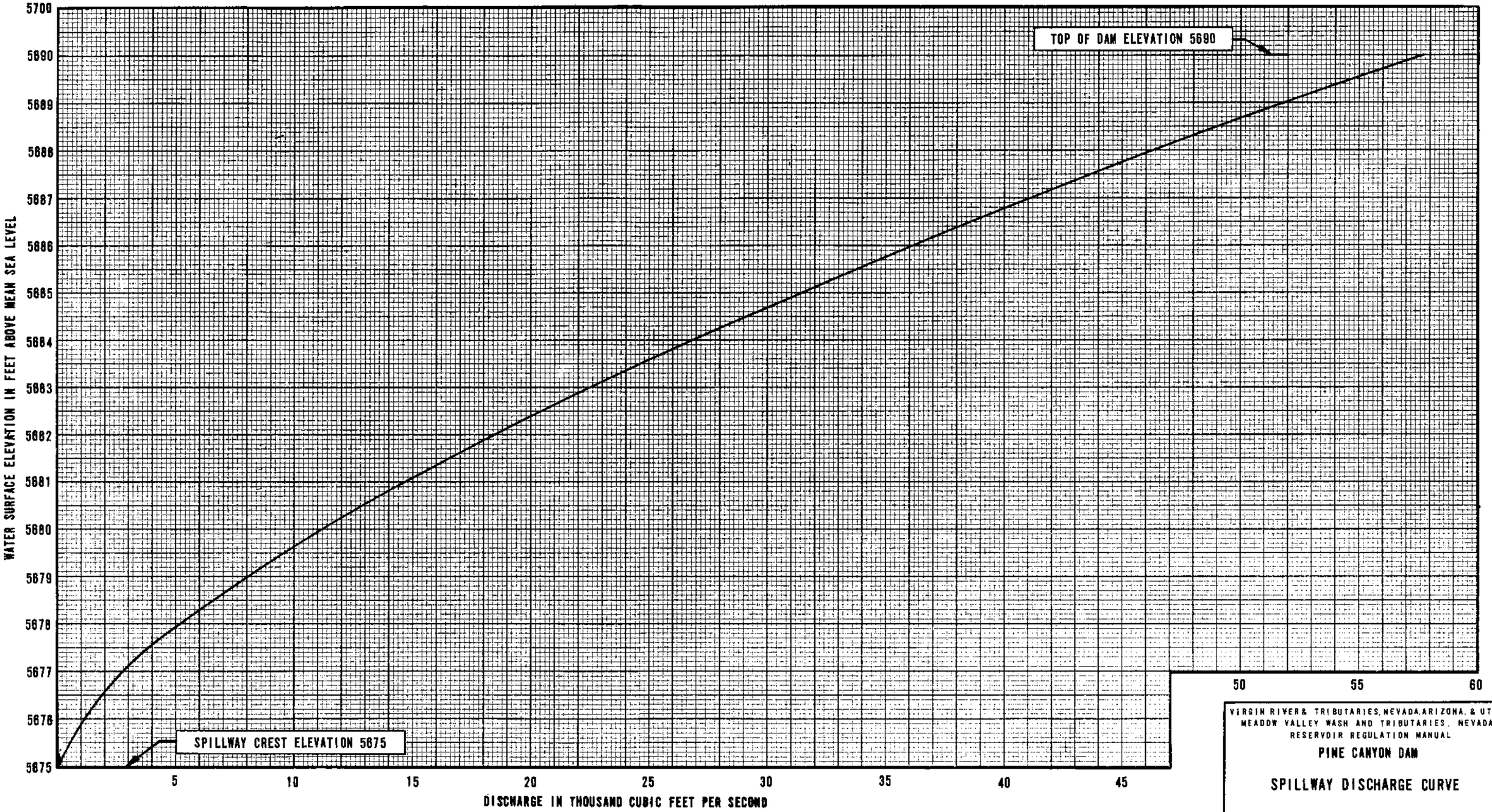
OUTLET DISCHARGE CURVE
3.5 FT. DIA. UNGATED CONDUIT

U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 8

The Plate you are attempting to access is not currently available.

For additional information, please contact the Los Angeles District Public Affairs Office at (213) 452-3908.



VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

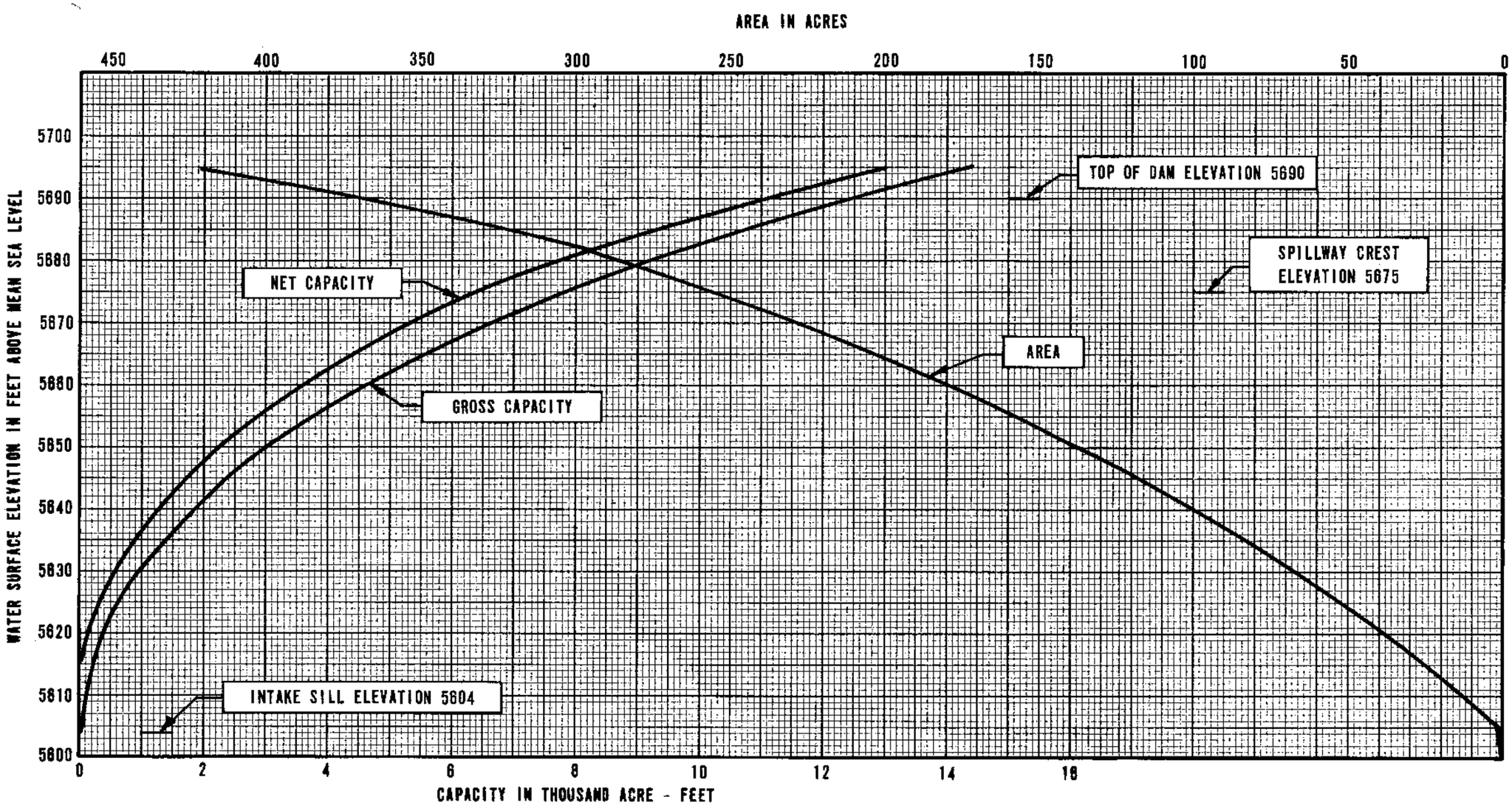
PINE CANYON DAM

SPILLWAY DISCHARGE CURVE

U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 10



NOTE: CURVES BASED ON SURVEY OF MARCH 1954

VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM

AREA AND CAPACITY CURVES

U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 11

DRAINAGE AREA	45 SQ MI
AVERAGE RAINFALL DEPTH OVER AREA:	
MAXIMUM 6-HOUR	4.5 INCHES
24-HOUR	8.0 INCHES
EFFECTIVE, MAXIMUM 6-HOUR	3.0 INCHES
EFFECTIVE, 24-HOUR	3.0 INCHES
RUNOFF FROM 24-HOUR RAINFALL	7,300 AC-FT
	3.0 INCHES

AVERAGE RAINFALL OVER AREA IN INCHES PER HOUR

0
2
4
6
8
1.0
10

RAINFALL LOSS

EFFECTIVE RAINFALL (SURFACE RUNOFF)

NOTE: RAIN PRIOR TO THAT OF 24-HOUR PERIOD ASSUMED TO PRODUCE NEGLIGIBLE RUNOFF.

PEAK INFLOW 10,500 C.F.S.

MAX. W.S. ELEVATION 5674.6

PEAK OUTFLOW 321 C.F.S.

DISCHARGE IN THOUSAND CUBIC FEET PER SECOND

0
2
4
6
8

0 6 12 18 0 6 12 18 0 6 12

TIME IN HOURS

1ST DAY — 2ND DAY — 3RD DAY

WATER SURFACE ELEVATION IN FEET ABOVE MEAN SEA LEVEL

5600
5610
5620
5630
5640
5650
5660
5670
5680

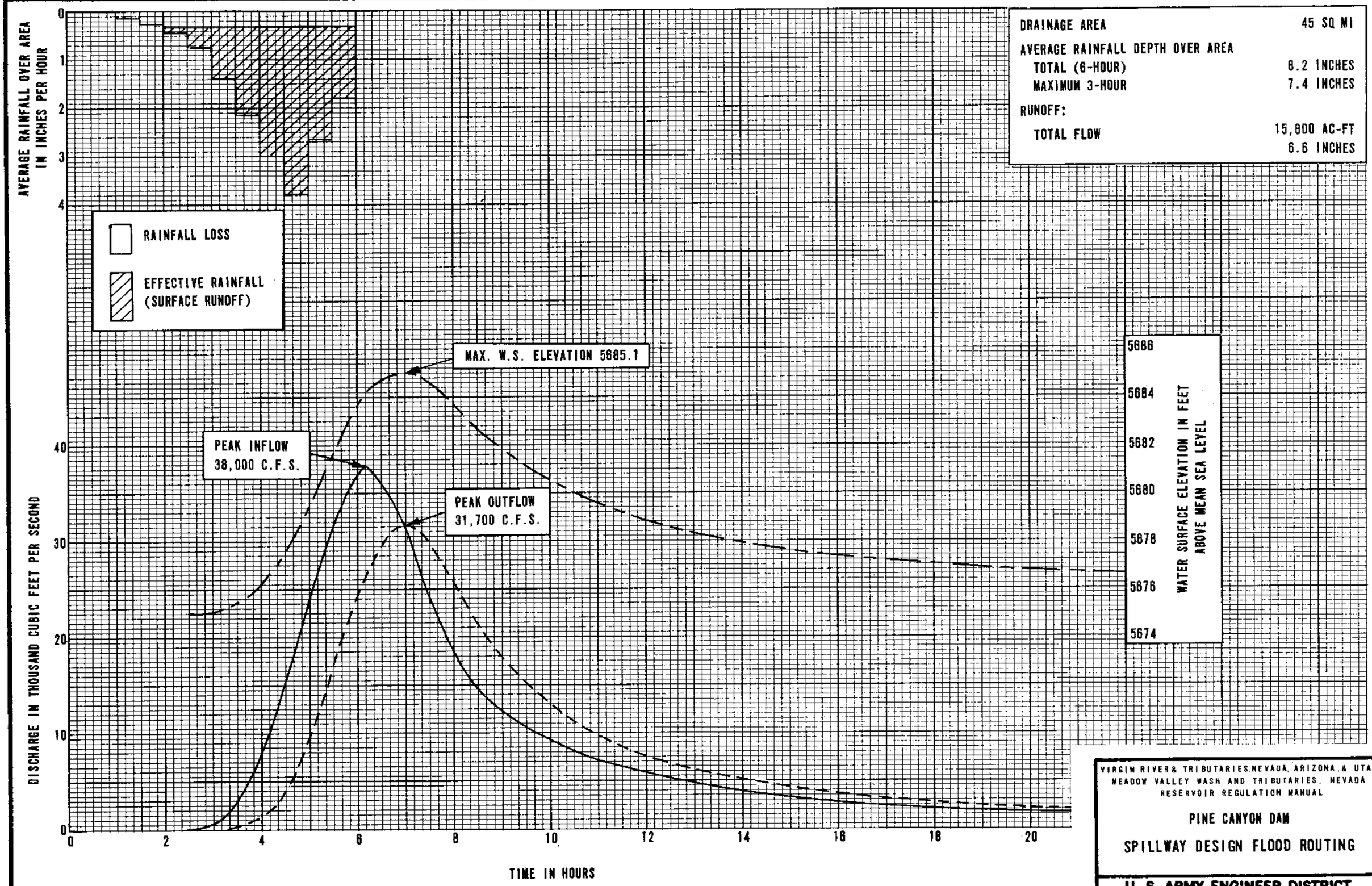
VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM

RESERVOIR DESIGN FLOOD ROUTING

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 12



DRAINAGE AREA	45 SQ MI
AVERAGE RAINFALL DEPTH OVER AREA	
TOTAL (6-HOUR)	8.2 INCHES
MAXIMUM 3-HOUR	7.4 INCHES
RUNOFF:	
TOTAL FLOW	15,800 AC-FT
	6.6 INCHES

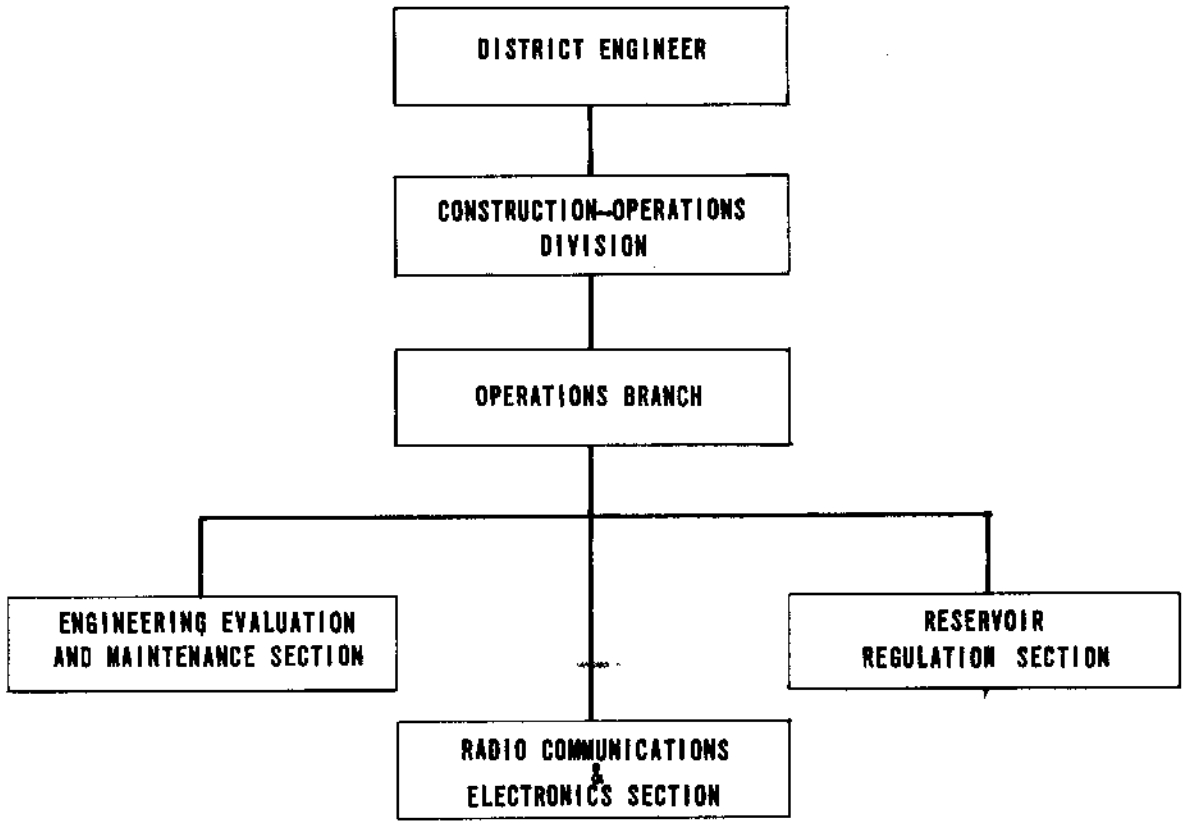
VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM

SPILLWAY DESIGN FLOOD ROUTING

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 13



NOTE: SEE PLATE 15 FOR NAMES AND TELEPHONE NUMBERS OF KEY PERSONNEL

VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM

ORGANIZATION FOR NORMAL OPERATION

U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 14

TITLE	NAME	OFFICE TELEPHONE	HOME TELEPHONE
DISTRICT ENGINEER	FOLEY, J.V. COLONEL	(213) 688-5300	(213) 377-4688 PALOS VERDES PENINSULA, CA
CHIEF CONSTRUCTION- OPERATIONS DIVISION	YOUNG, R.P.	(213) 688-5600	(714) 624-4659 CLAREMONT, CA
CHIEF OPERATIONS BRANCH	LAND, R.E.	(213) 688-5620	(213) 583-3632 HUNTINGTON PARK CA
CHIEF RESERVOIR REGULATION SECTION	FLANNERY, L.C.	(213) 688-5644	(213) 396-9859 SANTA MONICA, CA
CHIEF RADIO COMMUNICATIONS & ELECTRONICS SECTION	ERICKSON, E.N.	(213) 688-5645	(213) 355-7236 SIERRA MADRE, CA
CHIEF ENGINEERING EVALUATION & MAINTENANCE SECTION	HOOPPAW, C.K.	(213) 283-2757	(213) 691-2839 WHITTIER, CA

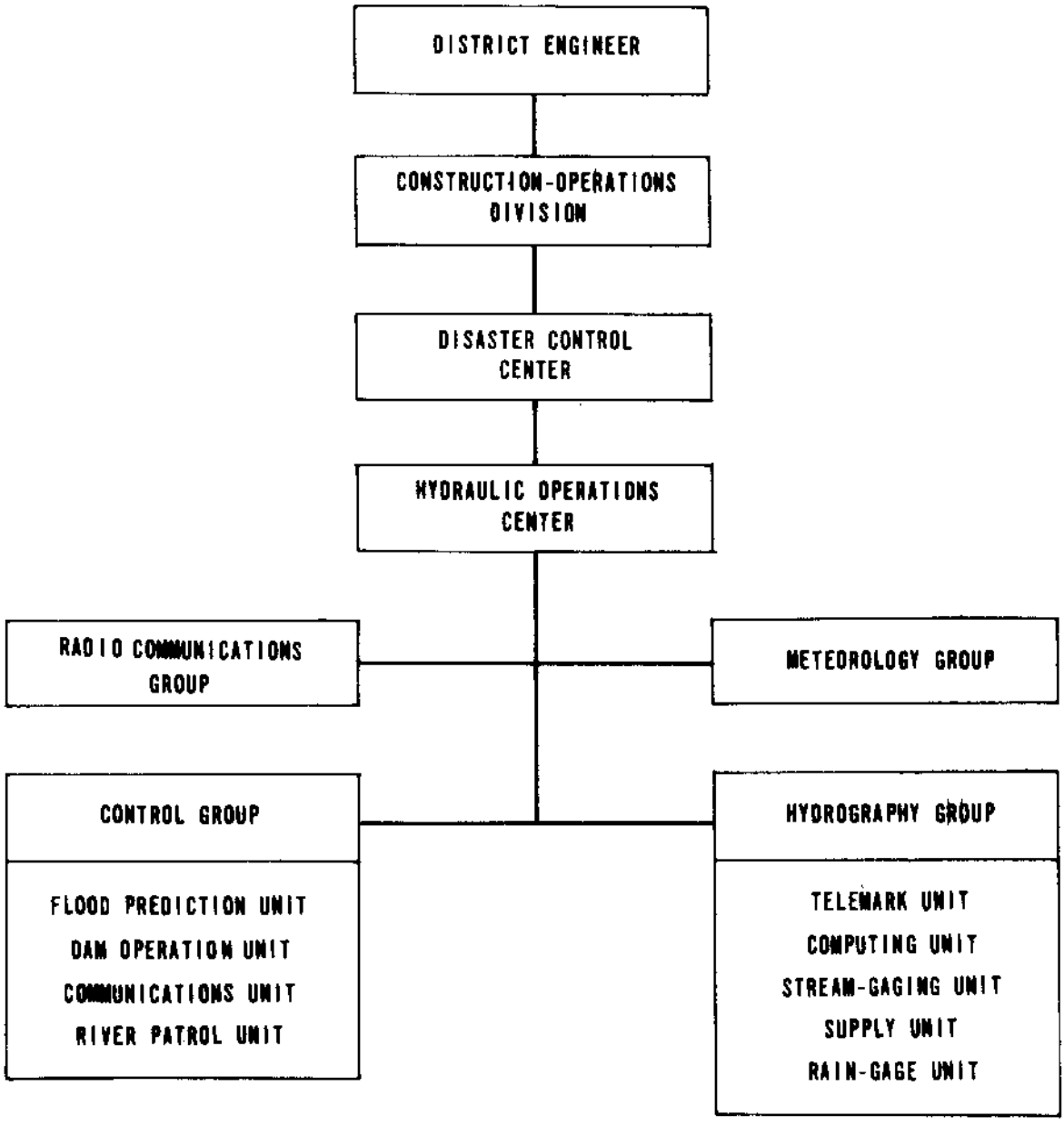
VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM

KEY PERSONNEL
FOR NORMAL OPERATION

U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 15



NOTE: SEE PLATE 17 FOR NAMES AND TELEPHONE NUMBERS OF KEY PERSONNEL.

VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM

ORGANIZATION

FOR FLOOD-EMERGENCY OPERATION

U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 16

TITLE	NAME	OFFICE TELEPHONE	HOME TELEPHONE
DISTRICT ENGINEER	FOLEY, J.V. COLONEL	(213) 688-5300	(213) 377-4688 PALOS VERDES PENINSULA, CA
CHIEF CONSTRUCTION- OPERATIONS DIVISION	YOUNG, R.P.	(213) 688-5600	(714) 624-4659 CLAREMONT, CA
CHIEF DISASTER CONTROL CENTER	LAND, R.E.	(213) 688-5620	(213) 583-3632 HUNTINGTON PARK CA
CHIEF HYDRAULIC OPERATIONS CENTER	FLANNERY, L.C.	(213) 688-5644	(213) 396-9859 SANTA MONICA, CA
CHIEF RADIO COMMUNICATIONS GROUP	ERICKSON, E.H.	(213) 688-5645	(213) 355-7236 SIERRA MADRE, CA
CHIEF CONTROL GROUP	SIENKIEWICH, A.	(213) 688-5644	(213) 433-8532 LONG BEACH, CA
CHIEF METEOROLOGY GROUP	PYKE, C.B.	(213) 688-4757	(213) 277-3393 BEVERLY HILLS, CA
CHIEF HYDROGRAPHY GROUP	PEREA, E.B.	(213) 688-5646	(213) 333-1191 LA PUENTE, CA

VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

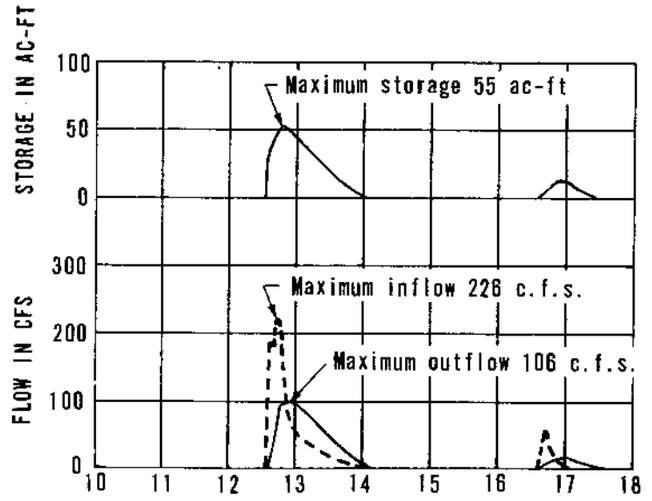
PINE CANYON DAM

KEY PERSONNEL

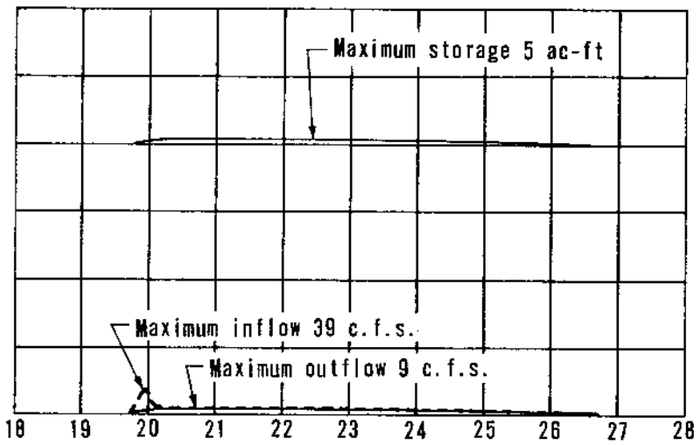
FOR FLOOD-EMERGENCY OPERATION

U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

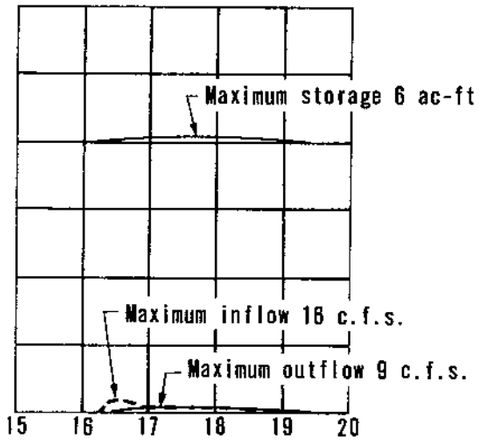
PLATE 17



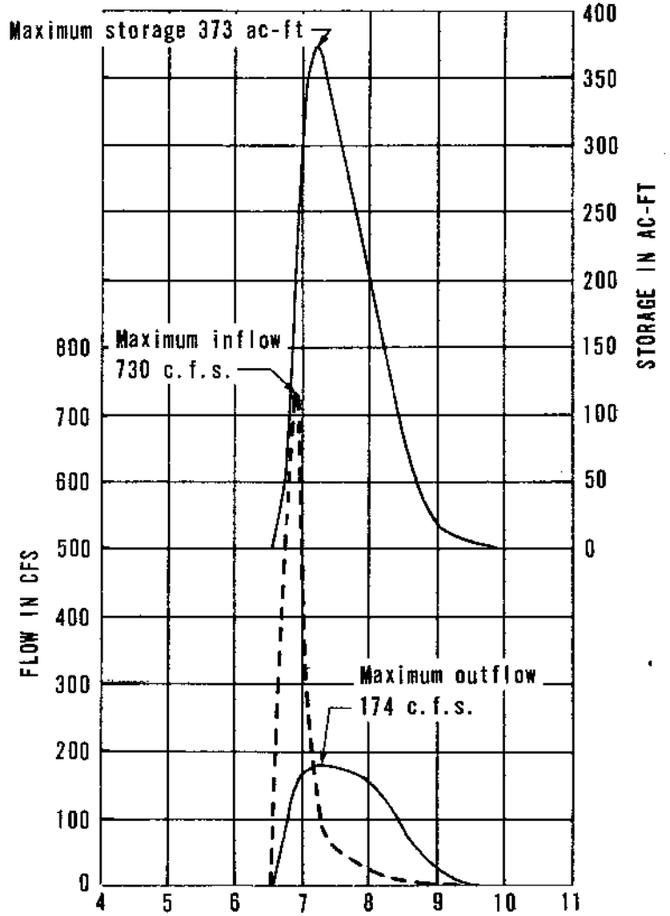
FEBRUARY 1962



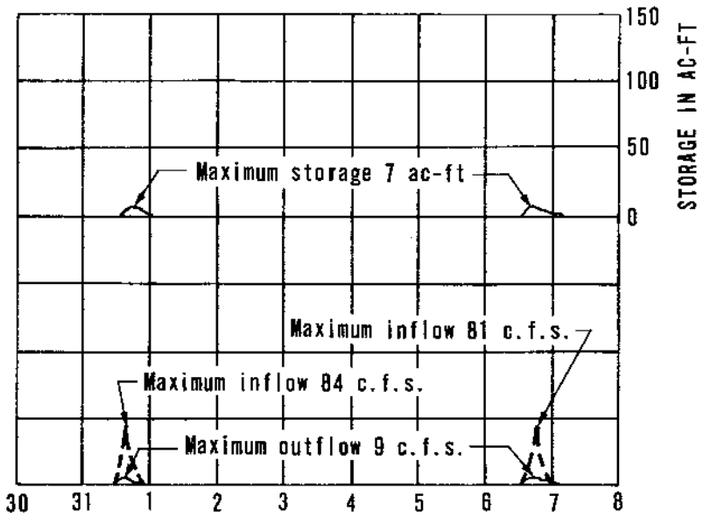
APRIL 1965



MARCH 1966



DECEMBER 1966



JULY 1968 AUGUST 1968

NOTE:

1. Periods of appreciable flow shown only.
2. Operation record from reservoir water surface records. The maximum inflow is the calculated peak hourly value.
3. Operation record is not available for the flow period of Dec. 30, 1965 to Jan. 2, 1966.

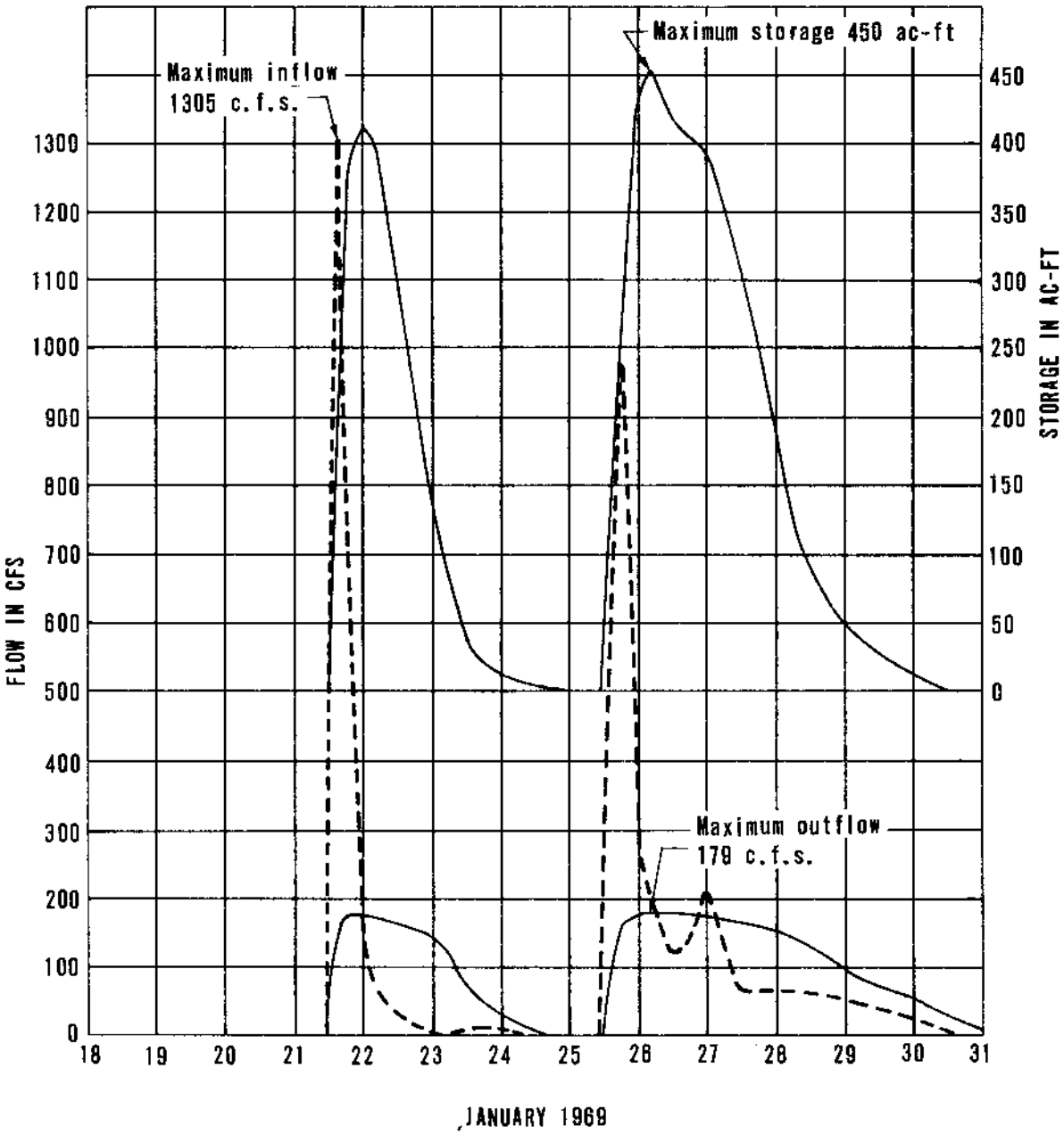
VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM

CONDENSED OPERATION RECORD

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 18



NOTE:

1. Periods of appreciable flow shown only.
2. Operation record from reservoir water surface records. The maximum inflow is the calculated peak hourly value.

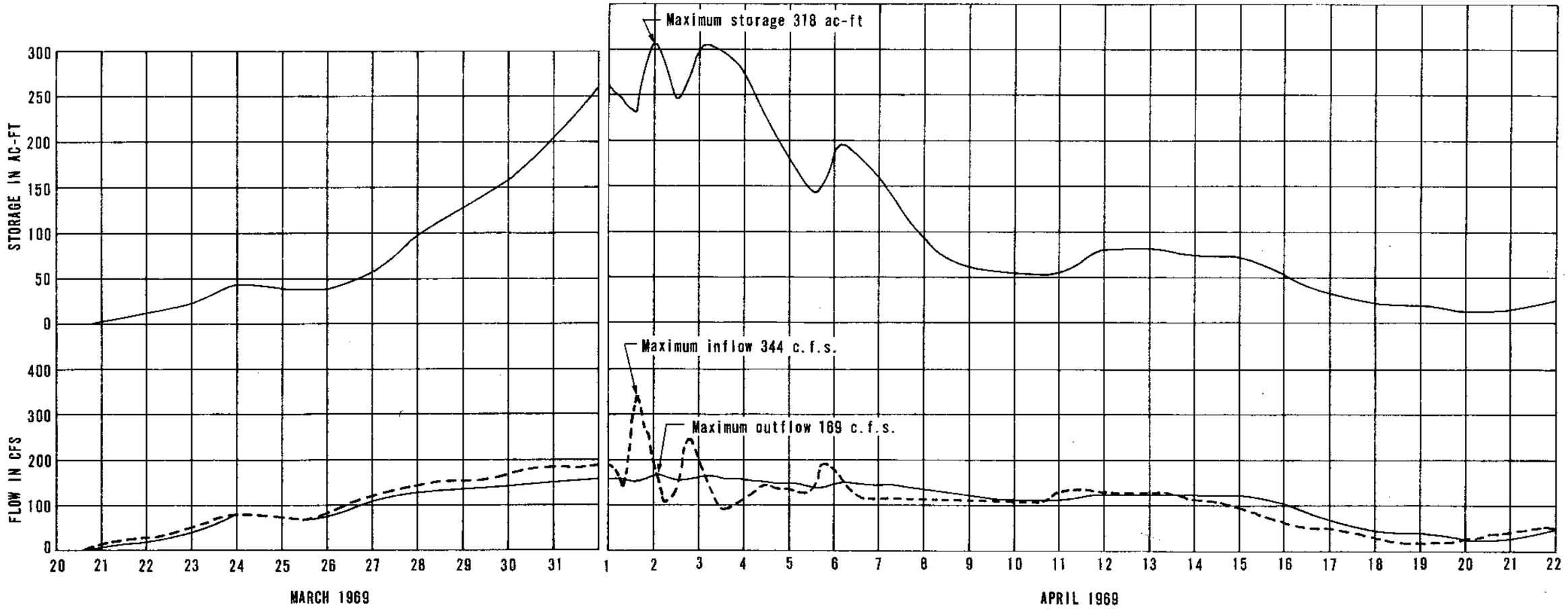
VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

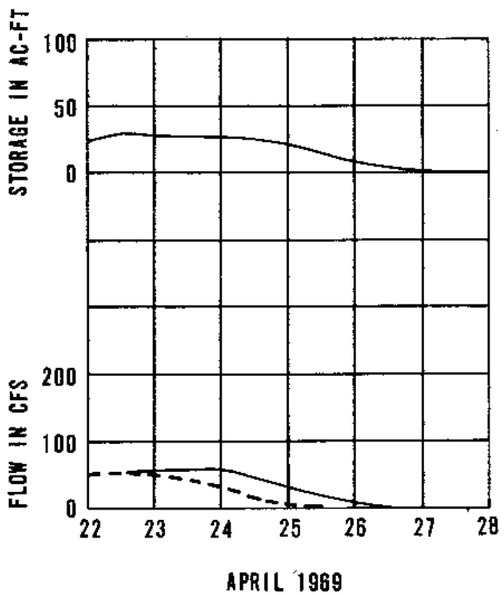
PINE CANYON DAM

CONDENSED OPERATION RECORD

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 19





NOTE:

1. Periods of appreciable flow shown only.
2. Operation record from reservoir water surface records. The maximum inflow is the calculated peak hourly value.

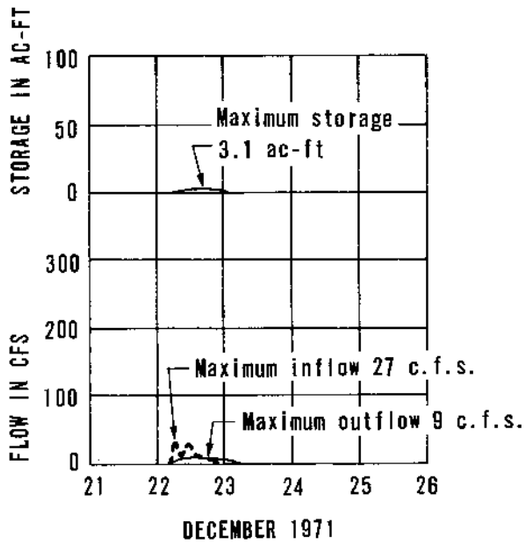
VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

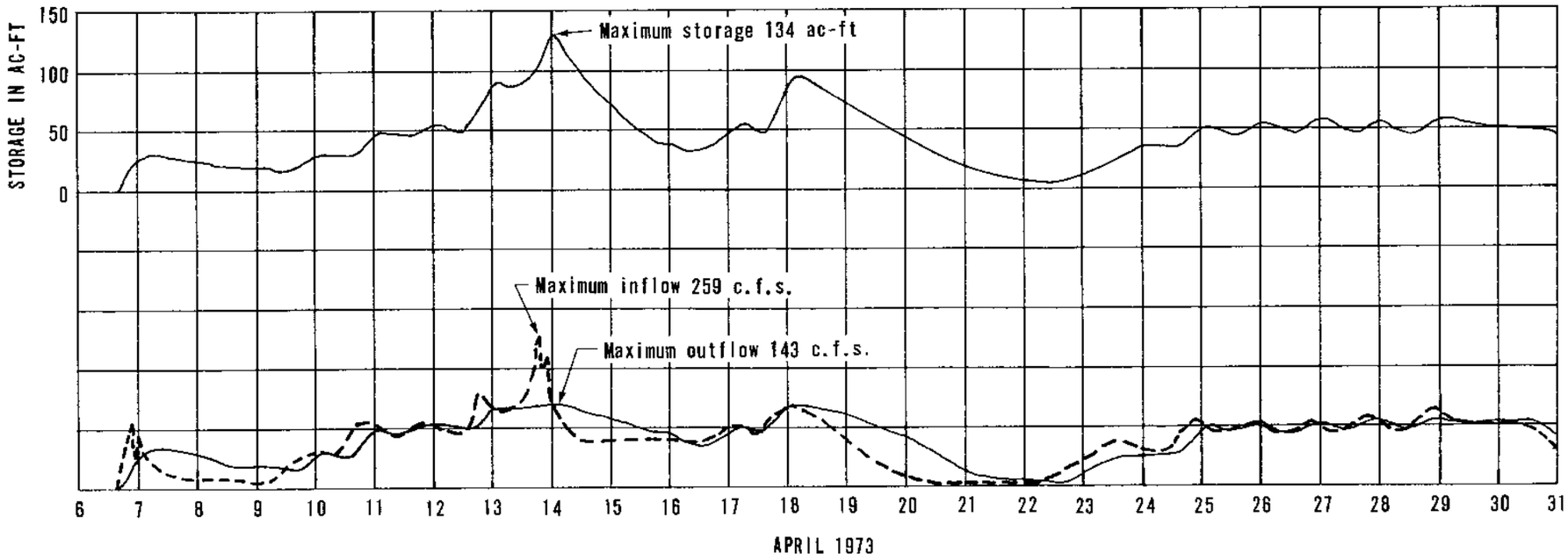
PINE CANYON DAM

CONDENSED OPERATION RECORD

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 20





NOTE:
1. Periods of appreciable flow shown only.

2. Operation record from reservoir water surface records. The maximum inflow is the calculated peak hourly value.

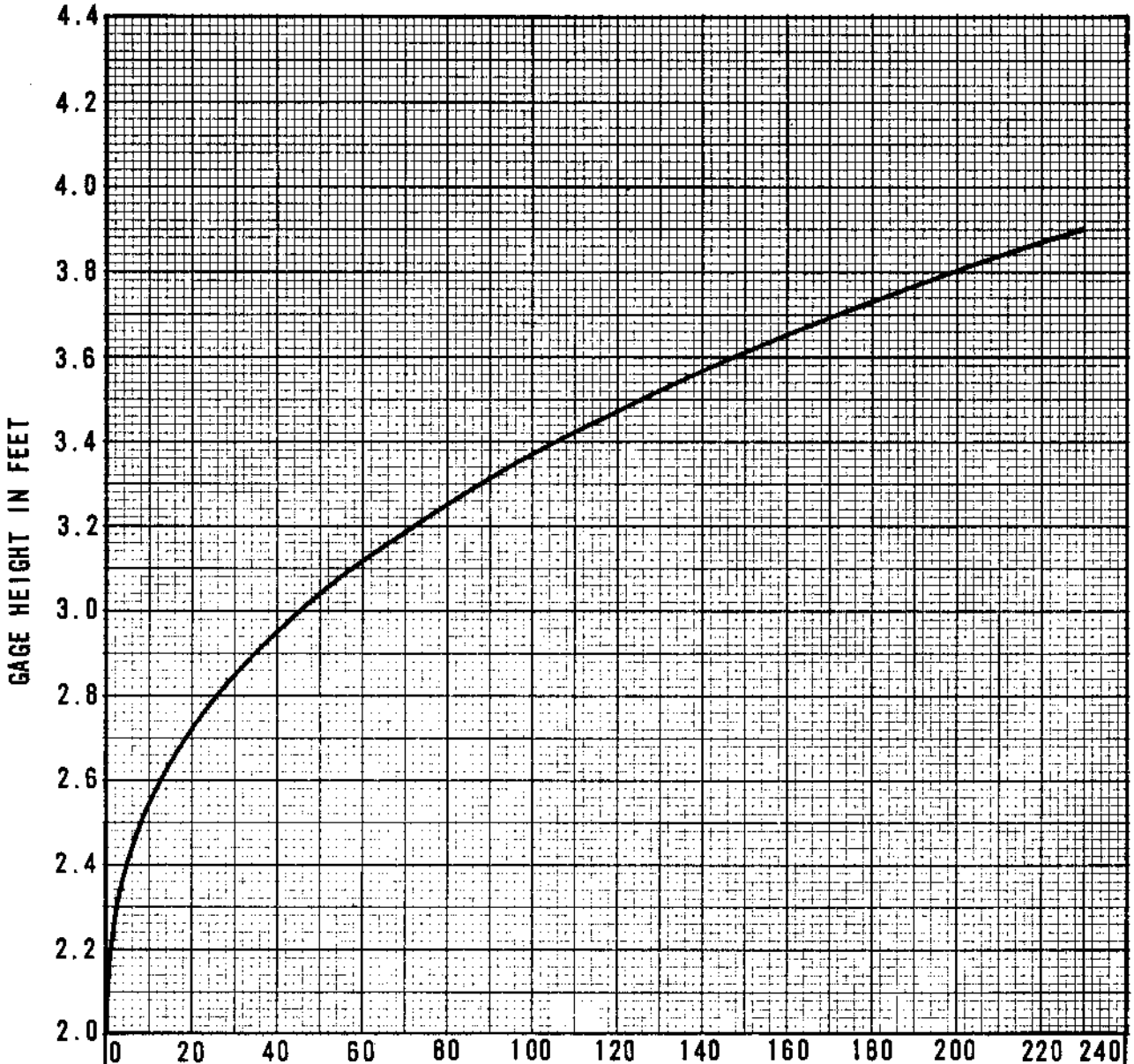
VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM

CONDENSED OPERATION RECORD

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 21



VIRGIN RIVER & TRIBUTARIES, NEVADA, ARIZONA, & UTAH
MEADOW VALLEY WASH AND TRIBUTARIES, NEVADA
RESERVOIR REGULATION MANUAL

PINE CANYON DAM

DISCHARGE RATING CURVE FOR PINE CANYON WASH STREAM GAGING STATION

U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: OCTOBER 1974

PLATE 22